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Physical activity, sedentary time and cardiometabolic health indicators among Mexican children

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Summary

We examined the independent associations of moderate to vigorous physical activity (MVPA) and sedentary time (ST) with cardiometabolic indicators in Mexican children (4–6 years of age). We conducted a cross-sectional study (n = 400) using the measures of MVPA and ST (7-day

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AUTHOR CONTRIBUTIONS

Dr Jauregui conceptualized, designed and executed the analyses; drafted the initial manuscript; reviewed and revised the manuscript. Dr Salvo processed accelerometer data and reviewed and revised the manuscript. Armando Olvera helped process accelerometer raw data, helped execute the analyses and draft the initial manuscript, and reviewed and revised the manuscript. Umberto Villa prepared the algorithm to estimate physical activity and sedentary behaviour outcomes, and reviewed and revised the manuscript. Dr Téllez-Rojo contributed to the conception, design and implementation of the study and drafted the article. Dr Schnaas completed the data acquisition and critically reviewed and revised the manuscript. Katherine Svensson designed the data organization and critically reviewed and revised the manuscript. Dr Oken contributed to the conception and design of the study and critically reviewed and revised the manuscript. Dr Wright contributed to the conception and design of the study and critically reviewed and revised the manuscript. Dr Baccarelli contributed to the conception and design of the study and critically reviewed and revised the manuscript. Dr Cantoral helped design and implementation of the study, conceptualize, design and execute the analyses, and reviewed and revised the final manuscript.

CONFLICT OF INTEREST

No conflict of interest was declared.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

accelerometry) and the following indicators: % body fat, waist circumference, body mass index (BMI) z-score, glycated haemoglobin, blood glucose, triglycerides, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, leptin, adiponectin and resting blood pressure. We examined the independent associations of MVPA and ST with cardiometabolic indicators through confounder-adjusted and mutually adjusted (including both MVPA and ST) linear regression models. Confounder-adjusted models showed that MVPA was associated with higher BMI z-scores and lower adiponectin levels in girls and lower body fat among boys. ST was associated with higher body fat, in the full sample, and lower LDL cholesterol among boys. After mutually adjusting for MVPA and ST, MVPA (10-minute increase) remained significantly associated with BMI z-score in girls ($\beta = 0.187$, 95% CI: 0.019, 0.356) and ST (60-minute increase) remained significantly associated with higher body fat ($\beta = 1.11\%$, 95% CI: 0.019, 2.203) among boys and higher glycated haemoglobin ($\beta = 0.047\%$ points, 95% CI: 0.000, 0.094) in the full sample. In preschool-aged children, the objective measures of ST and MVPA were associated with small differences in cardiometabolic health indicators. ST was unfavourably associated with some cardiometabolic indicators even after adjusting for MVPA, and thus appeared to have a more significant role than MVPA, especially in boys. Future longitudinal studies should confirm these results.

Keywords

accelerometer; children; sedentary time

1 | INTRODUCTION

Physical inactivity and sedentary behaviour are movement-related behaviours that can lead to adverse health outcomes among all age groups, including early childhood.^{1–4} It has also been recognized that physical inactivity and sedentary time (ST) may independently contribute to unhealthier cardiometabolic risk profiles.^{5,6} These behaviours are of particular relevance during the early years since this period is a critical window for growth and health programming^{7,8} and could represent the beginning of the process leading to chronic disease later in life.

Recently, the World Health Organization (WHO) for the first time recommended that, to obtain health benefits, children aged 3 to 4 years should engage in at least 180 minutes per week of physical activity, of which at least 60 minutes should be of moderate to vigorous physical activity (MVPA).⁹ Similarly, WHO recommends that children aged 5 to 17 years also accumulate 60 min/day of MVPA.¹⁰ Additionally, WHO recommends that children under 5 years of age should not be restrained for more than 1 hour at a time (eg, in prams/strollers) or sit for extended periods of time. Recommendations for children under 5 years of age were based on systematic reviews showing very low-quality evidence for ST on cardiometabolic and adiposity indicators¹¹; also, the evidence for MVPA on the same indicators was very low.⁴ The authors of the reviews recommended focusing on high-quality research that includes a wider range of direct measures of health indicators since most studies have focused on adiposity measures and account for potential confounding factors (eg, diet).^{4,11} To date, only few studies have examined the joint relations of ST and physical

activity with cardiovascular health among young children,¹² justifying more research in this area.

