Health Education and Public Health

2020; 3(2): 270 – 275 . doi: 10.31488 /heph.138

Research article

Exergaming and Body Mass Index among Female Adolescents in Riyadh, Saudi Arabia

Eiman M. Alghmdi*, W. Lawrence Beeson, Ernesto Medina, Anna Nelson, Hildemar Dos Santos

School of Public Health, Department of Healthy Lifestyle and Disease Prevention, Loma Linda University, United States

*Corresponding author: Eiman M. Alghmdi, School of Public Health, Department of Healthy Lifestyle and Disease Prevention, Loma Linda University, 24951 Circle Dr, Loma Linda, CA 92354, United States, Tel: +1(909)560-6730; E-mail: eghamdy@gmail.com, ealghmdi@llu.edu

Received: February 20, 2020; Accepted: March 23, 2020; Published: March 25, 2020

Abstract

The purpose of this study was to examine the association between exergaming and body mass index among female adolescents in Riyadh, Saudi Arabia. A sample of 200 female students age 10-14 years completed a self-administered questionnaire after obtaining parental consent. Anthropometric measurements took place at schools after the completion of the enrollment questionnaire. The survey instrument included scales adopted from the validated Adolescent Sedentary Activity Questionnaire (ASAQ) and modified to include questions for exergaming. A multiple linear regression model was conducted to examine the association of exergaming with BMI. The results showed a significant negative association between exergaming and BMI among Saudi female adolescents after adjusting for several covariates ($p<0.001$). This is the first study to examine the association between exergaming and BMI among Saudi girls and to explore exergaming as an alternative solution for being more active in a population with limited physical activity due to cultural norms.

Keywords: exergaming, body mass index, physical activity, female adolescent, Saudi Arabia, youth health.

Introduction

The epidemic of childhood obesity has been a major global health challenge with an eightfold increase since 1975 [1,2]. Obesity has a complex etiology combining genetic and environmental factors. Ultimately, it is an outcome of energy imbalance resulting from insufficient physical activity along with the consumption of energy-dense food [3]. Childhood and adolescent obesity has a negative impact on the overall quality of an individual's life and is associated with many health risk factors including hypertension, type II diabetes, cardiovascular diseases and psychosocial consequences [4]. The increase of childhood obesity has been documented as a significant global health challenge worldwide [5]. A report by Ng et al. (2010) estimated the global, regional and national prevalence for overweight and obesity among children and adolescents for the time period 1980-2013. There was an increase in childhood obesity prevalence in developed countries from 16.9% to 23.8% in boys and from 16.2% to 22.6% in girls; while in developing countries there was an increase in childhood obesity prevalence from 8.1% to 12.9% in boys and from 8.4% to 13.4% in girls [6]. In Europe, childhood obesity trend has become a public health concern similar to other developed countries, with a percentage of more than 40% being obese in Southern Europe and less than 10% in Northern Europe and with higher prevalence among girls compared to boys [7]. In developing countries, the Kingdom of Saudi Arabia has documented an increase of the childhood obesity trend over time with a significantly higher prevalence among females [8-10]. This could be associated with the absence of formal physical education among female children and adolescents due to the official Saudi Ministry of Education's prohibition of physical education programs for girls in public schools [11]. Such policy is consistent with the social norms of the Saudi culture [12].

The introduction of exergaming technology in the early 2000s has been found to be attractive for young people. It aids in the reduction of sedentary behaviors by keeping children active since it requires users to participate in full body motion to interact with the game in the privacy of their own homes [13]. Exergaming has been well adopted in the countries of the Gulf region including Saudi Arabia [14]. This technology could provide a potential alternative to increasing physical activity among female children in this geographic area.

