

Physical inactivity and its predictors among adolescents in Saudi Arabia

A cross-sectional comparison between cities with and without a Healthy Cities Program

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ABSTRACT

الأهداف: دراسة انتشار نقص النشاط البدني وزيادة المفرطة بتمضية الأوقات أمام الشاشات بين المراهقين الذين يعيشون في المدن المشاركة في برنامج المدن الصحية (HCP) والمدن الأخرى (NHCPs) في منطقة القصيم بالمملكة العربية السعودية.

المنهجية: أجري مسح لعدد 1133 مراهقاً من منطقة القصيم باستخدام طريقة أخذ العينات العشوائية المنهجية خلال الفترة من أبريل حتى سبتمبر 2017م. أجري تحليلات الانحدار اللوجستي متعدد المتغيرات للتحقق في تنبؤات المستويات غير الكافية من النشاط البدني وزيادة وقت الشاشة.

النتائج: بلغ معدل انتشار نشاط أقل من 60 دقيقة من النشاط البدني المعتدل إلى شديد الشدة في اليوم 82.4% ونسبة 59% لأقل من 3 أيام للنشاط البدني القوي في الأسبوع بين المراهقين. لم يكن هناك ارتباط كبير بين العيش في مدينة ضمن برنامج المدن الصحية والمستويات غير الكافية للنشاط البدني. كانت احتمالات زيادة وقت استخدام الشاشة أعلى في مدن برنامج المدن الصحية عن المدن الأخرى (نسبة الأرجحية: 1.49). كانت احتمالات عدم كفاية الجسم اليومي (نسبة الأرجحية: 0.47) والأسبوعية (نسبة الأرجحية: 0.78) أقل بين الأولاد منها بين الفتيات.

الخلاصة: تشير نتائجنا إلى عدم وجود دليل على أي تأثير لبرنامج المدن الصحية HCP على سلوكيات النشاط البدني للمراهقين. تتطلب هذه النتيجة مزيداً من التقييم المتعمق لتنفيذ ومخرجات برنامج المدن الصحية في المملكة العربية السعودية.

Objectives: To estimate the prevalence of insufficient physical activity and excessive screen time among adolescents living in cities participating in the Healthy Cities Program (HCP) and cities not running the program in the Qassim region of Saudi Arabia.

Methods: We surveyed 1133 adolescents from the Qassim region using systematic random sampling between April and September 2017. Multivariable logistic regression analyses were conducted to investigate the predictors of insufficient levels of PA and excessive screen time.

Results: The prevalence of <60 minutes of moderate-to vigorous-intensity physical activity/day was 82.4%

and <3 days of vigorous intensity physical activity/week among adolescents was 59%. There was no significant association between living in healthy cities (HCPs) and insufficient levels of physical activity. The odds of excessive screen time were higher in HCPs than in cities not running the program (NHCPs) (OR: 1.49). The odds of insufficient daily PA (OR: 2.19) are higher among girls than boys. Increasing age is positively associated with insufficient weekly PA (OR: 1.19). The prevalence of excessive recreational screen time is 84.6% with higher odds in HCPs than in NHCPs (OR: 1.51).

Conclusion: Our findings report a lack of evidence of any impact of the HCP on adolescents' physical activity behaviors. This outcome warrants a further in-depth evaluation of the process and outcomes of the HCP in Saudi Arabia.

Keywords: Healthy Cities Program, adolescents, physical activity, screen time, Saudi Arabia

