Association between overweight and obesity with school performance in secondary students in Merida, Mexico

Juan C. Salazar-Rendón^{1,2*}, Nina Méndez³ and Hugo Azcorra⁴

¹Departamento de Desarrollo Humano, Secretaría de Educación del Gobierno del Estado de Yucatán; ²Dirección de Nutrición, Servicios de Salud de Yucatán; ³Universidad Marista de Mérida; ⁴Departamento de Ecología Humana, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional. Merida, Yucatan, Mexico

Abstract

Background: Some studies have found a negative relationship between obesity and school performance in scholars. However, this topic has not been studied in depth in Mexico. This study aimed to analyze the association between overweight and obesity with school performance in secondary school students in Merida. **Methods:** Weight and height were measured, and body mass index was calculated in a sample of 566 secondary students in Merida. Nutritional status was classified in normal weight ($-2 < +1$ standard deviation [SD]), overweight ($+1 < 2$ SD) and obesity ($> +2$ SD) according to the World Health Organization criteria. The scores in language, mathematics, and sciences were used as indicators of school performance. Good performance was considered when the scores were ≥ 8 points and poor performance when scores were < 8 points. Logistic regression models were used to analyze the association between the variables. **Results:** The 44% of the sample met the criteria for overweight and obesity. After adjusting for school grade, type of school, number of absences, and Mayan surnames, we found that girls classified as obese had a significant risk of a poor performance in mathematics (odds ratio [OR]: 3.07; 95% confidence interval [CI]: 1.39-6.80) and language (OR: 2.55; 95% CI: 1.14-5.71) compared with those with healthy weight. **Conclusions:** Our results suggest that obesity represents a risk of having a lower school performance in girls but not in boys.

Key words: School performance. Body mass index. Obesity. Adolescents.

Asociación entre el sobrepeso y la obesidad con el rendimiento académico en estudiantes de secundaria de la ciudad de Mérida, México

Resumen

Introducción: Diversos estudios señalan una relación negativa entre la obesidad y el rendimiento académico en la población infantil. Sin embargo, este tema ha sido poco estudiado en México. El objetivo de este estudio fue analizar la asociación entre el sobrepeso y la obesidad con el rendimiento académico en estudiantes de secundaria de Mérida. **Métodos:** Se midió el peso y la talla y se calculó el índice de masa corporal (IMC) en una muestra de 566 alumnos de ambos sexos de escuelas secundarias públicas de Mérida. Se clasificó el estado nutricional de los adolescentes en peso normal ($-2 < +1$

Correspondence:

*Juan Carlos Salazar-Rendón
E-mail: juan.salazar@ssy.gob.mx
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desviaciones estándar [DE]), sobrepeso ($+1 < 2$ DE) y obesidad ($\geq +2$ DE) de acuerdo con los valores de referencia de la Organización Mundial de la Salud (OMS). Se utilizó el promedio de calificaciones obtenidas en las asignaturas de lenguaje, matemáticas y ciencias como un indicador del rendimiento académico. Se consideró desempeño mayor cuando el promedio fue ≥ 8 puntos y menor cuando fue < 8 puntos. El análisis de asociación entre las variables se realizó mediante modelos de regresión logística. **Resultados:** La prevalencia conjunta de sobrepeso y obesidad fue del 44%. Al ajustar para el grado escolar, el tipo de escuela, el número de ausencias y la procedencia maya del apellido, las adolescentes con obesidad tuvieron un riesgo significativo de tener desempeño menor en matemáticas (razón de momios [RM]: 3.07; IC 95%: 1.39-6.80) y lenguaje (RM: 2.55; IC 95%: 1.14-5.71) al compararlas con aquellas con peso saludable. **Conclusiones:** Los resultados sugieren que la obesidad es un factor de riesgo para tener un menor rendimiento académico en las adolescentes de entre 12 y 15 años, pero no entre los adolescentes de la misma edad.

Palabras clave: Rendimiento académico. IMC. Obesidad. Adolescentes.

Introduction

Obesity is currently a public health problem that affects people of all ages worldwide. During childhood and youth, obesity has been linked to a series of adverse events that increase the risk of cardiovascular, metabolic, joint and oncological diseases during adulthood^{1,2}. Recent estimates suggest that younger generations could have shorter and less healthy lives compared to their parents as a result of the obesity epidemic^{3,4}.