To help better understand the relation between health and MVPA and ST in this age group, this study aimed to examine the independent associations of objectively measured MVPA and ST with cardiometabolic indicators (ie, adiposity and direct measures of cardiometabolic markers) among children 4 to 6 years of age from Mexico City enrolled in the Programming Research in Obesity, Growth, Environment and Social Stressors (PROGRESS) cohort study.

2 | METHODS

2.1 | Participants and study design

We used cross-sectional data from the PROGRESS birth cohort in Mexico City. Details on the methods of the cohort are provided elsewhere.¹³ In 2007 to 2011, 1054 pregnant women were enrolled through the Mexican Social Security System. Mother-infant pairs were followed up at postpartum at the National Institute of Perinatology “Isidro Espinoza de los Reyes.” Data for this analysis were collected between 2013 and 2016 and included accelerometer-based MVPA and ST, adiposity and cardiometabolic measures when the children were 48 to 72 months of age (2013–2016).

Study protocols were approved by the institutional review boards of the Icahn School of Medicine at Mount Sinai Hospital, Harvard T. H. Chan School of Public Health, the National Institute of Public Health and the National Institute of Perinatology in Mexico. These institutions share the principal authority of the ethical conduct of the study. A parent/guardian provided written informed consent for child participation, and all children provided verbal assent to participate.

2.2 | Outcomes: adiposity and cardiometabolic indicators

The percentage of body fat (BF) and total body weight was estimated with a tetrapolar bioelectrical impedance using the InBody 370 or 230 (Biospace Co., Ltd.), in 10% and 90% of the sample, respectively. Because values on these two instruments differed systematically for children, we used a robust linear model fit on a calibration set of 36 children with concurrent measures to adjust the values (R^2 of 0.99 and 0.96 for BFM and PBF, respectively), this calibration was reported previously.¹⁴ Mean waist circumference was calculated from the average of two measurements above the iliac crests using a SECA measuring tape. Height was measured twice using a mechanical wall stadiometer Seca ECA to the nearest 0.5 cm (Hamburg, Germany) model 206.¹⁵ BMI z-scores for age and sex were calculated using the WHO norms. Children with a BMI z-score of >2 SD were classified as overweight.¹⁶

Venous blood samples (5 mL) were collected by a trained personnel. Samples were collected regardless of fasting condition and analysed at the laboratory of the hospital. HbA1c was measured by using a Miura 200 automated analyzer (ISE S.r.l., Rome, Italy); total cholesterol, HDL cholesterol and triglycerides were determined with an automated analyzer (Roche Diagnostics, Indianapolis, IN). LDL cholesterol was calculated based on the

Friedewald equation (LDL cholesterol = [total cholesterol] – [HDL cholesterol] – [triglycerides/5], in mg/dL). We measured leptin by ultrasensitive ELISA (R&D Systems, Minneapolis, MN) and adiponectin using an ELISA method from ALPCO Diagnostics Inc. (Salem, NH).

Children's resting blood pressure (after 3–5 minutes of rest) was measured twice using a SpaceLabs Healthcare automated oscillo-metric device (Ambulatory BP 90207 monitor, Washington) with a child-sized cuff.¹⁷ The average of the two measurements was calculated to obtain the mean systolic and diastolic blood pressure.

2.3 | Independent variables of interest: physical activity and ST

Actigraph GT3X (ActiGraph, Inc, Pensacola, FL) wrist-worn accelerometers were used to examine physical activity and ST. Trained physicians placed the accelerometers on children's nondominant wrist using hospital-style wrist straps. Mothers were instructed to supervise that their child did not remove it at any time, and to record sleep and nap times and accelerometer removal (if any) using a sleep diary. Seven days later, research staff retrieved the accelerometer and the sleep diary during a home visit. ActiLife version 6.8.2 was used for accelerometer initialization and data download. Data were collected and scored using 10-second epochs. Only the dates in between the dates of initiation and retrieval were considered for accelerometer data analysis. The days of initiation and retrieval were excluded because they were usually not a complete measurement day (less than 10 hours).¹⁸

Wear-time validation and scoring were performed using MATLAB (version 2018a, MathWorks, Inc., Natick, Massachusetts) using an algorithm developed by the investigators (Villa and Salvo) for processing multiple-day raw accelerometer data. Accelerometer data were considered valid if at least four 10-hour days with at least one weekend were recorded.¹⁹ Nonwear time was defined as accruing 20 or more consecutive minutes of no movement ("zero counts") in the accelerometer.^{20,21} The algorithm also removed sleep and nap time reported via the sleep diaries from the analysis. Average minutes per day of ST and MVPA were estimated using Johansson's cut points for the vertical axis.²²