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Physical activity (PA) is an essential component of good health and wellbeing, and a lack of PA increases one's risk of adverse health outcomes and decreases one's life expectancy.¹ The World Health Organization (WHO) recommends that children aged 5-17 years perform at least 60 minutes of moderate-to vigorous-intensity PA daily. Vigorous-intensity PA that strengthen muscles and bones should be performed at least 3 days per week.² The WHO has identified inadequate PA as the fourth leading cause of noncommunicable diseases (NCDs).³ A meta-analysis of 23 studies concluded that the risk of cardiovascular diseases declines with increasing rates of PA.⁴ Globally, insufficient PA is responsible for an estimated 6% of the burden of disease from coronary heart disease, 7% from type 2 diabetes, 10% from breast cancer, and 10% from colon cancer.¹ Insufficient PA was also responsible for 9% of the premature mortality from all causes (5.3 million deaths) globally in 2008.¹ In 2013, the WHO reported that an estimated 80% of adolescents aged between 11 and 17 years were inadequately physically active.^{3,5}

Several studies conducted in the Kingdom of Saudi Arabia (KSA) have reported high proportions of insufficient PA among both male (25.7-84.5%) and female adolescents (42.9-87.1%) and have recommended immediate public health interventions to prevent any future NCDs.⁶⁻⁸ A review of PA promotion initiatives in the KSA has revealed that a variety of public health programs to promote PA exist in the KSA. Most of these initiatives are nationwide and school-based and are mainly conducted by the Ministry of Health in collaboration with the Ministry of Education. However, the effectiveness of these programs has not adequately been evaluated.⁵ The WHO's Healthy Cities Program (HCP) was launched in the KSA in 1998. The program has been expanding through various phases since 1998, and 32 cities currently operate under the HCP, with 9 cities being recently accredited by the WHO as healthy cities.^{9,10} The HCP aims to enhance the health and quality of life of city residents through continual community participation and intersectoral partnerships.¹¹ The successful healthy city movement promotes a strong value-based commitment into developing a supportive community and improving

the daily conditions of urban life, encouraging local governments to include health concerns in all aspects of public policy. To promote consistency and high standards, a healthy city should continually improve its physical and social environments and expand the community resources that enable people to support each other to their maximum potential.¹² There are 3 conditions cities must fulfil to be recognized by the WHO as healthy cities. First, cities must join the regional movement on health and urbanization and then join the regional healthy cities network. The next step is to request an assessment to qualify as a healthy city and receive a certificate from the WHO. Cities must introduce activities and fulfil the 80 points criteria that will allow them to be recognized by the WHO as healthy cities. One of these 80 points criteria is to ensure that the city residents have access to sports facilities and green spaces where family members can participate in regular PA.¹²

The current study aimed to estimate the prevalence of insufficient PA and excessive recreational screen time among adolescents in Qassim, KSA. Furthermore, we compared these health risk behaviors between adolescents living in cities that joined the HCP (HCPs) and cities that were not participating in the program (NHCPs) within the Qassim region, KSA, and we investigated the sociodemographic predictors of these health risk behaviors among adolescents.

Methods. This cross-sectional study recruited adolescents school students in grade 10-12, using a multi-stage sampling technique. The survey process entailed 6 cities within the Qassim region: Buraidah, Onaiza, Alrass, Albukayriah, Albadea, and Almedhnab. Qassim is one of the 13 administrative regions in KSA located in the center of the country. According to the General Authority for Statistics (2017), Qassim region population was estimated to be 1.42 million. Within this population, approximately 15% are aged 10-19 years, and those aged 20-29 years represented approximately 18%.¹³

We calculated sample size using the Taro Yamane formula.¹⁴ The minimum required sample size for a probability value of 0.05 was 396, and for a probability value of 0.03, was 1079. Since a larger sample size provides a higher level of precision for prevalence estimates and offers greater power for subsequent multivariable analysis, we targeted 1133 students, anticipating a 5% nonresponse rate. Appendix 1 presents the sampling frame and sample size for each of the strata considered in the sampling. First, we purposively selected 6 cities in the Qassim region, KSA.

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Three of these cities, namely, Onaiza, Albukayriah, and Almedhnab, have participated in the HCP, while 3 other cities, namely, Buraidah, Alrass, and Albadea, have not participated in the HCP. Comparison cities were purposively selected as close possible matches to the HCP cities in terms of city characteristics. Second, we randomly selected 46 schools from a list of a total of 203 schools located in the 6 selected cities. Finally, using probabilities proportionate to the sample size, we recruited students from a list of all the students from the selected 46 schools.