In Mexico, the overweight and obesity prevalence in children under 18 has increased considerably during the recent decades reaching the highest value worldwide⁵. The National Survey of Health and Nutrition (ENSANUT, for its Spanish Acronym) of Midway 2016 indicates a combined overweight and obesity prevalence of 36.3% in Mexican adolescents between 12 and 19 years, with overweight predominating in female students (26.4% vs. 18.5%) and obesity in males (15% vs. 12.8%)⁶. In the Mexican state of Yucatán, the ENSANUT 2012 reported an overweight and obesity prevalence of 43.4% in adolescents, a figure that is above the national average, with a slightly higher prevalence in women than in men (44.1% vs. 42.7%)⁷.

Scientific evidence indicates that overweight and obesity can affect, among other things, the academic performance of children and adolescents, which suggests that overweight and obesity could be associated not only with chronic diseases but also with the school-age population academic development and the human capital during adulthood⁸⁻¹⁵. In this regard, in a study with a longitudinal design carried out in Thailand, Mo-suwan et al. reported a negative association between academic performance and obesity in adolescence (grades 7-9), but not in childhood (grades 3-6)¹⁰. In the US, Datar and Sturm studied a group of students from the time they entered pre-school until they

reached the third grade of primary school, and found that girls with obesity and those who during that period went from having a normal weight to suffer obesity were more likely to have a lower academic performance¹⁴. In both studies, obesity was determined when participants showed an exceeded BMI according to their age and sex.

Some authors have pointed out bad dietary and sleep habits, sedentary lifestyle and emotional problems as possible mechanisms of this phenomenon, as well as discrimination against people with obesity by their peers and teachers^{11,16-18}. It has been proposed that the association between overweight and obesity with academic performance violate the individuals' quality of life because young people with obesity would be more likely to have fewer years of formal education and less chance of getting better-paid jobs^{19,20}.

Although education spending has increased by more than 5% of gross domestic product in the recent years²¹, the Mexican educational system continues to face great challenges in its contribution to the human development of its population. The results obtained in tests to measure the country's educational progress have shown low levels of performance among Mexican students^{22,23}. The Planea 2015 test showed a poor performance in language and communication and mathematics among third-year secondary students, in which only 6.1 and 3.1% of the participants obtained a satisfactory level, respectively²². For its part, the Organisation for Economic Co-operation and Development (OECD) has applied the Program for International Student Assessment (PISA) to assess the achievements and skills acquired by students at the end of compulsory education, where the results obtained by Mexican adolescents place the country among the most lagging members of the organization. The 2015 PISA test results place Mexico below the OECD average in science, reading, and mathematics, where less than 1% of

Mexican students achieved excellence levels; when comparing results by gender, male students had better results in science and mathematics than female students, while female students outperformed male students in reading²³.

The objective of this study was to analyze the association between overweight and obesity with academic performance in a sample of adolescents from 12 to 15 years of age who attend secondary school in the city of Mérida, Yucatán.

Methods

Sample selection and description

During May and June 2016, five public secondary schools in the city of Mérida were visited, randomly selected by stratum. Three of them belonged to the technical secondary schools' sub-system, which is differentiated, by including in their curriculum, subjects focused on the work environment at a technical level, and the rest belonged to the general secondary schools' subsystem. Groups within the schools also were randomly selected. The sample consisted of a total of 566 adolescents (293 females and 273 males) between 12 and 15 years of age.

Anthropometric measurements

Weight and height were obtained in the adolescents who participated in the study using a digital scale with a 100 g precision (Omron® HBF 514c) and a stadiometer with a 0.1 cm precision (Seca® 213), respectively. Trained personnel made the measurements following the standardized procedures suggested by Lohman et al²⁴. In schools, participants were measured barefoot and in light clothing. Height and weight were used to calculate BMI ($\text{BMI} = \text{weight} [\text{kg}] / \text{height}^2 [\text{m}^2]$) of the participants, and the standardized values (z) of this indicator were calculated using the WHO reference values of 2007²⁵. The adolescents' nutritional status was classified into the following categories: normal weight ($-2 < +1$ SD), overweight ($+1 < 2$ SD) and obesity ($> +2$ SD).