2.4 | Covariates

The following primary caregiver (usually the mother) reported variables as school attendance, age, marital status, education and socioeconomic (SES) status of the family (using a validated questionnaire for categorizing SES in Mexican families).²³ Additionally, the following child-based variables were obtained from the records of the cohort: birth weight (<2500 g was classified as low birth weight²⁴), child sex, breastfeeding history and current total energy intake. In the case of energy intake, a validated food frequency questionnaire, which describes the consumption of 140 foods over the past 7 days, prior to the visit, was applied to the mother.²⁵ The amount of grams and millilitres of each food and beverage was estimated, and the total calories per day were calculated using the food composition tables compiled by the National Institute of Public Health. Instruments were administered by trained personnel using standardized procedures.

2.5 | Statistical analysis

Characteristics of study children are summarized using mean $\pm$ SD for continuous variables and n (%) for categorical variables. Chi-square test and t test were used to test the differences between boys and girls. Skewed variables (triglycerides and leptin) were log transformed to achieve normality.

We ran linear regression models to estimate the independent associations of MVPA (min/day) and ST (min/day) with each of the cardiometabolic indicators with adjustment for potential confounders. Model 1 was adjusted for child's age, gender, BF (for nonbody composition outcomes), energy intake (kcal), accelerometer wear time and household socioeconomic status. Model 2 was additionally adjusted for both exposures (ie, MVPA and ST) to mutually adjust exposures for each other (ie, MVPA and ST were both included in the same final model).

Results are expressed as regression coefficients representing the change in the outcome per 10-minute difference in daily MVPA or a 60-minute difference in daily ST, equivalent roughly to 1 SD outcome, respectively. All models were run in the total sample and stratified by sex based on exploratory analyses and previous reports,²⁶ suggesting differential associations for boys and girls for some indicators (ie, interaction terms such as gender $\times$ MVPA $P < .05$ for adiponectin, and gender $\times$ ST $P < .05$ for BMI z-score, body fat percentage and systolic blood pressure). The predicted effects of significant associations in model 2 were estimated using average marginal effects. All analyses were conducted using Stata/SE version 14.1 for Mac.

3 | RESULTS

Of the 1054 mothers originally recruited, 948 had delivery information and from them, 588 offspring had the available accelerometer data. The final analytical sample included 400 children (197 girls and 203 boys) with available outcome measures as well as valid accelerometer data as defined for this study. No differences were found between the analytic sample ($n = 400$) and the rest of the participants from the cohort at delivery (Table S1).

Children were 56.7 ± 6.4 months old on average, 51.0% were of low socioeconomic status, 8.5% had low birth weight and 5.5% had been exclusively breastfed for 6 months. Mothers had an average of 11.9 ± 2.7 years of education (Table 1). Overall, 9.3% of children were classified as overweight or obese.

Children engaged in 18.9 ± 10.5 daily minutes of MVPA and 524.2 ± 58.2 daily minutes of ST. Boys were more active than girls (21.0 ± 11.1 vs 16.8 ± 9.3 daily minutes of MVPA, $P = .0001$). Girls had higher levels of BF ($P < .01$) and leptin compared with boys ($P < .01$), whereas boys had higher levels of systolic blood pressure than girls ($P = .02$) (Table 1).

Table 2 shows the adjusted associations between MVPA and cardiometabolic indicators. After adjustment for potential confounders (model 1), an increase in MVPA had no significant associations with any of the studied indicators in the full sample. However, an increase in MVPA was associated with higher BMI z-scores and lower adiponectin levels in

girls and lower BF in boys. After adjustment for ST (model 2), most of these associations were lost, except for the positive association between MVPA and BMI z-score among girls.

Table 3 shows the adjusted associations between ST and cardiometabolic indicators. In model 1, a 60-minute increase in ST was associated with a higher percentage of BF in the full sample and higher levels of body fat and lower levels of LDL cholesterol among boys. After adjustment for MVPA (model 2), only the association between ST and body fat among boys remained significant; additionally, an increase in ST was associated with higher glycated haemoglobin in the full sample. Every additional 60 minutes of daily ST were associated with additional 1.111% of BF among boys or 0.047% higher glycated haemoglobin in the full sample (Table 3).