This study is part of a larger cross-sectional survey that aims to assess adolescent school students' health risk behaviors in the Qassim region, KSA. We used a structured questionnaire to gather information on the health risk behaviors and sociodemographic characteristics of the adolescents. Part of the questionnaire that we used in the analysis of this study included the adolescents' sociodemographic information as explanatory variables and their daily time spent in moderate- to vigorous-intensity PA (for example brisk walking, dancing, gardening, domestic chores, running, climbing up a hill or stairs, swimming, cycling, aerobic activities, indoor or outdoor sports); the number of times in a week they were involved in vigorous-intensity PA; and their daily recreational screen time (time spent watching television, smartphone, computer, or other display screens) as outcome variables.²

Data were collected between April and September 2017. The questionnaire was administered in the classrooms by the first author for the male students and by a trained female research assistant for the female students. A detailed written instructions concerning filling out the questionnaire were provided. In addition, verbal explanations were provided to the participants. However, the students provided their responses without any assistance or interference from the data collectors. The completed surveys were delivered back to the researcher, as well as to the assistant at the female schools. Students were considered excluded if they were absent during data collection or if they were aged above 19 years or less than 15 years.

We received ethical approval from the Human Research Ethics Committee, University of New England, Armidale, New South Wales, Australia (HE17-021). Approval was also received from the Ministry of Education, Qassim, KSA (38644423). Informed consent has been obtained from each participant in this study. The survey procedure was designed to protect students' privacy and anonymity. Hence, the survey collected no identifying information from the

participants and only the authors of this research had access to the data. There were no potential risks of any kind associated with this research study. Students were not provided any kind of incentives for participation. If the students felt uncomfortable, they were able to stop answering the questions and withdraw from the study at any time.

Statistical analysis. Data were processed using IBM SPSS Statistics for Windows, v.22.0 (IBM Corp. Armonk, NY, USA). Data were screened for missing values, outliers, and collinearity among the predictors included in logistic regression model. Participants and physical activity-related characteristics in HCPs and NHCPs were presented using frequency distributions. Comparisons of variables were made using the classification of the cities (HCPs and NHCPs) as grouping variables.

We conducted multivariable logistic regression analyses to investigate the association of insufficient (<60 minutes) daily moderate-to vigorous-intensity PA, insufficient (<3 times) weekly vigorous-intensity PA and excessive screen time (>2 hours) with the HCP and adolescents' sociodemographic characteristics. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

Results. Among adolescents, approximately one-third (32%) were living in HCPs and 68% were living in NHCPs. There was no evidence of collinearity issues among the predictor variables included in our logistic regression models. **Table 1** presents sociodemographic characteristics of the study participants. The majority of the participants were female (54.6%); Saudi citizens (91.4%); studying in state schools (85%); living with both parents (86.8%); and had either very good or excellent academic performance (86%). The majority (85.3%) of the adolescents were not receiving physical education in their schools. A total of 41.7% of the fathers and 38% of the mothers of adolescents had at least a university graduate-level education.

Table 2 presents prevalence of the different PA behavior among adolescents in the Qassim region, KSA. We found that over 82% of the adolescents reported performing moderate- to vigorous-intensity PA daily for less than 60 minutes. Regarding the weekly recommended level of PA, we found that 59% did not perform at least 3 days of vigorous-intensity PA weekly. On the other hand, we found that approximately 85% of the adolescents reported spending more than 2 hours a day watching screens, such as smartphones or television. Chi-squared tests revealed that there is no

statistically significant association between HCP and performing less than 60 minutes of daily moderate- to vigorous-intensity PA, and between HCP and performing less than 3 days of vigorous-intensity PA weekly. However, a statistically significant association was observed between HCP and having more than 2 hours daily of recreational screen time.

