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Screen time and adiposity in adolescents in Mexico

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Abstract

Objective: To assess the association of time spent viewing television, videos and video games with measures of fat mass (BMI) and distribution (triceps and subscapular skinfold thicknesses (TSF, SSF)).

Design: Cross-sectional validated survey, self-administered to students to assess screen time (television, videos and video games) and lifestyle variables. Trained personnel obtained anthropometry. The association of screen time with fat mass and distribution, stratified by sex, was modelled with multivariable linear regression analysis, adjusting for potential confounders and correlation of observations within schools.

Setting: State of Morelos, Mexico.

Subjects: Males (*n* 3519) and females (*n* 5613) aged 11 to 18 years attending urban and rural schools in Morelos.

Results: In males, screen time of >5 h/d compared with <2 h/d was significantly associated with a 0·13 (95 % CI 0·04, 0·23) higher BMI *Z*-score, 0·73 mm (95 % CI 0·24, 1·22) higher SSF and 1·08 mm (95 % CI 0·36, 1·81) higher TSF. The positive association of screen time with SSF was strongest in males aged 11–12 years. Sexual maturity appeared to modify the association in females; a positive association between screen time and SSF was observed in those who had not undergone menarche (*P* for trend = 0·04) but not among sexually mature females (*P* for trend = 0·75).

Conclusion: Screen time is associated with fat mass and distribution among adolescent males in Mexico. Maturational tempo appears to affect the relationship of screen time with adiposity in boys and girls. Findings suggest that obesity preventive interventions in the Mexican context should explore strategies to reduce screen time among youths in early adolescence.

Keywords
Body mass index
Triceps skinfold
Subscapular skinfold
Television viewing
Screen time

Consistent with worldwide trends, the prevalence of obesity in Mexico is increasing[1]. Between 1999 and 2006, the proportion of adults who were overweight or obese increased from 67 to 72 % in women and from 61 to 67 % in men[2,3]. Using international cut-off points, the prevalence of obesity in 1999 was 5·5 % in pre-school children and 19·5 % in children aged 5 to 11 years[4].

Understanding behavioural determinants of youth obesity trends is essential to developing effective public health approaches to prevention and control in different country contexts. In observational studies, television viewing in children and adolescents has been associated with increased adiposity and obesity[5–9] and predicted high BMI, smoking, low cardiorespiratory fitness and high serum cholesterol in early adulthood[10]. Randomized trials to limit television time and computer use among children in the USA resulted in a significant reduction of BMI[11] and lower BMI, triceps skinfold thickness (TSF), waist circumference and waist:hip ratio[12]. Decreases in television viewing also mediated the effect of a middle-school, interdisciplinary curriculum on obesity (classified as BMI and TSF >85th percentile) in young adolescent girls[13].

Previous studies of the association of screen time with youth obesity have inconsistently assessed the use of media other than television. Limited information on demographic, lifestyle and reproductive factors for chronic disease also may undermine the interpretability of results due to confounding by unmeasured variables. Furthermore, assessment of fat distribution in early puberty through skinfold thickness in addition to fat mass may unveil additional insights on chronic disease risk in Mexican youths. In the present study, we examined the association between time spent viewing television, videos

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and video games and anthropometric measures of fat mass and distribution in a large survey of adolescents in the State of Morelos in Mexico.

Research methods and procedures

Study population

The data presented here derive from a large, representative survey conducted in 1999 to assess the prevalence of chronic disease risk factors in youths in the State of Morelos, Mexico. The methods are described elsewhere[14]. Briefly, the study included a sample of youths aged 11 to 24 years attending public junior high schools, high schools and the State university. The sampling unit was the school. The study population comprised 13 293 individuals, 56 % of whom were female. The response rate was 98·6 %. An imbalance between males and females in the sample was due to both an underlying distribution that favours females and a higher response rate in this group. Signed informed consent forms were obtained separately from the study participants and from their parents prior to collection of information. Participants were asked to complete a self-administered questionnaire on general lifestyle, frequency of food consumption, physical activity, drug use and health-care use. The survey was conducted in classrooms during school hours; anthropometry on all participants was obtained by trained staff in school settings. The study was approved by the Human Subjects Committee of the National Institute of Public Health of Mexico.