According to the average marginal effects estimated, the association between ST and BF among boys would represent approximately 6.67 (6.24–7.09) percentage points more in those who spend 12 hours per day in ST (BF margins = 26.4% CI = 22.8–30.0) compared to peers who spend 6 hours in this behaviour (BF margins = 19.7% CI = 16.6–22.9). Similarly, the association between ST and glycated haemoglobin in the full sample would mean approximately 0.25 (0.22–0.28) percentage points more of glycated haemoglobin in children who spend 12 hours per day in ST (HbA1c margins = 5.4 95% CI = 5.2–5.6) compared with those who engage in 6 hours in this behaviour (HbA1c margins HbA1c = 5.1 95% CI = 5.0–5.3).

4 | DISCUSSION

This study aimed at understanding the independent effect of MVPA and ST on cardiometabolic indicators among Mexican preschool-aged children. Our results suggest that ST and MVPA are associated with small changes in cardiometabolic indicators. However, after mutually adjusting for both MVPA and ST, ST appeared to have a more significant role than MVPA, especially in boys.

MVPA is associated with more favourable cardiometabolic risk profiles among older children and adolescents.²⁷ In our study, this behaviour was associated with only a few cardiometabolic indicators. In line with previous reports,²⁷ higher levels of MVPA were associated with lower BF among boys. The increased energy expenditure for use by the muscle during and after MVPA sessions explains this effect.²⁸ However, this association was nonsignificant after adjusting for ST. A recent review of studies found that in children aged 0–4 years, physical activity was not consistently associated with adiposity, suggesting that other factors could be more relevant for this outcome during the early years.⁴ In line with these results, our study suggests that sedentary behaviour may be more relevant for cardiometabolic health at this age period. It is also possible that given that children in this study are relatively healthy and MVPA was relatively low (less than 1% met WHO guidelines for PA, data not shown), children could not reach the threshold to observe the beneficial effects of physical activity.

In our study, higher MVPA was associated with lower levels of adiponectin among girls. Plasma levels of this marker are reduced in the presence of metabolic and cardiovascular

diseases, such as obesity and type 2 diabetes; however, the effect of MVPA on adiponectin has been inconsistent.²⁹ Consistent with our findings, previous studies have reported lower levels of adiponectin among more active youth,^{30–32} and evidence exists that this association may be stronger in girls compared with boys.³¹ The expression or secretion of adiponectin could be reduced due to MVPA-improved insulin action,³³ an increase in the amount of the more sensitive biologically active isoform of adiponectin with increasing MVPA,³⁰ or an increased expression of adiponectin receptors due to elevated levels of MVPA.³⁴ Alternatively, it is also possible that these associations were confounded by time spent being sedentary, since they were no longer significant after adjusting for ST.

We also found unexpected associations between MVPA and BMI z-score among girls. BMI z-score is typically used as a surrogate measure of BF in adults. However, in our sample neither %BF, a more direct measure of BF, nor waist circumference, a measure of central adiposity, was associated with MVPA. This supports the hypothesis that among our sample of girls, BMI z-score may not be a good indicator of BF. In fact, studies indicate that among lean children, BMI z-score may be more related to the fat free (including muscle) mass.^{35,36} As in the association between MVPA and adiponectin, this relation could also be due to confounding by ST.

ST was associated with unfavourable levels of adiposity (%BF) in the full sample and among boys. However, after adjusting for MVPA, only the association between ST and adiposity indicators among boys remained significant. Studies using other self-reported measures of ST have found small unfavourable associations between adiposity measures and screen time and TV viewing among cross-sectional studies, but less consistent evidence from longitudinal data.³⁷ Similarly, after adjusting for MVPA, ST was associated with unfavourable levels of glycated haemoglobin. Previous evidence is scarce among preschool children,¹¹ and primarily null findings have been reported between sedentary behaviour and individual risk factors among school-aged children.³⁸ Nonetheless, results suggest that even at this young age, ST may be relevant for the early onset of alterations in the glucose metabolism.

Finally, we also observed that ST was associated with lower LDL cholesterol among boys, however this association was nonsignificant after adjusting for MVPA, indicating that this association was confounded by time spent being sedentary.

The magnitude of associations may not be considered meaningful at the individual level. However, from a public health perspective, these differences may represent important effects at the population level, as shown by differences in predicted estimations when comparing high and low levels of ST. It should be considered that our study was conducted in children with many potential years of life ahead of them, so the small effects seen at this age may accumulate larger effects later in life if these activity patterns persist. For instance, in adults, every additional 5 cm in waist circumference is associated with an additional 7% to 9% risk of all-cause mortality,³⁹ supporting the notion of increased risks if the differences that we observed in our study track into adulthood.