Academic performance measurement

Basic education in Mexico is made up of the following levels: preschool, primary and secondary; the latter level lasts three years and is directed to a population between 12 and 16 years old. The official grading scale

is numerical, from 5 to 10, with 6.0 being the minimum grade to pass. In the state of Yucatán, there are four subsystems of secondary education: general, state-run, technical and *telesecundaria* (distance-learning secondary school). For this study purposes, grades were used as an indicator of adolescents' academic performance; they were obtained from the school records and corresponded to the period of March-April of the 2015-2016 school year. The grades were classified into two categories: 1) good performance when they were at least 8 points; and 2) poor performance when they were less than 8 points. Although this cut-off point is arbitrary, the score 8 represents the intermediate point on the grading scale.

Ethical considerations

Authorization was obtained from the Secretaría de Educación del Estado de Yucatán (Ministry of Education of the State of Yucatan) to carry out the study in the selected schools. The researchers informed the directors of the schools, and the selected adolescents about the study objectives and asked for their consent to participate in the study. The informed consent of all the participants was obtained. For the maintenance of the adolescents' privacy, the anthropometric measurements were made in a space specifically destined for this activity assigned by the school's administration. The measurements were carried out solely in the presence of the research team.

Statistical analysis

The differences in the mean BMI values (absolute values and z scores) between the categories of academic performance and sex were analyzed using unpaired Student's T -tests. The χ^2 test was applied to examine the differences in the proportions of individuals belonging to each nutritional status group concerning the categories of academic performance. The analysis of the association between nutritional status and academic performance was carried out using logistic regression models. The response variable was the students' academic performance (0 = good performance, 1 = poor performance). Regression models were adjusted to predict language, mathematics, and science performance. Different models were developed for both sexes. The independent variable of interest was the students' nutritional status expressed by the BMI (0 = normal weight, 1 = overweight and 2 = obesity). The analysis was restricted to these categories since only five individuals

Table 1. General characteristics of the sample by sex

Variable	All participants	Male	Female	Difference
	Mean (SD)	Mean (SD)	Mean (SD)	
n	566 (100%)	273 (48%)	293 (52%)	-
Age	14.05 ($\pm$ 0.94)	14.13 ($\pm$ 0.93)	13.98 ($\pm$ 0.95)	t = 1.86, P = 0.064
Type of school				
General	249 (44%)	132 (48%)	117 (40%)	$X^2_{(1)} = 4.06$, p = 0.044
Technical	317 (56%)	141 (52%)	176 (60%)	
School grade level				
First	188 (33%)	86 (32%)	102 (35%)	$X^2_{(2)} = 0.76$, p = 0.681
Second	241 (43%)	118 (43%)	123 (42%)	
Third	137 (24%)	69 (25%)	68 (23%)	
Absences	Median = 2	Median = 2	Median = 2	z = -0.42, P = 0.673
Surnames				
Non-Mayan	301 (53%)	142 (52%)	159 (54%)	$X^2_{(1)} = 0.29$, p = 0.592
Mayan	265 (47%)	131 (48%)	134 (46%)	
Academic performance				
Language				$X^2_{(1)} = 22.08$, p < 0.001
Good	312 (55%)	123 (45%)	189 (65%)	
Poor	253 (45%)	150 (55%)	103 (35%)	
Mathematics				$X^2_{(1)} = 3.06$, p = 0.080
Good	274 (49%)	122 (45%)	152 (52%)	
Poor	291 (51%)	151 (55%)	140 (48%)	
Sciences				$X^2_{(1)} = 12.81$, p < 0.001
Good	359 (64%)	153 (56%)	206 (71%)	
Poor	206 (36%)	120 (44%)	86 (29%)	

SD, standard deviation; p, level of significance; X^2 , Chi-square test.

showed a low BMI (< -2 SD). All the models were adjusted for the students' school grade level (1 = first, 2 = second and 3 = third), the number of absences in the studied school-period (continuous variable), the type of school (0 = general and 1 = technical) and the Mayan origin of the student's surname (0 = without Mayan surnames and 1 = one or two Mayan surnames). The school type was used as an indicator of the students' socioeconomic conditions; in the local context, technical secondary schools receive students in more adverse socioeconomic conditions compared to the rest of the schools. Previous works indicate that students with Mayan ancestry tend to show a different academic performance from the rest of the population²⁶. The category of normal BMI and the following socioeconomic categories were used as references in the models' specification: first grade of secondary school, general school and without Mayan surnames. All the analyses were performed at a significance level of $\alpha = 0.05$ with the Stata[®] statistical package (StataCorp Lp 11.2).