Eligible individuals for the current analysis were 11 to 18 years of age with complete questionnaire and anthropometric information. We excluded young adults between 19 and 24 years of age because we considered adolescence the developmental stage most biologically relevant to the emergence of chronic disease in early adulthood. To reduce potential confounding by underlying conditions associated with disability and related inactivity, we excluded underweight individuals, defined as being below the 15th percentile for BMI[15] and for TSF[16,17]. The final analytic sample comprised 9132 participants, 62 % of whom were female. This sub-sample did not differ significantly from the original sample with respect to major sociodemographic characteristics.

Data collection

Screen viewing and physical activity were measured using a questionnaire validated in Mexican youths[18]. Individuals were asked about their usual daily hours viewing television, videos and video games (never, <1, 1–2, 2–3, 3–4, 4–5, 6–7 or >7) on weekdays, Saturdays and Sundays. Computer use was not collected because home computer use is uncommon in this population. Eighteen per cent of participants reported total daily screen time greater than 12 h. A weighted average of hours of screen viewing (weekdays, Saturday and Sunday) was computed to obtain an overall average screen time. We categorized screen time as <2, 2–2·9, 3–3·9, 4–4·9 and ≥5 h/d in order to limit the error introduced by multitasking (e.g. playing video games while watching television) and the influence of outliers. Total television and total video/video games were similarly categorized. A weighted average of hours of inactivity was calculated using weekday and weekend hours of sitting down, using private or public transportation, doing homework and sleeping. The questionnaire also included eleven items to evaluate weekly hours of recreational physical activities (never, <0·5, 0·5–2, 2–4 and 4–6)[17]. Weekly expenditure of metabolic equivalents (MET) of moderate and vigorous physical activity was estimated by multiplying the responses to questions by the activity-specific energy expenditure as reported by Ainsworth *et al.*[19]. Energy intake was estimated from a 103-item FFQ adapted from a questionnaire validated for the Mexican adult population[20]. Socio-economic status (SES) was assessed using an index derived from a principal components analysis for the Mexican population that includes number of rooms in the house, people living in the household, municipal services, sanitary conditions, educational level of the mother's most recent sexual partner, and ownership of home, car, television, video recorder and telephone. Three categories were constructed using tertiles of the principal component score[21].

Height, weight, TSF and subscapular skinfold thickness (SSF) were measured using standardized procedures by trained personnel. Height and weight were measured using daily gauged portable stadiometers and portable Tanita scales (Tanita Corp., Itabashini-Ku, Tokyo, Japan), respectively. For skinfolds, the average of three measurements using Lange callipers (Beta Technology, Inc., Santa Cruz, CA, USA) was used and expressed in millimetres. BMI was calculated as weight/height^2 (kg/m^2) using the measured anthropometric data. Age- and sex-specific standard deviation scores (*Z*-scores) for BMI were calculated using the 2000 guidelines of the Centers for Disease Control and Prevention[15]. The age-specific cut-off points for overweight and obesity of the International Obesity Taskforce were used to estimate their prevalence. These cut-off points use an international reference population comprising children and adolescents from six different countries[22]. These cut-offs were used for descriptive purposes only, to permit comparisons of BMI distribution with other countries.

Statistical analysis

We analysed females and males separately. Means and standard deviations were estimated for screen viewing time within categories of selected participant characteristics and the distribution was compared across categories with the Kruskal–Wallis test. For ordinal predictors, we tested for linearity using linear regression. Next, we constructed linear regression models to explore the

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Table 1 Characteristics of 9132 Mexican adolescents from public schools in Morelos, Mexico (1999)

	Males (*n* 3519)		Females (*n* 5613)	
Variable	Mean	SD	Mean	SD
Age (years)	13·8	1·8	13·9	1·7
Energy intake (kJ/d)	17 975	5306	16 670	5332
Moderate-to-vigorous physical activity (MET/week)	110	42	90·8	47·3
Total screen time* (h/d)	5·9	3·0	5·4	3·0
BMI (*Z*-score)	0·48	0·97	0·58	0·84
Triceps skinfold thickness (mm)	14	7	22	7
Subscapular skinfold thickness (mm)	11	5	15	5
Obesity† (%)	6·7		6·0	
Overweight† (%)	30·0		30·5	
Mean age at menarche (years)	–		11·4	1·1

MET, metabolic equivalents.
*Average daily hours of viewing television, videos and video games combined.
†International Obesity Taskforce cut-off points for BMI for age and sex[22].