4.1 | Strengths and limitations

To our knowledge, this is the first study in Mexican young children examining the independent associations between ST and MVPA with a series of cardiometabolic indicators. Strengths of this study include the objective measures of time in MVPA and ST, as well as the use of biochemical indicators, reducing misclassification errors and eliminating recall bias. However, there are important limitations that should be acknowledged. First, the cross-sectional design does not allow to establish causality or direction of effect. However, with the exception of adiposity measures, it is unlikely that cardiometabolic outcomes affect MVPA or ST. In fact, evidence in older children and adults supports that MVPA and ST interventions have an impact on several cardiometabolic indicators.⁴⁰ Second, this sample is not representative of all Mexican children. Third, children were not required fasting when blood samples were collected due to their young age, which may have decreased our ability to identify significant associations between ST and MVPA with some cardiometabolic markers. However, HbA1c, HDL-cholesterol, leptin and adiponectin are not affected by fasting. Fourth, we used a specific reduction procedure of accelerometer data. Given that a standardized accelerometer data collection and reduction procedures for early years children has not been established, we used the best available evidence in this study.¹⁸ As a consequence, the comparability of our results may be limited to those using similar procedures. Additionally, given the nature of movement-related variables (ie, sleep, ST, light activity and MVPA), where increases in one behaviour will inherently cause decreases in another, and it is not possible to include all variables in the same model without violating the noncollinearity assumption. Therefore, it is not possible to completely rule out residual confounding in the associations by time spent sleeping or in light activities. Other analytical approaches, considering the compositional nature of physical activity, could provide more insights into the association between movement behaviours and cardiometabolic indicators. Finally, we used sleep diaries to remove sleep time, which do not perfectly capture the onset and offset of sleep periods. Although small variations in ST could be expected by using other methods to remove sleep time, the associations reported between ST and health indicators should not vary importantly.⁴¹

5 | CONCLUSION

In conclusion, this study provides that more evidence on the association between objective measures of physical activity and ST is associated with cardiometabolic health indicators in children aged 48 to 72 months. We found that ST was associated with some adverse cardiometabolic indicators even after adjusting by MVPA. These associations seemed to be stronger among boys compared with girls. MVPA was not associated with indicators probably due to the low levels of physical activity among this sample. Taken together, results underscore the relevance of promoting MVPA and reducing ST since the early ages. Given the cross-sectional nature of the study preventing the limiting ability to establish causality or direction of effect, future longitudinal or experimental studies should confirm these results.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- In adults, high levels of sedentary behaviour increase the risk of cardiometabolic biomarkers such as serum lipids, whereas physical activity decreases it.
- In early childhood, reports are insufficient and with inconsistent evidence of these relations.

WHAT THIS STUDY ADDS

- Results suggest that in early childhood, sedentary time may be unfavourably associated with some health indicators.
- These associations seemed to be stronger among boys compared with girls.
- MVPA was not associated with indicators probably due to the low levels of physical activity among this sample.

TABLE 1

Characteristics of participants in the full sample and by gender

	Full sample (n = 400)	Girls (n = 197)	Boys (n = 203)
Age (months), mean $\pm$ SD	56.7 (6.4)	56.1 (5.9)	57.2 (6.8)
Low birth weight, n (%)	34 (8.5)	22 (11.2)	12 (5.9)
Gestational age (weeks), mean $\pm$ SD	38.9 (1.4)	38.9 (1.3)	38.9 (1.5)
Exclusive breastfeeding for 6 months, n (%)	22 (5.5)	12 (6.1)	10 (4.9)
Energy consumption (kcal), mean $\pm$ SD	1650.8 (601.2)	1601.9 (576.4)	1698.3 (622.0)
Family characteristics			
Socioeconomic status, n (%)			
Low	204 (51.0)	99 (50.3)	105 (51.7)
Medium	154 (38.5)	78 (39.6)	76 (37.4)
High	42 (10.5)	20 (10.2)	22 (10.8)
Mother's age at pregnancy >35y, n (%)	43 (10.8)	20 (10.2)	23 (11.3)
Mother's marital status, n (%)			
Married or living with someone	329 (82.25)	160 (81.2)	169 (83.2)
Separated	71 (17.75)	37 (18.8)	34 (16.8)
Mother's education (years), mean $\pm$ SD	11.9 (2.7)	12.0 (2.6)	11.8 (2.8)
Movement-related behaviours			
Moderate to vigorous physical activity (min/day), mean $\pm$ SD	18.9 (10.5)	16.8 (9.3)	21.0 (11.1)
Sedentary time (min/day), mean $\pm$ SD	524.2 (58.2)	520.1 (59.1)	528.1 (57.2)
Health indicators			
Body fat (%), mean $\pm$ SD	23.9 (5.8)	25.0 (5.7)	22.8 (5.8)
Waist circumference (cm), mean $\pm$ SD	52.3 (4.9)	52.7 (5.1)	51.9 (4.7)
BMI (z-score), mean $\pm$ SD	0.2 (1.0)	0.2 (1.0)	0.2 (1.1)
Glucose (mg/dL), mean $\pm$ SD	86.0 (12.5)	84.8 (12.0)	87.2 (12.9)
Cholesterol (mg/dL), mean $\pm$ SD	162.1 (26.6)	164.7 (28.7)	159.6 (24.3)
Triglycerides (mg/dL), median $\pm$ SD	82.2 (42.5)	80.7 (28.3)	83.6 (53.0)
HbA1c (%), mean $\pm$ SD	5.3 (0.3)	5.3 (0.3)	5.2 (0.3)
HDL (mg/dL), mean $\pm$ SD	49.5 (9.1)	49.0 (8.7)	50.0 (9.4)
LDL (mg/dL), mean $\pm$ SD	96.1 (23.7)	99.5 (24.1)	92.8 (22.8)
Systolic pressure (mmHg), mean $\pm$ SD	81.4 (7.4)	80.6 (8.1)	82.2 (6.5)