Results

Table 1 describes the general characteristics of the studied sample. The mean age of the students was 14.05 years (SD: 0.94) and the distribution according to their grade level was 33, 43 and 24% in the first, second and third grades, respectively. 56% of the participants were recruited in technical schools, and 47% had at least one surname of Mayan origin. Higher proportions (with statistical significance) of women showed higher performance in language and science.

Females showed significantly higher BMI values than males (mean: 22.66 kg/m² [SD: 3.91] vs. mean: 21.99 kg/m² [SD: 3.92], p < 0.05) (Table 2). From the studied individuals, 44% were overweight or obese (overweight: 28%, obese: 16%), the figures were very similar between both sexes (males: 42%, females: 44%). Female students with lower academic performance in mathematics showed significantly higher BMI (absolute) values than those with higher academic performance. It was also observed that female students with lower academic

Table 2. Descriptive statistics of the BMI and the proportion of individuals in the different nutritional status categories according to academic performance in language, mathematics, and science

Indicator	All participants	Language		Mathematics		Sciences	
	Mean (SD)	Good	Poor	Good	Poor	Good	Poor
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Females							
BMI (kg/m ²)	22.66 (3.91)	22.38 (3.86)	23.23 (3.96)	22.17 (3.46)	23.24 (4.27)	22.45 (3.87)	23.24 (3.95)
		t = -1.78, P = 0.060		t = -2.36, P = 0.019		t = -1.58, P = 0.115	
BMI-Z	0.58 (0.79)	0.77 (1.03)	0.95 (0.99)	0.72 (0.93)	0.95 (1.10)	0.78 (1.02)	0.96 (1.01)
		t = -1.47, P = 0.141		t = -1.87, P = 0.061		t = -1.78, P = 0.060	
BMI							
Normal	56% (164)	58% (109)	53% (54)	59% (90)	52% (73)	58% (119)	51% (44)
Overweight	30% (87)	31% (58)	28% (29)	32% (48)	28% (39)	28% (58)	34% (29)
Obesity	14% (41)	11% (21)	19% (20)	9% (13)	20% (28)	14% (28)	15% (13)
		X ² = 3.74, p = 0.154		X ² = 7.79, p = 0.020		X ² = 1.20, p = 0.548	
Males							
BMI (kg/m ²)	21.99 (3.92)	21.76 (3.81)	22.17 (4.02)	21.80 (3.80)	22.13 (4.02)	21.83 (3.99)	22.18 (3.84)
		t = -0.86, P = 0.391		t = -0.69, P = 0.491		t = -0.73, P = 0.466	
BMI-Z	0.56 (0.99)	0.73 (1.18)	0.83 (1.19)	0.71 (1.18)	0.84 (1.20)	0.73 (1.21)	0.85 (1.17)
		t = -0.64, P = 0.520		t = -0.89, P = 0.373		t = -0.87, P = 0.385	
BMI							
Normal	57% (153)	57% (68)	57% (85)	56% (66)	58% (87)	57% (86)	56% (67)
Overweight	26% (69)	27% (33)	24% (36)	30% (36)	22% (33)	25% (37)	27% (32)
Obesity	16% (47)	16% (19)	19% (28)	14% (17)	20% (30)	18% (27)	17% (20)
		X ² = 0.62, p = 0.732		X ² = 3.08, p = 0.215		X ² = 0.19, p = 0.907	

SD, standard deviation; p, level of significance; t, Student's t-test; BMI, body mass index; BMI-Z, BMI Z-score normal weight (-2 < +1 SD), overweight (+1 < +2 SD) and obesity (> +2 SD).

performance in this area showed a significantly higher proportion of overweight and obesity compared to those with high academic performance. This result was not found in males for any analyzed knowledge area.