In **Tables 3-5**, we present the results of the bivariate

and multivariable logistic regression analyses of adolescents' participation in PA and screen time by city classification, gender, type of school, academic performance, receiving or not receiving physical education in schools, living with or without both parents, nationality, parents' education, and age. None of the variables included had missing values; hence, all cases were included in analyses.

We did not find any evidence of a statistically significant association between living in HCPs or NHCPs and insufficient daily PA (OR: 1.06; 95% CI: 0.76-1.47) after adjusting for the effect of other sociodemographic variables. Among the sociodemographic variables, only gender was found to have statistically significant association with insufficient (<60 minutes of moderate- to vigorous-intensity) daily PA in both bivariate and multivariable logistic regression analyses. We found that girls were more likely (OR: 2.19; 95% CI: 1.54-3.11) to do insufficient daily moderate- to vigorous-intensity PA than boys, given that all the other variables in the model were held constant. However, no evidence of association was observed between insufficient daily moderate- to vigorous-intensity PA and age, type of school, receiving physical education in schools, academic performance, nationality, and parents' educational attainment (**Table 3**).

Regarding engaging in insufficient weekly vigorous-intensity PA (doing vigorous-intensity PA less than 3 days a week), in our multivariable logistic regression analysis, we did not find any evidence of an association between performing insufficient weekly vigorous-intensity PA and living in HCPs (OR: 1.26; 95% CI: 0.97-1.64) after adjusting for the effect of other sociodemographic variables of the adolescents. However, we found evidence of a significant association between performing insufficient weekly vigorous-intensity PA and adolescents age in both bivariate and multivariable logistic regression analyses. Older adolescents were more likely to perform insufficient amount of vigorous-intensity PA in a week. A one-year increase in age

Table 1 - Characteristics of the participants (N=1133).

Characteristics	n	(%)
<i>Living in healthy cities</i>		
Yes	364	(32.1)
No	769	(67.9)
<i>Gender</i>		
Female	619	(54.6)
Male	514	(45.4)
<i>Age</i>		
15 years	42	(3.7)
16 years	369	(32.6)
17 years	395	(34.9)
18 years	327	(28.9)
<i>School type</i>		
Private	170	(15.0)
State	963	(85.0)
<i>Academic performance</i>		
Poor, average or good	158	(13.9)
Very good or excellent	975	(86.1)
<i>Receiving physical education in school</i>		
Yes	167	(14.7)
No	966	(85.3)
<i>Living with both parents</i>		
Yes	983	(86.8)
No	150	(13.2)
<i>Nationality</i>		
Non-Saudi	97	(8.6)
Saudi	1036	(91.4)
<i>Fathers have bachelor or higher education</i>		
Yes	472	(41.7)
No	661	(58.3)
<i>Fathers have bachelor or higher education</i>		
Yes	430	(38.0)
No	703	(62.0)

Table 2 - Prevalence of different physical activity behaviors among adolescents in the Qassim region of Saudi Arabia.

Physical activity behaviors	Prevalence (95% CI)			P-value*
	HCPs	NHCPs	Total	
Daily <60 minutes of moderate- to vigorous-intensity physical activity	83.0 (78.7 – 86.7)	82.2 (79.3 – 84.8)	82.4 (80.1 – 84.6)	0.747
Weekly <3 days of vigorous-intensity physical activity	62.6 (57.4 – 67.6)	57.2 (53.6 – 60.7)	59.0 (56 – 61.8)	0.083
Daily >2 hours of recreational screen time	88.2 (84.4 – 91.3)	83.0 (80.1 – 85.6)	84.6 (82.4 – 86.7)	0.023

*Chi-squared test, 2-sided, CI: confidence interval, HCPs: Cities with healthy cities program, NHCPs: Cities without healthy cities program

was associated with 1.19 (95% CI: 1.04-1.37) times increased odds of performing insufficient weekly PA, provided that all the other variables in the model were held constant. Our bivariate analyses suggest that girls are more likely to do insufficient weekly vigorous-

intensity PA compared to the boys (OR: 1.29; 95% CI: 1.01-1.63). However, after adjusting for the effects of confounding variables no such association was observed (OR: 1.21; 95% CI: 0.92-1.59). Our bivariate analysis also suggests that Saudi adolescents are more likely to

Table 3 - Predictors of insufficient daily moderate- to vigorous-intensity physical activity among adolescents in Saudi Arabia, logistic regression analyses.