	Full sample (n = 400)	Girls (n = 197)	Boys (n = 203)
Diastolic pressure (mmHg), mean ± SD	50.3 (6.3)	50.0 (6.9)	50.5 (5.7)
Leptin (ng/mL), median ± SD	3047.5 (2949.6)	3500.1 (3089.7)	2597.8 (2739.7)
Adiponectin (ng/mL), mean ± SD	15 287.2 (7217.1)	15 573.0 (7318.3)	15 006.8 (7128.5)

Notes: Significant ($P < .05$) differences are presented in bold and were estimated using chi-square or Student's t tests.

TABLE 2
Associations between moderate-to-vigorous physical activity and health indicators among Mexican preschoolers

	Full sample (n = 400)			Girls (n = 197)			Boys (n = 203)		
	β^d (95% CI)	R ²		β^d (95% CI)	R ²		β^d (95% CI)	R ²	
Model 1 ^b									
Body fat (%)	-0.565 (-1.135, 0.006)	0.049		0.022 (-0.877, 0.922)	0.004		-0.986 (-1.730, -0.242)	0.045	
Waist circumference (cm)	0.123 (-0.355, 0.601)	0.058		0.576 (-0.210, 1.363)	0.052		-0.195 (-0.787, 0.398)	0.089	
BMI z-score	0.048 (-0.054, 0.151)	0.005		0.195 (0.046, 0.343)	0.045		-0.054 (-0.195, 0.088)	0.018	
Glycated haemoglobin (%)	-0.003 (-0.040, 0.034)	0.026		-0.019 (-0.076, 0.037)	0.040		0.007 (-0.043, 0.057)	0.015	
Glucose (mg/dL)	-0.821 (-2.189, 0.547)	0.045		-0.408 (-2.477, 1.662)	0.058		-1.182 (-3.075, 0.712)	0.031	
Triglycerides (log mg/dL)	-0.014 (-0.058, 0.030)	0.029		-0.016 (-0.073, 0.042)	0.065		-0.012 (-0.078, 0.054)	0.039	
Total cholesterol (mg/dL)	-0.142 (-3.030, 2.747)	0.033		-3.335 (-8.358, 1.689)	0.033		1.869 (-1.464, 5.203)	0.069	
HDL cholesterol (mg/dL)	-0.047 (-1.041, 0.947)	0.022		-0.018 (-1.556, 1.521)	0.014		-0.207 (-1.533, 1.119)	0.072	
LDL cholesterol (mg/dL)	0.275 (-2.275, 2.825)	0.053		-2.954 (-7.133, 1.225)	0.051		2.439 (-0.752, 5.629)	0.060	
Systolic pressure (mm Hg)	0.438 (-0.266, 1.141)	0.134		-0.394 (-1.543, 0.754)	0.221		0.832 (-0.015, 1.678)	0.096	
Diastolic pressure (mm Hg)	0.414 (-0.182, 1.010)	0.144		0.406 (-0.570, 1.382)	0.212		0.302 (-0.436, 1.040)	0.105	
Leptin (log ng/mL)	0.012 (-0.057, 0.081)	0.313		0.003 (-0.108, 0.103)	0.362		0.016 (-0.074, 0.106)	0.255	
Adiponectin (ng/mL)	-476.7 (-1255.9, 302.4)	0.030		-1659.5 (-2950.0, -368.9)	0.045		336.0 (-621.6, 1293.6)	0.079	
Model 2 ^c									
Body fat (%)	-0.268 (-0.953, 0.417)	0.054		0.109 (-0.911, 1.130)	0.004		-0.370 (-1.325, 0.585)	0.065	
Waist circumference (cm)	0.249 (-0.323, 0.822)	0.060		0.613 (-0.279, 1.504)	0.053		0.057 (-0.700, 0.813)	0.094	
BMI z-score	0.071 (-0.051, 0.194)	0.006		0.187 (0.019, 0.356)	0.045		0.013 (-0.168, 0.194)	0.025	
Glycated haemoglobin (%)	0.022 (-0.023, 0.066)	0.038		0.011 (-0.054, 0.077)	0.061		0.024 (-0.039, 0.088)	0.020	
Glucose (mg/dL)	-0.414 (-2.074, 1.247)	0.048		-0.027 (-2.430, 2.375)	0.061		-0.694 (-3.102, 1.714)	0.034	
Triglycerides (log mg/dL)	0.013 (-0.040, 0.066)	0.039		-0.002 (-0.068, 0.065)	0.069		0.037 (-0.046, 0.120)	0.062	
Total cholesterol (mg/dL)	-0.746 (-4.253, 2.761)	0.034		-3.321 (-9.160, 2.518)	0.033		0.745 (-3.490, 4.979)	0.073	
HDL cholesterol (mg/dL)	-0.257 (-1.463, 0.949)	0.024		0.160 (-1.627, 1.947)	0.015		-0.815 (-2.493, 0.863)	0.080	
LDL cholesterol (mg/dL)	-0.920 (-4.00, 2.166)	0.059		-3.328 (-8.183, 1.528)	0.051		0.279 (-3.736, 4.295)	0.079	
Systolic pressure (mm Hg)	0.615 (-0.228, 1.459)	0.136		-0.051 (-1.248, 1.349)	0.230		0.659 (-0.421, 1.740)	0.097	
Diastolic pressure (mm Hg)	0.490 (-0.225, 1.206)	0.144		0.422 (-0.687, 1.531)	0.212		0.473 (-0.468, 1.415)	0.107	
Leptin (ng/mL)	0.010 (-0.093, 0.083)	0.313		-0.026 (-0.149, 0.097)	0.365		0.045 (-0.069, 0.158)	0.259	

