A model linking video-gaming, sleep quality, sweet drinks consumption and obesity among children and youth

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Abbreviations:

WtHR = Waist to height ratio; BMI = Body Mass Index; SD= Standard Deviation; PSQI = Pittsburgh Sleep Quality Index; RMSEA = Root Mean Square of Approximation; CFI = Comparative Fit Index; IFI = Incremental Fit Index; SRMR = Standardized Root Mean Square Residual; CI = Confidence interval; cm = Centimeters

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What is already known about this subject:

- The prevalence of pediatric obesity is high.
- The prevalence of video-gaming among children and youth is high and on the rise.
- Pediatric obesity is associated with videogame use duration.

What this study adds:

- Videogaming duration before bedtime is associated with reduced sleep quality.
- Average videogaming session duration is associated with increased sweet drinks consumption while playing videogames.
- Poor sleep quality and sweet drinks consumption are linked, and can mediate the association between videogaming patterns and pediatric obesity.

Summary

Background: There is a growing need to curb pediatric obesity.

Objective: To untangle associations between videogame use attributes and obesity as a first step toward identifying and examining possible interventions.

Methods: Cross-sectional time-lagged cohort study was employed using parent-child surveys (t1) and objective physical activity and physiological measures (t2) from 125 children/adolescents (mean age = 13.06, 9-17 year olds) who play videogames, recruited from two clinics at a Canadian academic children's hospital. Structural equation modeling and analysis of covariance were employed for inference.

Results: (1) self-reported video game play duration in the four hour window before bedtime is related to greater abdominal adiposity (waist-to-height ratio) and this association may be mediated through reduced sleep quality (measured with the Pittsburgh Sleep Quality Index); and (2) self-reported average videogame session duration is associated with greater abdominal adiposity and this association may be mediated through higher self-reported sweet drinks consumption while playing videogames and reduced sleep quality.

Conclusions: Video game play duration in the four hour window before bedtime, typical videogame session duration, sweet drinks consumption while playing video games and sleep quality have aversive associations with abdominal adiposity. Pediatricians and researchers should further explore how these factors can be altered through behavioral or pharmacological interventions as a means to reduce pediatric obesity.

Introduction

Video-gaming is one of the most popular leisure activities among North American youth; over 72% of teenagers (84% of teen boys) play videogames¹. Recent reports indicate that youth (13 years and older) spend an average of 6.3 hours per week on videogames, and this number has been growing over the last several years, in part, due to the increased availability of smartphones and mobile devices². Moreover, only 30% of the 8-18 years old population segment have parental rules regarding media use³ and 8.5 percent of American youth develop addiction-like symptoms to videogames and meet common addiction criteria⁴.

This pattern of video-gaming has been associated with a myriad of academic, social, psychological and physiological problems including shortened sleep duration, reduced sleep quality, diminished academic performance and increased attention problems⁴. It is also associated with increased caloric intake; especially the intake of high calorie, low nutritional quality food⁵. Furthermore, video gaming has been linked to obesity and especially abdominal adiposity⁶; though this association is not direct and may be mediated through sleep, sedentary time and other factors⁷. Such associations suggest that videogame use and the mediating variables may be important target metrics for pediatric weight management interventions, as obesity is highly prevalent amongst North American children and youth and is associated with multiple adverse physical and psychosocial outcomes in childhood and adulthood⁸.

Therefore, this study seeks to (1) point to specific videogame use patterns (specific attributes such as timing and duration of video-gaming) which may be related to childhood obesity, and (2) identify variables which may mediate this association. While most studies on this association focus on daily use duration⁹ as the driver of the aforementioned problems, we propose to examine more specific videogame use patterns including average video gaming session duration

and timing of video game use with a focus on the pre-bedtime period. The possible mediating variables we focus on include poor sleep quality and sweet drinks consumption while playing videogames. Understanding of these videogame use patterns and possible mediating variables may provide a more nuanced understanding of what constitutes unhealthy video gaming habits and direct researchers toward more focused interventions.