The results of the logistic regression models for each knowledge area are shown in tables 3 to 5. We found that the obesity category was significantly associated to a higher risk of poor academic performance in language (OR: 2.55, 95% confidence interval [CI]: 1.14-5.71) and mathematics (OR: 3.07, 95% CI: 1.39-6.80), this result was significant in women but not in men. The number of absences in the studied school-period increased the probabilities of poor performance in all academic areas for men and women. Moreover, the models suggested that young people both females and males were more likely to have poor performance in the language area in technical secondary schools. None of the interactions between the independent variables was significant.

Discussion

The overweight and obesity prevalence found in this research (44%) is comparable to the reported in the ENSANUT 2012⁷ (43.4%) among young people between 12 and 19 years old living in Yucatán, also with the one obtained by the National School Health Survey (ENSE, for its Spanish acronym) in 2008²⁷ (41%) in Yucatán high school students between 12 and 16 years of age. These similarities give reliability to our results and confirm that overweight and obesity continue to be an alarming public health problem among adolescents living in Yucatán.

Different studies that address the association between obesity and academic performance show discrepant results; some studies have found a positive association, while others have not seen a relationship^{8-15,28-32}. These discrepancies could be due to differences in age

Table 3. Logistic regression model of biosocial factors for poor academic performance in language

	n	Females		p value	n	Males		p value
		OR (95% CI) raw	OR (95% CI) adjusted			OR (95% CI) raw	OR (95% CI) adjusted	
BMI								
Normal	164	1	1	-	153	1	1	-
Overweight	87	1.01 (0.58-1.75)	1.19 (0.63-2.26)	0.588	69	0.87 (0.49-1.54)	0.83 (0.44-1.54)	0.547
Obesity	41	1.92 (0.96-3.85)	2.55 (1.14-5.71)	0.023	47	1.18 (0.61-2.29)	1.13 (0.54-2.36)	0.738
School grade level								
1 st grade	101	1	1	-	85	1	1	-
2 nd grade	123	2.10 (1.18-3.72)	2.13 (1.10-4.14)	0.025	115	0.85 (0.48-1.48)	1.07 (0.58-2.00)	0.823
3 rd grade	68	1.81 (0.93-3.51)	1.11 (0.52-2.37)	0.794	69	1.16 (0.61-2.20)	0.76 (0.37-1.58)	0.465
Absences	292	1.24 (1.16-1.33)	1.26 (1.17-1.36)	< 0.001	269	1.19 (1.10-1.29)	1.21 (1.12-1.32)	< 0.001
Type of school								
General	116	1	1	-	129	1	1	-
Technical	176	2.75 (1.62-4.66)	3.03 (1.64-5.62)	< 0.001	140	2.12 (1.30-3.44)	2.19 (1.28-3.76)	0.004
Surnames								
Non-Mayan	158	1	1	-	138	1	1	-
Mayan	134	1.05 (0.65-1.69)	0.93 (0.52-1.66)	0.808	131	1.52 (0.94-2.46)	1.58 (0.93-2.67)	0.089

OR, odds ratio; SD, standard deviation; p, level of significance; CI, confidence interval

Normal weight (-2 - < +1 SD), Overweight (+1 - < 2 SD), Obesity (> +2 SD).

The model was adjusted for the following variables: school grade level, number of absences in the studied school-period, type of school and student's Mayan ancestry according to the presence of Mayan surnames.

Table 4. Logistic regression model of biosocial factors for poor academic performance in mathematics

	n	Females		p value	n	Males		p value
		OR (95% CI) raw	OR (95% CI) adjusted			OR (95% CI) raw	OR (95% CI) adjusted	
BMI								
Normal	164	1	1	-	153	1	1	-
Overweight	87	1.01 (0.59-1.69)	1.07 (0.61-1.89)	0.876	69	0.70 (0.40-1.23)	0.59 (0.32-1.11)	0.101
Obesity	41	2.66 (1.28-5.49)	3.07 (1.39-6.80)	0.006	47	1.34 (0.68-2.63)	1.05 (0.51-2.18)	0.899
School grade level								
1 st grade	101	1	1	-	85	1	1	-
2 nd grade	123	1.21 (0.71-2.05)	1.08 (0.60-1.92)	0.802	115	0.78 (0.44-1.38)	0.86 (0.47-1.60)	0.643
3 rd grade	68	0.98 (0.53-1.82)	0.56 (0.28-1.13)	0.104	69	0.46 (0.24-0.87)	0.28 (0.12-0.55)	< 0.001
Absences	292	1.21 (1.13-1.29)	1.24 (1.15-1.34)	< 0.001	269	1.15 (1.07-1.23)	1.20 (1.11-1.30)	< 0.001
Type of school								
General	116	1	1	-	129	1	1	-
Technical	176	1.01 (0.63-1.61)	0.86 (0.51-1.45)	0.596	140	1.27 (0.79-2.05)	1.38 (0.81-2.36)	0.243
Surnames								
Non-Mayan	158	1	1	-	138	1	1	-
Mayan	134	1.04 (0.66-1.65)	1.10 (0.65-1.84)	0.732	131	1.31 (0.81-2.12)	1.44 (0.85-2.44)	0.175