Exergaming

Exergaming are videogames that require users to participate in full body motion to interact with the game [15] while also including strength, flexibility and balance activities. Exergames have a variety of different type of fitness activities such as rhythmic dancing games, virtual sports simulator, motion sensor video cameras, censored pads, virtual bicycles and balance board simulators technology [16]. These games require both a console and a screen such as the Wii (Nintendo) and Xbox Kinect (Microsoft) devices. Exergames can produce different levels of physical activity that vary from moderate to vigorous and can be associated with physiological benefit [15]. Past research found a strong correlation between exergaming and energy expenditure with an increase up to 300% above resting levels with a higher energy expenditure reported for dance stimulation games [17]. Moreover, exergaming intervention studies showed a variety of outcomes including changes in physiological responses, metabolic equivalents (METs), ventilation responses (VO2max) and perceived exertion [18-20].

Currently, there is limited research about the association of exergaming and body mass index (BMI) among adolescents to reduce sedentary behaviors in Saudi Arabia. The purpose of this study was to examine this association and determine whether exergaming could provide an alternative solution to achieve the daily requirement of physical activity among Saudi female adolescents.

Methods

Participants and recruitment

Prior to commencing the survey, an approval from the Ministry of Education (MOE) in Saudi Arabia was obtained for conducting the survey. Institutional review board approval was obtained from the Loma Linda University, California, US.

This was a cross-sectional research study for Saudi female students aged 10-14. Random sampling was used to select five schools out of 50 in different regions of Riyadh, Saudi Arabia and participation in this study was voluntarily. Upon completion of the informed consent letter by their parents, two hundred female participants completed a self-administered questionnaire with the help of their parents. Anthropometric measurements of weight and height took place at schools under controlled conditions following the completion of the enrollment questionnaire.

Instrument

The survey instrument included items and scales adopted from a validated tool known as the Adolescent Sedentary Activity Questionnaire (ASAQ) that assessed the time spent watching TV, videogames as well as sitting hours during weekdays and weekend. The survey questions included the type and duration of exergaming [21]. The reliability estimates for all items in the ASAQ questionnaire is acceptable ($R \geq 0.70$)[22, 23]. The instrument also included questions on dietary intake and current physical activity in addition to the use of exergaming devices. The questions on the survey were translated into Arabic using the back-method translation [24].

The anthropometric measurement for BMI was conducted by measuring the height in meters (m) using the portable Leicester Height Measure, and the weight in kilograms (kg) using a medical scale (Health O Meter). The BMI was calculated using the formula: weight (kg)/(height (m))2. The resultant BMI data were converted to the centile values by using the CDC BMI for age growth chart [25]. BMI was categorized into four categories: below 5th percentile for underweight, 5th to less than 85th percentile for normal, 85th to less than 95th percentile for overweight, 95th percentile or greater for obese.

Based on their responses to the survey questions, participants were divided into two groups: those who participated in exergaming (n=100) and those who did not (n=100)

Data analysis

Bivariate analysis including chi-squared test and Spearman's correlation as well as multiple linear regression analyses were conducted using SPSS (IBM SPSS, Inc., Ver. 25.0, Armonk, NY) to determine the association between BMI and exergaming.

Results

Table 1 shows the demographic characteristics of the participants. The exergamer group had a significant higher education level of their fathers in comparison to the non-exergamer group (bachelor degree 53% vs. 44%, graduate degree 23% vs. 17%) ($p=0.001$). There also was a significant shift towards a higher socioeconomic level amongst the exergamers (high=22%) compared to the non-exergamers (high=15%) ($p=0.02$). There was no difference between the two groups regarding participating in sports outside of exergaming. Comparing student characteristics by overweight/obesity status, there was a significant difference in BMI among exergamers and non-exergamers (overweight 7% vs. 53% and obesity 1% vs. 15%; $p<0.01$) respectively.

Table 1. Demographics of study participants.

Variable	Exergamers Group (%) n=100	Non-Exergamers Group (%) n= 100	p-value
Age (yrs)			
10	9	8	
11	25	22	
12	26	24	0.91
13	24	25	
14	16	21	
Grade			
5	26	27	
6	32	30	0.95
7	42	43	
Residence in Riyadh			
North			
South	45	43	
East	9	8	
West	27	23	0.60
Central	10	18	
	9	8	
Mother's education level			
No school completed	3	10	
High school	12	25	
Diploma	20	14	0.20
Bachelors	57	43	
Graduate	8	8	
Father's education level			
No school completed	0	12	
High school	11	16	
Diploma	13	11	0.001
Bachelors	53	44	
Graduate	23	17	
Socioeconomic level			
Low			
Middle	0	5	
High	78	80	0.02
	22	15	