Consistent with prior studies^{10,11}, this study predicts that abdominal adiposity is positively related to poor sleep quality and consumption of sweet drinks while playing videogames, after accounting for physical activity levels. The study then suggests, based on the idea that sugary drinks can inhibit sleep^{12,13}, that these predictors are not independent and that the intake of sweet drinks while playing videogames can be associated with a reduction in sleep quality. Finally, we propose that unique videogame use patterns influence each of these direct predictors of abdominal adiposity. We argue that when one's typical videogame session duration is high, he or she will have more opportunity and stronger motivation to consume sweetened drinks during this session. This is consistent with findings that when unhealthy snacks and drinks are available to video gamers (young adults), they consume them as they keep on playing, which produces an average energy surplus of 655 calories per hour in regular games, and 376 calories per hour in active (motion controlled) games¹⁴. In addition, it is proposed that longer videogame use prior to bedtime is a unique contributor to decline in sleep quality, consistent with prior studies¹⁵; presumably through suppressed melatonin release and intrusive thoughts about the videogame⁶.

Methods

Procedure and Participants

A cross-sectional time-lagged study design was employed. Inclusion criteria were age below 18, self-reported video game player, guardian consent and participant assent. The sample was recruited from children and adolescents who were outpatients of one of two hospital clinics (pediatric lipid clinic and weight management) at McMaster Children's Hospital. It was part of a larger study focusing on children's Sleep and Physical Activity (SPA). The protocol was approved by the Hamilton Health Sciences Research Ethics Board. Two hundred children visiting these clinics were invited during the 2015 school year to voluntarily participate in this study, out of which 157 agreed. After excluding 32 who do not play video games, a paper-based survey was used during the recruitment visit to record self-report videogame use information, sweet drink consumption while playing videogames, and sleep quality (completed with nurse assistance and no guardian involvement). Guardians completed a demographic questionnaire at this point which captured their annual income ranges. Fitbit devices were given to participants for a period of one week for capturing physical activity; training was provided by a nurse. Three to ten weeks after survey recording (average of 6 weeks), abdominal obesity measures were collected in a follow-up clinic visit.

Measures

Measures were based on validated established instruments. The primary outcome was abdominal adiposity, measured using the waist to height ratio (WtHR). Height was measured with a Harpenden stadiometer to the nearest 0.5 cm using a standardized approach. Waist circumference was measured on an unclothed abdomen at the midpoint between the costal margin and the iliac crest with a non-stretchable standard tape measure attached to a spring balance. This measure of obesity is advantageous to others (e.g., BMI) as it better captures central fat distribution, is

related to cardiometabolic health indicators and is adjusted to inter-individual differences in body size related to age¹⁶.

Exposures examined included videogame use, subjective evaluation of sleep quality and self-reported nutritional intake – all were completed by questionnaire. Videogame use characteristics examined included session duration, number of days in the week that participants game and videogame use in the four hour period prior to going to bed, Videogame session duration was measured with one item based on a measure of session duration¹⁷: “On average, what is the length (in minutes) of a typical video game playing session?”. The source study reported an average of 1.5 hours and SD=2 in their sample, which is similar to what we observed in the current study. Hours of videogame use before bedtime was operationalized with an adaptation of a direct question of duration of videogame use:” How many minutes do you usually use videogames in the 4 hour period prior to going to bed?” Finally, we also asked how many days per week the child / adolescent played video games (Considering your typical behaviour for the previous 4 weeks, how many days per week do you play videogames?).