	Full sample (n = 400)		Girls (n = 197)		Boys (n = 203)	
	β (95% CI)	R ²	β (95% CI)	R ²	β (95% CI)	R ²
Adiponectin (ng/mL)	-104.9 (-1051.9, 842.1)	0.036	-1440.6 (-2950.7, 69.5)	0.047	851.8 (-359.7, 2063.3)	0.091

Notes: Significant ($P < .05$) differences are presented in bold. Sample sizes may vary according to the outcome variable.

Abbreviations: CI, confidence interval; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

^a Beta values represent the change associated with a 10-minute increase in moderate to vigorous physical activity.

^b Model 1 adjusted for child's sex, age, percentage of body fat (for non-body composition outcomes), daily energy intake, monitor wear time and household socioeconomic status.

^c Model 2 additionally adjusted for sedentary time.

TABLE 3
Associations between sedentary time and health indicators among Mexican preschoolers

	Full sample (n = 400)			Girls (n = 197)			Boys (n = 203)		
	β^b (95% CI)	R ²		β^b (95% CI)	R ²		β^b (95% CI)	R ²	
Model 1^b									
Body fat (%)	0.705 (0.118, 1.29)	0.053		0.123 (-0.700, 0.947)	0.004		1.379 (0.535, 2.223)	0.062	
Waist circumference (cm)	0.096 (-0.395, 0.587)	0.058		-0.191 (-0.914, 0.533)	0.043		0.417 (-0.251, 1.085)	0.094	
BMI z-score	0.003 (-0.102, 0.109)	0.003		-0.094 (-0.232, 0.043)	0.021		0.112 (-0.047, 0.272)	0.025	
Glycated haemoglobin (%)	0.034 (-0.005, 0.072)	0.035		0.051 (-0.001, 0.104)	0.060		0.015 (-0.043, 0.075)	0.016	
Glucose (mg/dL)	1.012 (-0.439, 2.462)	0.047		0.725 (-1.227, 2.677)	0.061		1.443 (-0.798, 3.683)	0.032	
Triglycerides (mg/dL)	0.043 (-0.003, 0.090)	0.039		0.027 (-0.027, 0.082)	0.069		0.068 (-0.010, 0.145)	0.057	
Total cholesterol (mg/dL)	-0.685 (-3.749, 2.379)	0.033		1.608 (-3.155, 6.371)	0.025		-2.704 (-6.641, 1.232)	0.072	
HDL cholesterol (mg/dL)	-0.241 (-1.296, 0.813)	0.023		0.256 (-1.196, 1.708)	0.015		-0.579 (-2.144, 0.987)	0.075	
LDL cholesterol (mg/dL)	-1.693 (-4.391, 1.005)	0.057		0.887 (-3.082, 4.855)	0.040		-4.363 (-8.100, -0.626)	0.079	
Systolic pressure (mm Hg)	-0.018 (-0.752, 0.717)	0.131		0.856 (-0.205, 1.920)	0.230		-0.793 (-1.774, 0.324)	0.215	
Diastolic pressure (mm Hg)	-0.136 (-0.759, 0.486)	0.140		-0.153 (-1.062, 0.756)	0.209		0.019 (-0.873, 0.835)	0.102	
Leptin (ng/mL)	-0.011 (-0.083, 0.062)	0.313		-0.031 (-0.130, 0.069)	0.365		0.024 (-0.083, 0.131)	0.256	