BMI category			
Healthy weight	92	32	
Overweight			
Obese	7	53	<0.01
	1	15	
Practice sport			
Yes	57	57	1.00
No	43	43	

*p value is based on Chi-square test

For the dietary intake (Table 2), there were no significant differences between the two groups except for the fruits and vegetables intake: 89% of the exergamers consumed fruit three or more times per week compared with only 66% of the non-exergamers (p<0.01). Vegetable intake was also greater with 75% of the exergamers eating vegetables three or more times per week compared with 65% of the non-exergamers (p=0.03). Conversely, 52% of the exergamers consumed snacks three or more times per week compared to 67% of the non-exergamers (p=0.04).

Table 2. Self-reported dietary intake of the adolescent females.

Variable	Exergamers Group (%) n=100	Non-Exergamers Group (%) n= 100	p-value
Home-cooked meals intake			
Every day	90	86	
Three times/week	8	13	0.44
Once/week	2	1	
Fast food intake			
Every day	2	3	
Three times/week	20	13	
Once/week	43	34	
Every two weeks	20	20	0.31
Once/month	13	17	
Rarely/never	2	13	
Fruit intake			
Every day	45	41	
Three times/week	44	25	<0.01
Once/week	9	17	
< Once/week	2	17	
Vegetables intake			
Every day	43	46	
Three times/week	32	19	
Once/week	10	11	0.03
1-3 times/month	11	9	
Rarely/never	4	15	
High sugar-sweetened beverages intake			
Every day	16	33	
Three times/week	36	24	
Once/week	25	19	
Every two weeks	6	3	0.06
Once/month	8	10	
Rarely/never	9	11	

In regard to the correlation between exergaming on weekdays and other activities, we found a significant inverse correlation with watching TV (rho=-0.183, p=0.01) whereas the correlation was positive for interacting with the computer (rho=0.237, p=0.001) (Table 3). Exergaming on the weekends was also inversely correlated with watching TV (rho=-0.203, p<0.001) and sitting (rho=-0.195, p=0.01), but was positively correlated with interacting with the computer (rho=0.237, p<0.001) (Table 3).

The results of a multiple linear regression model that was adjusted for sedentary activities to predict the association between BMI percentile (adjusted for age) and exergaming are shown in Table 4.

Playing exergames was a significant strong predictor to lower BMI percentile (β= -16.57, 95% CI: -21.44, -11.691, p<0.001). The adjusted R2 for all the predictors in this model is 31%. In another multiple linear regression model adjusting for dietary intake (Table 5), playing exergames was still the strongest and only significant predictor to a lower BMI percentile (adjusted for age) among all other independent variables (β= -21.78, 95% CI: -26.37, -17.192, p<0.001). The adjusted R2 for this model is 30%.

Discussion

The findings from our study show a significant negative association between exergaming and BMI among female adolescents in Riyadh, Saudi Arabia. This is the first study that looks into this association among Saudi adolescent girls illustrating the possibility of exergaming as an alternative solution to increase physical activity for girls in this country. Other studies (usually in the form of clinical trials) have investigated exergaming in a variety of countries have reported similar outcomes. In New Zealand for example, children aged 10-14 showed a statistically significant beneficial effect on BMI for the exergaming group compared to the control group after 24 weeks (-0.24 kg/m2, p=0.02) [26]. In another community-based weight management program that used exergaming, 48 children aged 10-16 who were overweight or obese participated in a multidisciplinary weight management program that included exergaming for ten weeks. The results showed a significant average BMI change of -0.48 kg/m2 (p<0.002) [27].

It was seen in our study that exergaming was significantly and inversely correlated with watching TV on weekdays and weekend. The literature has explored the possibility of exergaming in reducing sedentary behaviors such as TV watching and minimizing other risky behaviors associated with screen time such as snacking and overeating [28-31] and that may contribute in lower BMI. A significant difference in fruit and vegetables consumption between exergamers and non-exergamers in this study could be another contributing factor that explains the BMI difference between both groups.