Sleep quality was measured with the Pittsburgh Sleep Quality Index (PSQI) which has been shown to be valid and reliable¹⁸ including in samples of adolescents¹⁹. This self-report index includes 19 items grouped into seven domains, scored 0 – 3. The total score can range from 0 – 21 with lower scores consistent with better sleep quality. Sweet drinks consumption while playing videogames was adapted from a semi-quantitative food frequency questionnaire²⁰. It asked respondents to report on how often (from 1= less than once per month/never to 9=more than 3 times per day) they consume sugary drinks (Soft Drinks (Coke, Kool-Aid), Sports Drinks (Gatorade) and Fruit and Vegetable Juices) when they play videogames. Daily intake was calculated based on the responses.

The study controlled for age and sex as sleep and videogame play can be modulated as a function of these factors^{2,3}. It also controlled for physical activity operationalized as the number of steps participants recorded on their FitBit device, divided by (adjusted for) the number of minutes they wore the device (they wore it for about one week, including one weekend, but not all of the time). Family socioeconomic status (family income reported by guardians) was also accounted for as it has been shown to relate to sugar-sweetened drink intake, habits and obesity prevalence.

Statistical Analysis

After preliminary analyses, we used the structural equation path modeling facilities of AMOS 24. This approach was taken given the complex mediational network of effects we hypothesize. In order to alleviate concerns regarding normality assumptions, we employed bootstrapping with 500 resamples for parameter estimation; an approach which does not make any distributional assumptions²¹. Sample size for power of 0.8 and $\mu=0.1$ for Root Mean Square of Approximation (RMSEA) was calculated for a model with 16 degrees of freedom²². The required sample was 122, which we exceeded in this study. Goodness of fit was assessed with combined fit indices criteria as specified by Hu and Bentler²³.

Results

The sample included 125 children and adolescents. Their characteristics are given in Table 1. The inter-correlations among the model's constructs are included in Table 2 with the Control variables on the bottom.

The model was initially estimated with all control variables. It presented good fit [$\chi^2(4)=7.21$ non-significant with $p<0.13$, CFI=0.97, IFI=0.98, RMSEA=0.081 with $p\text{-close}<0.24$, and SRMR=0.025]. Hypothesized effects, excluding the effect of sweet drinks consumption while

playing videogame on abdominal obesity, were statistically significant at least at $p < 0.05$.

Several control variables (Income, sex, physical activity, and days per week of videogame play) had no significant effects on endogenous constructs and for parsimony reasons they and non-significant control effects and correlations were removed. The model was re-estimated and presented good fit [$\chi^2(16) = 20.72$ non-significant with $p < 0.19$, CFI=0.95, IFI=0.96, RMSEA=0.049 with $p\text{-close} < 0.47$, and SRMR=0.063]. The standardized path coefficients, p -values (in parentheses) and explained variance in endogenous constructs (SMC=square multiple correlations) are shown in Figure 1.

As demonstrated in Figure 1, video-gaming before bedtime is associated with lower sleep quality among children and adolescents and longer typical (average) video-gaming sessions is associated with higher consumption of sweet drinks while playing videogames. This sweet drinks consumption is associated with reduced sleep quality among children and adolescents. While poor sleep quality is linked to increased abdominal adiposity, sweet drinks consumption while playing videogames is not directly linked to obesity. It is indirectly linked to obesity, though, through reduction in one's sleep quality. Physical activity was not associated with sweet drinks consumption, sleep quality or abdominal adiposity.

The model implies that poor-sleep quality and sweet drinks consumption while playing videogames mediate the association between videogame use patterns and abdominal adiposity. The results also imply that the association between sweet drinks consumption while playing videogames and abdominal adiposity is mediated through reduction in sleep quality. To statistically test these proposed mediational mechanisms, confidence intervals for and the significance of the indirect associations were calculated using bootstrapping with 500 resamples and bias-corrected significance estimation²¹. The standardized indirect association between

duration of video-gaming before bedtime and abdominal adiposity was 0.064 (95%CI=[0.013;0.136], $p(\text{two-tailed}) < 0.02$). The standardized indirect association between typical video-gaming session duration and abdominal adiposity was -0.003 (95%CI=[-0.055;0.046], $p(\text{two-tailed}) < 0.86$); and the standardized indirect association between sweet drinks consumption while playing videogames and abdominal adiposity was 0.056 (95%CI=[0.015;0.117], $p(\text{two-tailed}) < 0.016$).