OR, odds ratio; SD, standard deviation; p, level of significance; CI, confidence interval

Normal weight (-2 - < +1 SD), Overweight (+1 - < 2 SD), Obesity (> +2 SD).

The model was adjusted for the following variables: school grade level, number of absences in the studied school-period, type of school and student's Mayan ancestry according to the presence of Mayan surnames.

groups and socioeconomic characteristics among the studied populations, as well as the different methods used to assess academic performance in children and young people.

Table 5. Logistic regression model of biosocial factors for poor academic performance in sciences

	n	Females		p value	n	Males		p value
		OR (95% CI) raw	OR (95% CI) adjusted			OR (95% CI) raw	OR (95% CI) adjusted	
BMI								
Normal	164	1	1	-	153	1	1	-
Overweight	87	1.35 (0.77-2.38)	1.46 (0.80-2.67)	0.222	69	1.11 (0.63-1.96)	1.25 (0.66-2.37)	0.488
Obesity	41	1.26 (0.60-2.64)	1.22 (0.54-2.73)	0.630	47	0.95 (0.49-1.84)	1.07 (0.51-2.23)	0.859
School grade level								
1 st grade	101	1	1	-	85	1	1	-
2 nd grade	123	1.36 (0.75-2.48)	1.13 (0.59-2.14)	0.718	115	1.86 (1.06-3.29)	2.01 (1.07-3.79)	0.030
3 rd grade	68	2.01 (1.03-3.93)	1.59 (0.78-3.23)	0.202	69	1.02 (0.53-1.96)	0.64 (0.29-1.39)	0.256
Absences	292	1.14 (1.08-1.20)	1.14 (1.08-1.20)	< 0.001	269	1.18 (1.10-1.26)	1.24 (1.15-1.34)	< 0.001
Type of school								
General	116	1	1	-	129	1	1	-
Technical	176	0.84 (0.50-1.40)	0.77 (0.44-1.35)	0.364	140	0.46 (0.28-0.74)	0.44 (0.25-0.77)	0.004
Surnames								
Non-Mayan	158	1	1	-	138	1	1	-
Mayan	134	0.56 (0.34-0.95)	0.59 (0.34-1.03)	0.064	131	0.86 (0.53-1.38)	0.94 (0.55-1.61)	0.813

OR, odds ratio; SD, standard deviation; p, level of significance; CI, confidence interval

Normal weight (-2 - < +1 SD), Overweight (+1 - < 2 SD), Obesity (> +2 SD).

The model was adjusted for the following variables: school grade level, number of absences in the studied school-period, type of school and student's Mayan ancestry according to the presence of Mayan surnames.

In the current study, it was found that women with a higher BMI showed an increased risk of having poor academic performance. Our findings coincide with those reported by Sabia¹³, who found a negative relationship between BMI and the grades obtained by white women between 14 and 17 years old in the US. However, this association lost its significance in non-white women and males of the same age range. Our results also coincide with those reported by Datar and Sturm, who followed American children during their early years in primary education and found that excessive weight gain during the first years of primary school was a significant risk factor for obtaining adverse results in academic performance among girls, but not in boys¹⁴.