The change in BMI and weight loss associated with exergaming has been discussed in the literature. In a study that measured the energy cost of six forms of exergaming, the researchers found a four to eight-fold increase of physical activity energy expenditure above resting level for all different forms of exergames, and that is equivalent to moderate-vigorous intensity [32]. One of the most desired exergames among girls was found to attract this age group and significantly increase the energy

Table 3. Bivariate comparison of activities among study subjects (n=200).

CORR (p value)	ExerG WD												
ExerG WD	1												
ExerG WE	.933 (<.001)	1											
Sport	.075 (.29)	.094 (.18)	1										
TV WD	-.183 (.01)	-.205 (<.001)	.022 (.75)	1									
TV WE	-.189 (.01)	-.203 (<.001)	-.031 (.66)	.732 (<.001)	1								
Video WD	.121 (.09)	.075 (.29)	-.085 (.23)	-.210 (<.001)	-.167 (.02)	1							
Video WE	.179 (.01)	.136 (.06)	-.101 (.16)	-.186 (.01)	-.162 (.02)	.719 (<.001)	1						
VG WD	.006 (.94)	-.052 (.47)	-.185 (.01)	-.010 (.89)	-.002 (.98)	-.097 (.17)	.020 (.78)	1					
VG WE	-.050 (.48)	-.114 (.12)	-.118 (.09)	.091 (.20)	.146 (.04)	-.139 (.05)	-.078 (.27)	.644 (<.001)	1				
Comp WD	.237 (.001)	.221 (.002)	.103 (.15)	-.055 (.44)	.038 (.59)	.051 (.47)	.018 (.80)	-.002 (.98)	.035 (.62)	1			
Comp WE	.229 (<.001)	.237 (<.001)	.131 (.06)	-.076 (.28)	.048 (.50)	-.007 (.92)	.010 (.88)	.040 (.57)	.074 (.29)	.688 (<.001)	1		
Sit WD	-.131 (.06)	-.128 (.07)	-.012 (.86)	.169 (.02)	.221 (<.001)	.013 (.85)	-.059 (.41)	.017 (.81)	.052 (.46)	.050 (.49)	.071 (.32)	1	
Sit WE	-.172 (.02)	-.195 (.01)	0.63 (.37)	.124 (.08)	.176 (.01)	-.026 (,72)	-.10 (.16)	-.095 (.18)	.093 (.19)	.065 (.36)	.025 (.73)	.693 (<.001)	1

Spearman Correlation Coefficients between variables. Values in parenthesis include P values; bolded are statistically significant (<0.05)
ExerG WD: exergaming in hours/weekdays; ExerG WE: exergaming in hours/weekend; Sport:Hours of sport/week; TV WD: watching TV in hours/weekdays; TV WE: watching TV in hours/weekend; Video WD: watching video in hours/weekdays; Video WE: watching video in hours/weekend; Comp WD:using computer in hours/weekdays; Comp WE: using computers in hours/ weekend; VG WD: playing inactive videogames in hours/weekdays; VG WE:playing inactive videogames in hours/weekend; Sit WD:sitting hours/weekdays; Sit WE:sitting hours/weekend

Table 4. Regression Coefficients and p-values for exergaming and sedentary variables in a regression model predicting BMI percentile adjusted for age (n=200).

Exposure	**Coefficient (95% CI)**	**P value**
Exergaming (yes vs. no)	-16.566 (-21.44, -11.691)	< 0.001
TV WD	.062 (-.607, .732)	0.854
TV WE	.88 (-.215, 1.976)	0.114
Video WD	-.018 (-.689, .654)	0.958
Video WE	.716 (-.561, 1.993)	0.270
VG WD	.396 (-.196, .987)	0.189
VG WE	.119 (-.871, 1.11)	0.812
Comp WD	-1.072 (-2.089, -.054)	0.039
Comp WE	.200 (-1.273, 1.673)	0.789
Sit WD	-.209 (-.962, .544)	0.585
Sit WE	.778 (-.340, 1.896)	0.171