These findings indicate that videogame play duration before bedtime, typical video-gaming session duration and sweet drinks consumption while playing videogames are statistically significantly indirectly linked to abdominal adiposity in this study population. In addition, older children consume more sweet-drinks while video-gaming compared with younger children. All of these associations were after controlling for clinic affiliation effects; as expected, patients of the weight management clinic presented higher levels of abdominal adiposity compared with patients of the lipid clinic.

Lastly, a post-hoc Analysis of Variance comparison of good versus poor sleepers, using the cutoff suggested by the Pittsburgh Sleep quality Index¹⁸ was performed. The results are given in Table 3 and suggest that poor and good sleepers significantly differ in their video-gaming time before bedtime, duration of typical video-gaming sessions, sweet drinks consumption while playing videogames and abdominal adiposity, all of which are higher among poor sleepers.

Discussion

This study adhered to calls to better understand how children and youth's video-gaming habits may translate into health problems including obesity¹⁴. This was done as a first step in a program of research aimed at developing interventions targeting the predictors and mediational

mechanisms of childhood obesity. It is generally known that excessive video gaming can be associated with obesity⁷, but health researchers have an incomplete picture regarding the mechanisms which underlie this association; and they have a narrow view regarding video-gaming use patterns with almost sole focus on videogame duration as the target metric. It has been suggested that reduced sleep⁶ and increased calorie intake²⁴ are important translational mechanisms as both are related to video-gaming and can be adversely linked to cardio-metabolic processes and indices¹⁴. Addressing these issues, this study sought to examine how specific overlooked video-gaming facets (play duration before bedtime and typical video-gaming session duration) are linked, through sleep quality and sweet drink consumption modulations, with abdominal adiposity, after accounting for several controls, including physical activity. The findings suggest that video-gaming duration before bedtime is a key risk factor for abdominal adiposity as it is related to lower sleep quality of children and youth which in turn is associated with greater abdominal adiposity. This adds to prior research which has examined daily videogame play duration¹⁴ but not timing of gaming. This suggests that future research should examine the efficacy of interventions targeting pre-bedtime video-gaming as a means to reduce childhood obesity. These may include healthcare provider education of parents and children, development and enforcement of healthy family video gaming use policies and the use of technical measures to block video gaming use before bedtime.

The findings further suggest that longer video-gaming sessions can be problematic as they are linked to a higher intake of sugar sweetened drinks while playing videogames. This increased intake, in turn, further contributes to reduced sleep and ultimately to elevated abdominal adiposity. Previous research in adults suggests that the consumption of energy drinks can interfere with sleep and recent population based studies suggest that consumption of energy

drinks is increasing, especially in adolescents²⁵. This is particularly significant given recent media attention highlighting the marketing of energy drinks to improve ‘gaming success’, reflected in the naming of some beverages as fuel for gaming and the development of gaming websites by energy drink producers²⁶. We do not unfortunately have information on the specific sugar sweetened beverages consumed in our study, but this will be an important area for future research.

The findings also point to two mediational mechanisms that are interdependent. Studies have discussed the link between reduced sleep duration and childhood obesity and how video-gaming may adversely influence sleep duration⁶. Sleep quality, though, a broader concept which taps into many dimensions of sleep (duration, latency, efficiency, and disturbances) received less attention. The findings of this study show that an index score based on these sleep dimensions is an important possible mediational mechanism between videogame use before bedtime and obesity. Furthermore, poor sleepers have greater abdominal adiposity compared with good sleepers²⁷. They are also more likely than good sleepers to engage in lengthier video-gaming sessions, including before bed time and consume more sweet drinks while playing videogames. Hence, future intervention studies should focus on ways to increase sleep quality and not just duration. Behavioral approaches to improving sleep hygiene and sleep quality in adults have been shown to improve self-reported sleep quality²⁸. While fewer studies are available in children and adolescents, several studies do suggest that educational / behavioral approaches to improving sleep hygiene are efficacious²⁹. Pharmacotherapeutic approaches (e.g., melatonin) also appear to improve delayed onset insomnia in children over the short term, but long term efficacy and safety have been less well studied. Current recommendations suggest an initial focus on improving sleep hygiene³⁰, including strict avoidance of computers and video games