Adiponectin (ng/mL)	751.4 (-68.4, 1571.1)	0.035		1088.6 (-128.12305.4)	0.024		371.4 (-128.1, 2305.4)	0.024	
Model 2^c									
Body fat (%)	0.551 (-0.154, 1.257)	0.054		0.170 (-0.764, 1.105)	0.004		1.111 (0.019, 2.203)	0.065	
Waist circumference (cm)	0.236 (-0.351, 0.8224)	0.060		0.071 (-0.745, 0.887)	0.053		0.457 (-0.399, 1.313)	0.094	
BMI z-score	0.044 (-0.082, 0.169)	0.006		-0.015 (-0.169, 0.139)	0.045		0.121 (-0.083, 0.326)	0.025	
Glycated haemoglobin (%)	0.047 (0.000, 0.094)	0.038		0.057 (-0.005, 0.118)	0.061		0.033 (-0.042, 0.108)	0.020	
Glucose (mg/dL)	0.764 (-0.998, 2.525)	0.048		0.711 (-1.557, 2.980)	0.061		0.937 (-1.913, 3.786)	0.034	
Triglycerides (log mg/dL)	0.051 (-0.005, 0.108)	0.039		0.027 (-0.036, 0.090)	0.069		0.094 (-0.004, 0.193)	0.062	
Total cholesterol (mg/dL)	-1.133 (-4.855, 2.588)	0.034		-0.025 (-5.488, 5.538)	0.033		-2.162 (-7.173, 2.850)	0.073	
HDL cholesterol (mg/dL)	-0.396 (-1.675, 0.883)	0.024		0.332 (-1.356, 2.020)	0.015		-1.171 (-3.155, 0.814)	0.080	
LDL cholesterol (mg/dL)	-2.243 (-5.516, 1.029)	0.059		-0.699 (-5.284, 3.885)	0.051		-4.160 (-8.910, 0.590)	0.079	
Systolic pressure (mm Hg)	0.336 (-0.543, 1.215)	0.136		0.880 (-0.327, 2.087)	0.230		-0.321 (-1.569, 0.926)	0.097	
Diastolic pressure (mm Hg)	0.145 (-0.600, 0.891)	0.144		0.032 (-1.000, 1.062)	0.212		0.319 (-0.768, 1.407)	0.107	
Leptin (ng/mL)	-0.005 (-0.093, 0.083)	0.313		-0.043 (-0.159, 0.073)	0.365		0.056 (-0.078, 0.191)	0.259	

	Full sample (n = 400)			Girls (n = 197)			Boys (n = 203)		
	β^a	(95% CI)	R ²	β^a	(95% CI)	R ²	β^a	(95% CI)	R ²
Adiponectin (ng/mL)	688.2	(-311.1, 1687.6)	0.036	395.7	(-1012.5, 1803.8)	0.047	992.0	(-442.1, 2426.0)	0.091

Notes: Significant (P < .05) differences are presented in bold. Sample sizes may vary according to the outcome variable.

Abbreviations: CI, confidence interval; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

^a Beta values represent the change associated with a 60-minute increase in sedentary time.

^b Model 1 adjusted for child's sex, age, percentage of body fat (for non-body composition outcomes), daily energy intake, monitor wear time and household socioeconomic status.

^c Model 2 additionally adjusted for moderate to vigorous physical activity.