The model R^2= 0.35, Adjusted R^2=0.31
TV WD:watching TV in hours/weekdays; TV WE: watching TV in hours/weekend; Video WD:watching video in hours/weekdays; Video WE: watching video in hours/weekend; Comp WD:using computer in hours/weekdays Comp WE: using computers in hours/ weekend; VG WD:playing inactive videogames in hours/weekdays; VG WE: playing inactive videogames in hours/weekend; Sit WD: sitting in hours/weekdays; Sit WE: sitting in hours/weekend

Table 5. Regression Coefficient and p-values for exergaming and dietary variables in a regression model predicting BMI percentile adjusted for age (n=200).

Exposure	**Coefficient (95% CI)**	**P value**
Exergaming (yes vs. no)	-21.780 (-26.369, -17.192)	< 0.001
HCM	-.161 (-.525, .203)	0.385
Fast food	.358 (-.080, .797)	0.108
Fruit	.010 (-.251, .272)	0.938
Vegetable	-.131 (-.362, .100)	0.264
HSSB	-.182 (-.402, .037)	0.102
Milk	.110 (-.081, .302)	0.257
Snack	-.131 (-.369, .106)	0.277

The model R^2= 0.33, Adjusted R^2=0.30
HCM: Home cooked meals days/month; Fast food: Fast food intake days/month; Fruit: fruit intake days/month; Vegetable: vegetable intake days/month; HSSB: High sugar sweetened beverages intake days/month; Milk: Milk intake days/month; Snack: snack intake days/month

expenditure is associated with dance stimulation games (300% above resting levels) [17]; this exergame was the highest played among exergame subjects in our study (66% reported to play "Just Dance"). When looking at similar studies that focused on exergaming for teen girls only, significant benefits were reported with exergaming interventions including the decrease in abdominal subcutaneous adiposity and an increase in bone mineral density after completing 36 hours of dance exergaming in 3 month ($p<0.05$) [33]. Additionally, an increase in total physical activity hours ($p=0.03$) as well as a reduction in TV watching hours ($p=0.01$) were significantly reported in a 12 weeks exergaming intervention among overweight and obese adolescent girls [34].

Exergaming has been reported to have a variety of benefits. The American Heart Association convened a panel to explore the role of exergames in reducing sedentary behaviors and promoting health and fitness and they highlighted that exergaming could be a potential gateway to physically active lifestyles across all age groups promoting lifelong regular physical activity [35]. The current peer-reviewed research suggest that exergaming has a positive health-related outcomes including the potential for lower BMI and weight loss [26, 27, 35, 36] consistent with our study finding.

This is the first study that examined the association between exergaming and BMI among Saudi female adolescents and explored exergaming as an alternative solution to promote physical activity among this population. Some of the limitations of this study are that the cross-sectional design does not establish causality between exergaming and BMI among this population, and the fact that responses were self-reported. Further intervention research in this field, especially in terms of longitudinal study designs, is needed to understand the effect of exergaming on BMI and other health-related outcomes among Saudi female adolescents.

Looking at the current COVID-19 pandemic, public health scientists are predicting an exacerbation in childhood obesity rate associated with school closure and the lack of physical activity and an increase in sedentary time associated with quarantine and social distancing [37]. The finding from this study shows that exergaming could be an alternative solution during this time for children to be more physically active by exercising from home using active video gaming and reducing sedentary time.

Conclusion

Exergaming is associated with lower BMI among female adolescent in Saudi Arabia. This could be an alternative solution for being more active in a population with limited physical activity options due to cultural norms.

Abbreviation

BMI: Body Mass Index; METs: Metabolic Equivalents; VO2max: Ventilation Responses; MOE: Ministry of Education; ASAQ: Adolescent Sedentary Activity Questionnaire.

Acknowledgments

The authors would like to thank the participants in this study. This study was not funded.

Author Disclosure Statement

No competing financial interests exist.

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To cite this article: Alghmdi EM, Beeson WL, Medina E, et al. Exergaming and Body Mass Index among Female Adolescents in Riyadh, Saudi Arabia. Health Education and Public Health. 2020; 3:2.