prior to bedtime³¹. Thus, the growing evidence base suggests that behavioral trials can be efficacious in improving sleep quality in children and adolescents and should be considered. Their influence in reducing obesity or improving physical health has not been fully studied.

We also note that older youth consume more sweet drinks while playing videogames than younger children. This implies that interventions should be age specific (focused on prevention in younger children and reduction / substitution in older youth). The efficacy of this approach should be examined in future research. Moreover, in our sample females had longer video-gaming sessions before bedtime compared to males (see correlation in Table 2). National statistics typically examine general video gaming use and not specific attributes; they suggest that male teens are more active than females in video-gaming¹. Our findings indicate that perhaps a closer examination of sex-based differences in video-gaming patterns is needed as females, though in general play less than males, can engage in more problematic behaviors than males (e.g., playing in general for shorter periods of time, but doing so before bedtime). This line of inquiry merits future research.

Several limitations should be noted. First, our sample was comprised of children who were outpatients of specific pediatric clinics. Hence, caution with generalization should be exercised. Second, our design did not allow for examination of changes in abdominal adiposity. Hence, causality cannot be fully supported with the existing data. Future longitudinal designs would address this limitation. While it is of interest that sweet drink consumption during video gaming sessions was associated with poor sleep quality, the reasons why this is so are not fully known. We did not unfortunately have detailed information regarding the nature of the sweet drink (e.g., caffeinated or not) or the timing of consumption that may have contributed to our understanding of the reasons for this linkage. Lastly, this study detects potential targets to intervene upon, but

does not test the efficacy of such interventions on reducing abdominal adiposity. Future studies may focus on testing such interventions.

Conclusions

This study demonstrates that the associations between video-gaming facets and abdominal adiposity are complex and indirect; different videogame use patterns can be linked to different possible mediational process including play duration before bedtime and sweet drink consumption during video-gaming sessions, which can be intertwined and ultimately be associated with childhood obesity. The design and testing of interventions to address these potentially modifiable correlates of abdominal obesity should be considered. Furthermore, pediatricians, family practitioners and other health care professionals, educators and parents should be aware of the inter-relationships between behaviors associated with adverse health outcomes.

Conflict of Interest Statement

The authors have no conflicts of interest relevant to this article to disclose.

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Dr. Turel conceptualized and designed the study, ran analyses, drafted the initial manuscript, and approved the final manuscript as submitted.

Ms. Romashkin conceptualized and designed the study, obtained funding, acquired the data, ran analyses, provided critical revisions, and approved the final manuscript as submitted.

Dr. Morrison conceptualized and designed the study, obtained funding, acquired the data, provided critical revisions, oversaw the project, and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Tables

Table 1 Sample characteristics (n=125)[<]