association of BMI *Z*-scores, TSF and SSF with screen time using the SAS SURVEYREG procedure to account for the non-independence of the observations given that the primary sampling unit was the school and that observations within schools may be correlated (SAS version 8; SAS Institute Inc., Cary, NC, USA). Potential confounders of these associations considered in the multivariable model included age, height, SES tertile, single-parent family, birth in a hospital, father's educational level, mother's educational level, family income, family health insurance, weekly MET of moderate-to-vigorous physical activity, daily hours of inactivity excluding screen time, type of community (urban, suburban, rural), total energy intake, diagnosis of asthma, dieting and frequency of restaurant dining. Given the rapid change in adipose tissue distribution, linear growth, metabolic and hormonal environment during adolescence, we hypothesized that age would modify the relationship of screen time with adiposity. Based on the results of this analysis we considered *post hoc* sexual maturity as another potential effect modifier. Sexual maturity was also considered a confounder. Females who had undergone menarche and males who reported having had an ejaculation were considered sexually mature. We also considered living in a rural environment and moderate-to-vigorous physical activity to be modifiers of this relationship because physical activity affects adipose tissue and individuals in a rural environment may be more active. Results are presented as age-adjusted and multivariate-adjusted.

Results

Table 1 shows the characteristics of the study population. Male adolescents reported a higher energy intake and greater MET of moderate and vigorous physical activities than females. After transforming questionnaire categories on media use to continuous variables, among males, a greater amount of total daily hours of screen time was spent watching television (2·7 (SD 1·9) h) than watching videos (1·9 (SD 1·8) h) and playing video games (1·8 (SD 1·9) h). On average, females spent 2·8 (SD 1·9) h watching television, 1·6 (SD 1·8) h on videos and 1·3 (SD 1·8) h playing video games every day. Menarche was reported by 5229 (93·2 %) of female participants. The prevalence of obesity was slightly higher in males; approximately one-third of males and females were overweight.

Table 2 Daily hours of television, video and video game use by sociodemographic characteristics of Mexican adolescents from public schools in Morelos, Mexico (1999)

	Males		Females	
Variable	Mean	SD	Mean	SD
Age (years)				
11–12	5·9	2·9	5·6	3·0
13–14	5·7	3·1	5·3	3·0
15–16	6·0	2·9	4·7	2·9
17–18	6·6	2·7	6·1	3·0
Community type				
Rural	5·3	3·1	5·1	3·0
Suburban	5·9	2·9	4·9	3·0
Urban	6·6	2·8	6·1	2·9
Socio-economic status				
Low	6·2	2·9	5·1	3·1
Medium	5·3	3·1	5·2	3·0
High	6·6	2·7	5·8	2·9
Medical insurance				
Uninsured	6·2	2·9	5·5	3·0
Insured	5·7	3·0	5·3	3·0
Dieting				
To lose weight	6·1	3·1	5·0	3·0
To gain weight	6·1	3·1	6·2	2·8
Not on a special diet	5·9	3·0	5·4	3·0

Total daily screen time by different sociodemographic characteristics is described in Table 2. Significant differences in the mean daily screen time were observed for age, type of community, SES and medical insurance in males and females ($P < 0·01$). Adolescent girls who reported they were dieting to lose weight reported significantly less screen time

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than those who said they wanted to gain weight. Mean screen time increased significantly with the level of urbanicity and, in females, screen time increased with increasing SES ($P<0\cdot01$). Energy intake increased significantly with increasing screen time in males and females ($P<0\cdot001$). The mean daily energy intake in males was 15 305 kJ for <2 h of screen time/d and 18 759 kJ for >5 h/d. Females had a mean daily energy intake of 15 166 kJ for <2 h of screen time/d and 17 581 kJ for >5 h/d.

In males, screen time was positively related to BMI *Z*-score in age-adjusted and multivariate-adjusted analyses. In the multivariate-adjusted model, males with >5 h screen time/d had a 0·13 (95 % CI 0·04, 0·23) higher BMI *Z*-score compared with males with <2 h/d (*P* for trend <0·003). In females, screen time was positively related with BMI *Z*-score in age-adjusted analyses but not in multivariate-adjusted analyses (Table 3).

Screen time was positively related to TSF and SSF in males. After adjusting for confounding variables, males with >5 h of screen time/d had a 1·08 mm (95 % CI 0·36, 1·81) greater TSF compared with males reporting <2 h/d (*P* for trend = 0·01). Similarly, after adjusting for confounding variables, males with >5 h of screen time/d had a 0·73 mm (95 % CI 0·24, 1·22) greater SSF compared with males with <2 h/d (*P* for trend = 0·006). In females, screen time was positively related to TSF and SSF in age-adjusted but not multivariate-adjusted analyses.