Our results show that young women with obesity criteria have a higher risk of having a poor performance in language and mathematics specifically. Similar results have been found by Judge and Jahns⁹, Mo-suwan et al.¹⁰ and Datar et al.¹⁵ who reported in different studies a significant association between obesity and lower academic performance in mathematics and language in pre-school, school-age and adolescent children, regardless of sex. However, Judge and Jahns⁹ found that the association is attenuated after controlling the influence of socioeconomic variables and maternal education. Another study conducted on children in

primary education in Canada found that participants who had presented obesity during preschool and had achieved later a healthy weight in primary school were able to improve their grades in mathematics³². Unlike our findings, these studies do not report whether their results varied according to the sex of the participants.

The possible mechanisms that explain the relationship between overweight and obesity with academic performance are not yet clear. The literature shows an association between cognitive function and adiposity, in which functions of cognitive control, visuospatial skills, and mental ability are altered in children with excessive adiposity^{33,34}. In this sense, Portillo-Reyes et al. analyzed the neuropsychological performance and nutritional status of a sample of Mexican children between 8 and 12 years old from the low socioeconomic level that belonged to urban environments. The results showed that children with obesity had a lower performance than children with healthy weight in tasks related to memory, abstract reasoning, and in following instructions³⁵.

Health habits such as diet, physical activity, and sleep, as well as psychosocial factors, have been proposed as links between overweight and obesity with poor academic performance during childhood and youth¹¹. Studies conducted in Canada and Korea have

found that the habit of eating breakfast and a healthy diet are factors associated with higher academic performance in children and adolescents³⁶⁻³⁸. In particular, Kang and Park reported that adolescents who did not eat breakfast had lower grades in language, mathematics, and foreign language compared with those who did eat it³⁸. Haapala et al. reported that certain diets, such as the Mediterranean or the Baltic, were associated with better reading skills, but not with better arithmetic skills among Finnish children who were in the first years of primary school³⁹.

Regarding sleep habits, a study conducted in Mexico analyzed the academic performance of a group of adolescent girls between 15 and 18 years of age, finding that those participants who covered the obesity criteria and who also had daytime hypersomnia had a 0.7% lower academic performance than their peers with a healthy weight and without sleep disorders¹⁶.

The physical activity benefits seem to extend to academic performance, as suggested by Kantomaa et al., who found that physically active adolescents were twice as likely to have better grades compared to sedentary adolescents⁴⁰. For their behalf, Carlson et al.⁴¹ reported that in North American girls attending primary school, greater physical activity time (70-300 min/week) was associated with academic improvement in mathematics and reading. Another study conducted in the US, with students in the third and fifth grades in public schools, reported that aerobic fitness was positively associated with general academic performance, and in mathematics and reading areas⁴². Endorphins release could regulate these benefits because they improve the mood also could be provided by the socialization that implies the practice of a sport.

Some evidence supports the role of psychosocial factors in academic performance. It has been reported that children who have obesity suffer from more mockery and bullying than their peers; this harassment could decrease their self-esteem and consequently affect their academic performance⁴³⁻⁴⁵. It is possible that the overweight and obesity influence on academic performance is largely manifested in women. This influence seems to have consequences that affect women's education, employment, healthcare and interpersonal relationships^{46,47}. Crosnoe found that obese girls were less likely to attend university after finishing high school compared to their peers with a healthy weight; this difference was not observed among men with overweight and obesity⁴⁸.

The present study has some limitations that should be discussed. On the one hand, because it is a cross-sectional study, it is not intended to indicate that

obesity has a causal effect on academic performance, but that both factors are associated. On the other hand, the analyzed school grades belong to only one two-month period of the school year, so they do not represent the students' overall performance. Moreover, the teaching staff of the schools assigned the grades, so the possibility of some inherent bias in the teachers' criteria and their evaluation cannot be rejected.

In summary, the present results showed that girls with obesity had an increased risk of having poor academic performance in language and mathematics. These results were not observed in males in any analyzed area. In the future, it is necessary to study the role of other factors, such as socioeconomic level, diet, and physical activity, in the academic performance of the school-age population with the aim of implementing policies directed to improve their health conditions and increase their possibilities of human development.

Ethical responsibilities

Protection of humans and animals. The authors declare that no experiments have been conducted on humans or animals for this research.

Data confidentiality. The authors declare that they have followed the protocols of their work center on the publication of patients' data.

Right to privacy and informed consent. The authors have obtained the informed consent of the patients and subjects referred to in the article. These documents are in possession of the corresponding author.

Conflicts of interest

The authors declare no conflicts of interest.

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