Characteristics/ Clinic	Weight management clinic (n=79)	Lipid clinic (n=46)	All (n=125)
	Range (Mean) [Std. Deviation]		
Age (years)	10-17 (12.86) [2.21]	9-17 (13.39) [2.24]	9-17 (13.06) [2.22]
Male Sex n(%)	46 (58%)	38 (83%)	84 (67%)
Height (cm)	138.3-191.5 (160.82) [11.36]	142.0-198.0 (164.39) [12.44]	138.3 - 198.0 (162.1) [11.85]
Waist circumference (cm)	67.0-140.5 (96.23) [15.88]	54.0-124.0 (83.57) [18.04]	54.0 - 140.5 (91.57) [17.73]
Waist-to-Height Ratio	0.43-0.84 (0.60) [0.08]	0.34-0.70 (0.51) [0.10]	0.34 - 0.84 (0.56) [0.09]
Videogame play before bedtime, Yes n(%)	68 (86.1%)	39 (84.8%)	107 (85.6%)
Videogame play before bedtime (minutes)	0-240 (101.03) [59.83]	0-240 (94.5) [54.87]	0 - 240 (98.62) [57.92]
Days per week play videogames (days)	0.1-7.0 (4.59) [2.19]	1.0-7.0 (5.07) [1.82]	0.1 - 7.0 (4.76) [2.06]
Typical videogame session duration (minutes)	1-480 (97.52) [95.07]	10-320 (93.70) [63.31]	1 - 480 (96.12) [84.52]
Sleep quality index	0-13 (4.63) [3.02]	1-11 (4.35) [2.25]	0 - 13 (4.53) [2.76]
Poor Sleep quality classification n (%; based on PSQI cutoff of 5)	27 (34.2%)	11 (23.9%)	38 (30.4%)
Physical Activity (step count per minute of wearing the device) ^{<<}	6.00-32.83 (13.32) [3.76]	6.91-47.01 (15.00) [6.69]	6.00-47.01 (13.94) [5.08]
Family annual income (\$ Canadian)	<49,999 = 14 (17.7%), 50,000 - 69,999 = 16 (20.3%), 70,000- 99,999 = 28 (35.5%), >100,000 = 21 (28.6%)	<49,999 = 6 (13.0%), 50,000 - 69,999 = 8 (17.4%), 70,000- 99,999 = 19 (41.3%), >100,000 = 13 (28.3%)	<49,999 = 20 (16%), 50,000 - 69,999 = 24 (19.2%), 70,000- 99,999 = 47 (37.6%), >100,000 = 34 (27.2%)

[<]Sample characteristics are presented by clinic in order to illuminate potential similarities and differences.

^{<<} Can be interpreted as a global measure of level of activity; Higher steps per minute indicate more physical activity.

Table 2 Descriptive Statistics and Inter-variable Correlations (n=125)^κ

	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10
(1) Video-gaming duration before bedtime (minutes)	58.39	75.65										
(2) Typical video-gaming session duration (minutes)	96.12	84.52	0.11									
(3) Sleep Quality Index	4.53	2.76	.33**	.21*								
(4) Sweet drinks consumption while playing videogame	1.08	1.79	0.03	.25**	.29**							
(5) Abdominal adiposity (Waist to height ratio)	0.56	0.10	0.10	0.18	.20*	-0.01						
(6) Age	13.06	2.22	.27**	0.08	.29**	.28**	0.12					
(7) Days per week playing videogames	4.76	2.06	0.17	.24**	0.00	0.01	-0.03	-0.07				
(8) Family annual income	2.71	1.02	-0.08	-.19*	0.03	0.00	-0.02	-0.04	0.06			
(9) Physical activity (steps/min)	13.94	5.08	-.28**	0.00	-0.13	0.02	-0.13	0.02	-0.06	0.07		
(10) Sex (0=Male, 1=Female)	NA		.22*	-0.14	0.04	-.21*	0.09	-0.16	-0.11	-0.02	-0.02	
(11) Clinic program (0=Weight management, 1=Lipid)	NA		-0.05	-0.02	-0.05	-0.00	-.45**	0.12	0.11	0.06	0.06	-.25**

* p<0.05 ** p<0.01

^κ A higher sleep quality index is indicative of poorer sleep quality

Table 3 Differences between good and poor sleepers (cutoff of PSQI=5; n=125)