Age did not modify the association between screen time and BMI *Z*-score or TSF in males or females. Nevertheless, the association between screen time and SSF differed significantly by age categories in males (*P* interaction = 0·005). A significant linear trend of increasing SSF with greater screen time was found in younger but not older males (Fig. 1). In females, age did not modify the association between screen time and SSF. The association was however modified by sexual maturity; screen time was positively related to SSF among females who had not undergone menarche (*P* for trend = 0·04) but not among sexually mature females (*P* for trend = 0·75; Fig. 2).

Males spent 54 % of their screen time on videos and video games, while females spent 48 %. For males, we found a significant increasing trend only in BMI *Z*-score when we analysed videos and video games independently of television (*P* = 0·03). No association with television by itself was found. In females, no associations were observed when television and videos/video games were analysed independently.

Discussion

The present study evaluated the association between time spent viewing television, videos and video games and measures of fat mass and distribution in a large survey of Mexican adolescents in the State of Morelos. In males, BMI *Z*-score, TSF and SSF were directly associated with

Table 3 Adjusted difference (and 95 % confidence interval) in BMI *Z*-score, triceps (TSF) and subscapular (SSF) skinfold thicknesses by television, video and video game use among Mexican adolescents from public schools in Morelos, Mexico (1999)

		BMI *Z*-score				TSF				SSF			
		Males		Females		Males		Females		Males		Females	
Television, video and video games (h/d)		Age-adjusted	Multivariate-adjusted*	Age-adjusted	Multivariate-adjusted*	Age-adjusted	Multivariate-adjusted*	Age-adjusted	Multivariate-adjusted*	Age-adjusted	Multivariate-adjusted*	Age-adjusted	Multivariate-adjusted*†
<2		Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
2–2·9	Difference	0·09	0·04	−0·01	−0·02	0·98	0·72	−0·09	−0·34	0·46	0·38	0·22	0·08
	95 % CI	−0·08, 0·25	−0·10, 0·17	−0·08, 0·06	−0·09, 0·05	−0·07, 2·02	−0·25, 1·70	−0·61, 0·43	−0·87, 0·20	−0·26, 1·18	−0·20, 0·95	−0·17, 0·62	−0·33, 0·48
3–3·9	Difference	0·16	0·03	0·04	0·02	1·11	0·47	0·68	0·28	0·84	0·26	0·54	0·29
	95 % CI	0·03, 0·29	−0·09, 0·15	−0·03, 0·12	−0·06, 0·10	0·31, 1·90	−0·40, 1·34	−0·05, 1·41	−0·46, 1·02	0·21, 1·47	−0·36, 0·88	0·05, 1·02	−0·29, 0·77
4–4·9	Difference	0·22	0·05	0·08	0·04	1·67	0·93	0·94	0·28	1·20	0·39	0·72	0·33
	95 % CI	0·10, 0·33	−0·06, 0·15	−0·01, 0·18	−0·05, 0·14	0·64, 2·70	−0·09, 1·95	0·17, 1·71	−0·49, 1·06	0·53, 1·87	−0·20, 0·98	0·08, 1·35	−0·27, 0·94
≥5	Difference	0·35	0·13	0·09	0·02	2·01	1·08	1·32	0·35	1·73	0·73	0·85	0·22
	95 % CI	0·22, 0·48	0·04, 0·23	0·00, 0·17	−0·07, 0·10	1·30, 2·72	0·36, 1·81	0·62, 2·03	−0·29, 0·98	1·09, 2·36	0·24, 1·22	0·32, 1·38	−0·22, 0·68
P for trend		<0·001	0·003	0·026	0·64	<0·001	0·011	<0·001	0·14	<0·001	0·006	0·003	0·45

*Adjusted for age, height, socio-economic status, single-parent family, birth in hospital, parental education level, family income, family health insurance, physical activity, inactivity excluding television, video and video games, community type, sexual maturity, diagnosis of asthma, dieting and frequency of restaurant dining.
†History of pregnancy and spontaneous abortion also included in females.