	Video-gaming duration before bedtime (minutes)		Typical video-gaming session duration (minutes)		Sweet drinks while playing videogame Score		Abdominal adiposity (Waist to height ratio)	
	Good sleepers	Poor Sleepers	Good sleepers	Poor Sleepers	Good sleepers	Poor Sleepers	Good sleepers	Poor Sleepers
Mean	43.80	91.80	80.16	132.63	0.73	1.91	0.55	0.60
Std. Deviation	67.20	84.00	58.15	118.79	1.31	2.39	0.08	0.11
Std. Error	7.20	13.80	6.23	19.27	0.14	0.39	0.01	0.02
p-value	0.001		0.001		0.001		0.007	

Figures

Figure 1 Structural Model (n=125)^{*,**}

* Model Fit Indices: [$\chi^2(16)=20.72$ non-significant with $p<0.19$, CFI=0.95, IFI=0.96, RMSEA=0.049 with p-close<0.47, and SRMR=0.063].

** The figure includes standardized path coefficients (on arrows), p-values (in parentheses) and explained variance in endogenous constructs (SMC=square multiple correlations, underneath the endogenous ellipses)

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2-7-2017

Dear Editorial Team,

The attached manuscript incorporates revisions based on feedback from the review team of Pediatric Obesity. Below we explain how each comment from was addressed.

Thank you once more,
The authors

Reviewer 1

Review Comments	Rebuttal/ changes
The manuscript by Turel and colleagues examined associations between videogame use facets and obesity as a first step towards informing possible interventions. The idea is very interesting and the study provides valuable information. I only have minor corrections to suggest.	Thank you very much! We have carefully addressed every comment from the review team. We believe that the current version of the manuscript has been substantially improved due to the insightful feedback provided by the review team.
- P.2 (what is already known about this subject): I would remove the word “increasing” here. It is clear that the prevalence of pediatric obesity is high globally; however, we are now seeing a plateau in the past years in several countries.	Removed as requested
- There are many typos throughout the manuscript (e.g. the objective on page 2 should read “and obesity”, not “as obesity”). Please make sure to pay attention to details throughout.	The manuscript was proofread and typos were fixed.
- P.11: “Furthermore, poor sleepers have greater abdominal adiposity compared with good sleepers”. This sentence should be referenced. I suggest Dutil C and Chaput JP. Lack of sleep as a contributor to obesity in adolescents: impacts on eating and activity behaviors. Int J Behav Nutr Phys Act (2016).	The reference was added as requested.
- Table 1: please indicate that the “poor sleep quality” classification comes from the PSQI and using a score of 5 or more. Also, this table reports on physical activity level of participants. More detail is needed in the methods section (e.g. how many days of assessment, at least one weekend day etc).	The cutoff for poor and good sleepers is reported in Tables 1 and 3. Details regarding physical activity measurement are provided.
- Please make sure to include sample size in all tables and figures (they should stand alone without reference to the text).	Done.
- Figure: Please add details in the legend. Readers should be able to interpret it without reference to the text. Statistical analyses should also be provided in the legend.	Done.

Reviewer 2

Review Comments	Rebuttal/ changes
This is a cross-sectional examination of the associations of video game play duration with sweetened beverage consumption, sleep quality, and abdominal adiposity measured by waist-to-height ratio in 125 children and adolescents who are patients enrolled in a Children's Hospital. The participants were recruited from a larger parent study on Sleep and Physical Activity. Associations were observed between video game play duration and abdominal adiposity, poor sleep quality, and sweet drink consumption. Testing a mediation model strengthened the novelty of the findings.	Thank you very much! We have carefully addressed every comment from the review team. We believe that the current version of the manuscript has been substantially improved due to the insightful feedback provided by the review team.
What this study adds -What does "typical videogaming session duration" mean? -What are "videogaming facets"?	We define concepts in the main text. We changed "typical" to "average", and video-gaming "facets" to video-gaming "patterns". The revised terms are clearer.
Summary -What does this mean: "videogaming use facets as obesity" - What methods were used to measure abdominal adiposity, sleep quality, sweet drink consumption, and videogame play duration? -What were the "biological measures"?	1. fixed 2. measures were added to the summary and reported in detail in the main text. 3. "biological" was replaced with "physiological"
Introduction -Reference 1 is from 2002 and needs to be updated. -Reference 3 is from 2010 – is there a more recent statistic to cite given the proliferation of media and potential change in parental rules/behaviors? -A few statements need citations (e.g. over 90% of children play videogames; videogames are one of the most popular leisure time activities).	- reference was updated - no better reference was found - citations were added, as requested.
Methods -Please provide more detail on whether surveys were administered to parents, to children, or to parents with children's assistance. For instance, were the video games questions directed to the parent regarding the child, or did the child complete? If the former, include the specific questions in the manuscript rather than questions using "you". -Do parents reliably report on their child's video game use? -Did parents complete the sleep quality questionnaire? Has this been validated for parents to report on children's sleep habits and sleep quality? This appears to be a self-report tool. -Same regarding dietary intake tool. -Provide validity and reliability information for the Fitbit. Did the parents complete a log to calculate minutes the child	1. Details provided. Administered to children with nursing staff assistance. Parents reported family income separately. 2. Parents did not report on child's video-gaming. The children did. 3. Parents did not complete the PSQI. Children did. 4. same for dietary intake. Completed by children. 5. No validity checks were done in this study. However, prior studies show that it is reliable. Nevertheless, it is just a control variable in our study and its accuracy is not central to our results. 6. average is reported (6 weeks).

<p>wore the device?</p> <p>-What was the average follow-up time for assessing abdominal adiposity (range 3 to 10 weeks)?</p>	
<p>Results</p> <p>-Page 10, lines 23-25 – This is the first mention of two different clinics (weight management clinic and lipid clinic) and the hypothesis that there would be differences in abdominal adiposity. How is this relevant for the present analyses? Why present separately in the table? Why not present Table 1 by sex or age or some other participant characteristic?</p> <p>-Table 2 – what does “score” mean for # 4 sweet drinks while playing videogame? Is this total number of drinks? Is there an oz. or serving size represented?</p> <p>-Table 2 – Did females report longer videogaming duration compared to males? How does this align with national or other cohorts?</p> <p>-Table 2 – Is a higher sleep quality index indicative of poorer sleep quality? If yes, this should be noted as a footnote. Otherwise, the correlation appears that a higher sleep quality score was related to longer video gaming duration.</p> <p>-Figure 1. Define the numbers and numbers in parentheses, as well as SMC, in a footnote.</p> <p>-Table 3 – Define how good and poor sleepers are operationalized</p> <p>-Provide an interpretation for the steps/min value of physical activity reported.</p>	<p>1. We clarify our logic in the revision. this is a profound difference that we believe is important to present, in case physicians servicing specific clinics are interested in more nuanced details.</p> <p>2. The word "score" was removed. The sweet drinks measure is explained.</p> <p>3. This is discussed in the revised manuscript.: " Moreover, in our sample females had longer video-gaming sessions before bedtime compared to males (see correlation in Table 2). National statistics typically examine general video gaming use and not specific attributes; they suggest that male teens are more active than females in video-gaming 1. Our findings indicate that perhaps a closer examination of sex-based differences in video-gaming patterns is needed as females, though in general play less than males, can engage in more problematic behaviors than males (e.g., playing in general for shorter periods of time, but doing so before bedtime). This line of inquiry merits future research."</p> <p>4. sleep quality measurement details are provided in this revision.</p> <p>5. Figure 1 was improved as suggested</p> <p>6. cutoffs doe poor sleep are outlined in Table 3, as requested.</p> <p>7. Interpretation provided, as requested.</p>

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Author/s:

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Title:

A model linking video gaming, sleep quality, sweet drinks consumption and obesity among children and youth

Date:

2017-08-01

Citation:

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