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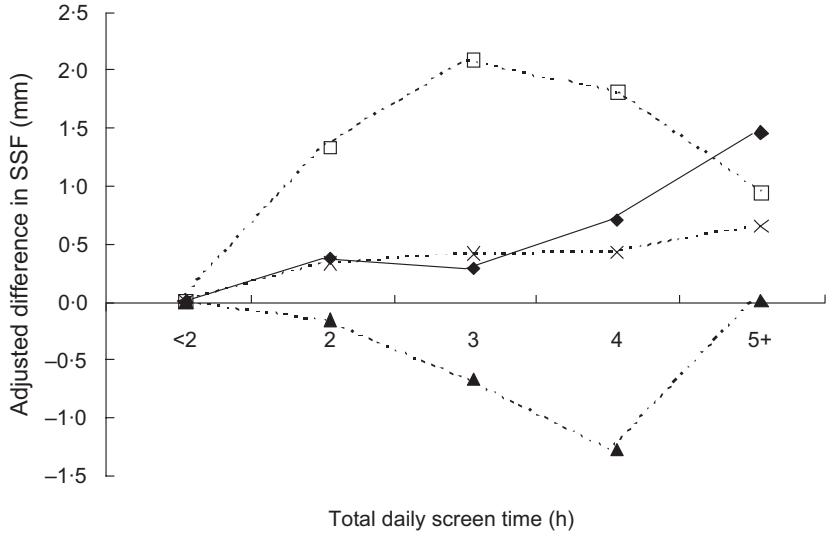

Fig. 1 Adjusted difference in subscapular skinfold thickness (SSF, mm) with total daily screen time (h) by age group (—◆—, 11–12 years; - - × - -, 13–14 years; - - ▲ - -, 15–16 years; - - □ - -, 17–18 years) in Mexican male adolescents from public schools in Morelos, Mexico (1999)

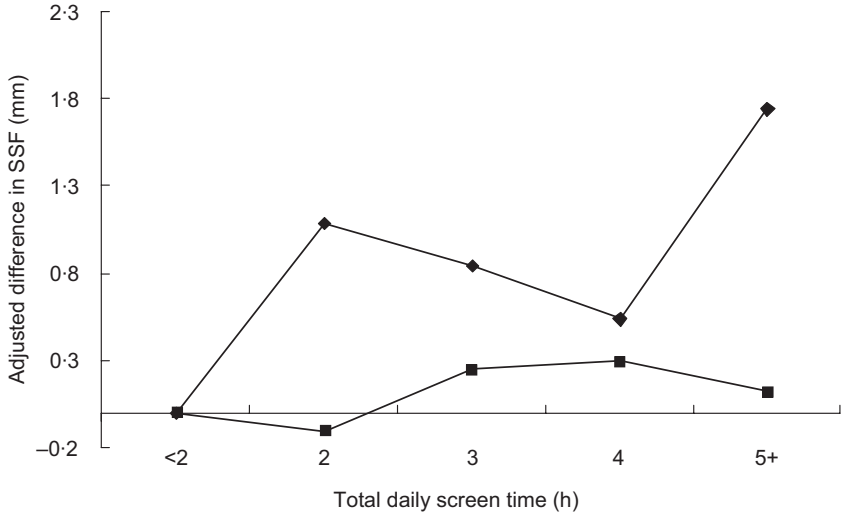

Fig. 2 Adjusted difference in subscapular skinfold thickness (SSF, mm) with total daily screen time (h) by sexual maturity (—◆—, premenarcheal; —■—, postmenarcheal) in Mexican female adolescents from public schools in Morelos, Mexico (1999)

time spent viewing television, videos and video games. The association of screen time with SSF seemed to be stronger in 11- and 12-year-old males compared with older youths. Conversely, no overall association of screen time and anthropometric measures was observed among Mexican female adolescents. An association between SSF thickness and screen time was observed in sexually immature females.

Our results are consistent with previous cross-sectional and longitudinal findings on television viewing and increased adiposity and obesity in Mexican and other populations[5–9,23–30]. Nevertheless, others have reported weak or no associations between television viewing and physical inactivity and adiposity[31–34]. Disparate results may be explained in part by differences in the age distribution of participants, the cross-sectional nature of some studies and the use of less comprehensive measures of media use. Nevertheless, two randomized controlled trials of interventions that reduced television and computer use lend strong support to a causal relationship between screen time and increased adiposity in younger children[11,12]. Moreover, a recent analysis on the combined influence of not meeting the current physical activity and screen time recommendations of 11 000–13 000 pedometer steps/d and <2 h/d found that overweight children were more likely to be non-compliant with these recommendations[35].

There are several indications that screen time plays a different role within age and sex groups due to differences

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in the tempo of physical development. Most studies where the link between screen time and increased adiposity or obesity was found included children younger than 10 years of age[7–9,11,12,25,28–30]. Studies that did not find the association had a mean age closer to 13 years[31–34]. In the current study, age did not appear to modify the association between screen time and BMI and TSF. However, screen time was directly associated with SSF among 11- and 12-year-old males, who may not have undergone sexual maturation. In line with previous reports[31,32], we observed a null overall association of screen time with adiposity in female adolescents. However, we explored whether sexual maturity modified the associations by stratifying on menarcheal status and observed a significant increasing trend in SSF thickness in sexually immature females (P for interaction = 0·053). SSF velocity and distance curves diverge markedly in males and females during maturation. Results of these *post hoc* analyses should be interpreted with caution. Nevertheless, given null findings in studies with older adolescents, the association of sedentary behaviour/inactivity with measures of central fat distribution may be partially explained by maturity and different maturational tempos between males and females.

When we evaluated television and videos/video games independently, we did not find an association with anthropometric measures of adiposity and obesity. Nevertheless, videos and video games represent close to 50 % of total screen time in this sample of Mexican adolescents. The association with measures of fat mass and distribution appeared to be driven by the combined effects of these three activities, underscoring the importance of measuring the use of all electronic media.

Mechanisms thought to underlie the relationship between screen time and adiposity are low energy expenditure due to the substitution of physical activity by television viewing and an increase in the consumption of energy-dense foods advertised on television. Recent data lend stronger support to energy intake as mediator of the effect of screen time on adiposity[36–38]. A reduction in television viewing and computer use was reported to significantly reduce daily energy intake by close to 300 kcal (1255 kJ) over two years, while no significant increase in physical activity was observed over the same period[11].

In the current study, we evaluated the association of screen time and adiposity in a large sample of adolescents using measures of both fat mass (BMI) and central (SSF) and peripheral (TSF) fat distribution. We closely captured recreational inactivity by using a questionnaire validated in Mexican children[9] that estimates time spent on television, video and video games on weekdays, Saturday and Sunday. Height, weight, TSF and SSF thickness were reliably measured with calibrated equipment by trained personnel using standardized procedures. SSF, a measure of central fat distribution, rarely has been available in population-based studies of this magnitude and our findings provide an interesting insight into its association with screen time during maturation. Consistency in results across different anthropometric measures with independent measurement errors may further support the presence of the associations found in the present report.

Our study has some limitations that temper interpretation of findings. First, causal inference is limited by the cross-sectional design of the study. We hypothesized that screen time was a determinant of increased adiposity, but we were unable to assess whether a reverse effect existed. Prior reports based on longitudinal data support the directionality of the observed association. Second, data on screen time and potential confounders are self-reported, creating a potential for recall bias. However, we believe that participants in this study population were unaware that screen time could be a cause of increased adiposity, so it is unlikely that obese or overweight adolescents would have reported screen time differently from their leaner counterparts. We are more concerned with the potential for inaccurate reporting that would attenuate of the associations. Third, our questionnaire did not include computer use. At the time the survey was conducted, the contribution of computer use to overall hours spent in front of a screen was probably very limited in this population. As in any observational study, our results may be explained by the influence of unmeasured confounders. However, we were able to reduce this possibility by adjusting for numerous socio-economic and lifestyle variables.

We conclude that screen time is associated with increased adiposity in Mexican adolescent males. The association may be partly influenced by maturation; screen time may be more important in younger adolescents and be more influential in determining central fat stores, as indicated by SSF. Our results underscore the importance of understanding modifiable determinants of adolescent obesity in the context of trends in Mexico. The high prevalence of obesity and overweight in adolescents may foreshadow an even greater surge in CVD and diabetes in Mexico as these adolescents enter young adulthood. Preventive interventions to promote physical activity and limit screen time have been explored in similar populations and were shown to be effective[39]. As seen in other populations[35], a thorough evaluation of recommendations on physical activity and screen time in the Mexican context would be important to support public policy. Future research should focus on accurately assessing screen time and physical activity and their association with adiposity at the national level and on identifying culturally tailored strategies to modify these behaviours in Mexican youths.

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