Predictors	Bivariate analysis		Multivariate analysis	
	OR (95% CI)	P-values	OR (95% CI)	P-values
Living in healthy cities	1.06 (0.76 – 1.47)	0.747	1.06 (0.76 – 1.49)	0.736
Age in years (increasing)	1.05 (0.88 – 1.25)	0.597	1.06 (0.88 – 1.28)	0.525
Female students	2.17 (1.6 – 3.0)	0.000	2.19 (1.54 – 3.11)	0.000
State school students	1.43 (0.96 – 2.14)	0.076	1.27 (0.84 – 1.92)	0.256
Receiving physical education in school	1.47 (0.99 – 2.20)	0.057	1.08 (0.69 – 1.69)	0.729
Very good or excellent academic performance	1.47 (0.98 – 2.21)	0.064	1.22 (0.80 – 1.88)	0.362
Living with both parents	1.04 (0.66 – 1.62)	0.880	1.13 (0.72 – 1.79)	0.599
Saudi citizens	1.0 (0.58 – 1.72)	0.992	0.95 (0.55 – 1.66)	0.862
Fathers have bachelor or higher education	1.22 (.89 – 1.67)	0.211	1.37 (0.97 – 1.93)	0.073
Mother have bachelor or higher education	0.87 (.64 – 1.19)	0.379	0.77 (0.54 – 1.09)	0.143

OR: odds ratio, CI: confidence interval

Table 4 - Predictors of insufficient weekly vigorous-intensity physical activity among adolescents in Saudi Arabia, logistic regression analyses.

Predictors	Bivariate analysis		Multivariate analysis	
	OR (95% CI)	P-values	OR (95% CI)	P-values
Living in healthy cities	1.25 (.97 – 1.62)	0.084	1.26 (0.97 – 1.64)	0.081
Age in years (increasing)	1.23 (1.07 – 1.41)	0.003	1.19 (1.04 – 1.37)	0.015
Female students	1.29 (1.01 – 1.63)	0.039	1.21 (0.92 – 1.59)	0.176
State school students	1.13 (0.81 – 1.57)	0.475	1.03 (0.73 – 1.44)	0.875
Receiving physical education in school	0.72 (0.52 – 1.0)	0.052	0.83 (0.57 – 1.21)	0.322
Very good or excellent academic performance	0.89 (0.63 – 1.26)	0.503	0.89 (0.62 – 1.28)	0.530
Living with both parents	0.71 (0.49 – 1.02)	0.061	0.76 (0.53 – 1.10)	0.149
Saudi citizens	1.52 (1.003 – 2.31)	0.049	1.4 (0.92 – 2.14)	0.119
Fathers have bachelor or higher education	0.81 (0.64 – 1.03)	0.080	0.89 (0.68 – 1.15)	0.369
Mother have bachelor or higher education	0.82 (0.65 – 1.05)	0.119	0.91 (0.69 – 1.18)	0.466

OR: odds ratio, CI: confidence interval

Table 5 - Predictors of excessive recreational screen time among adolescents in Saudi Arabia, logistic regression analyses.

Predictors	Bivariate analysis		Multivariate analysis	
	OR (95% CI)	P-values	OR (95% CI)	P-values
Living in healthy cities	1.53 (1.06 – 2.22)	0.024	1.51 (1.03 – 2.20)	0.033
Age in years (increasing)	1.0 (0.83 – 1.20)	0.973	0.98 (0.81 – 1.19)	0.820
Female students	1.39 (1.01 – 1.92)	0.046	1.01 (0.69 – 1.49)	0.949
State school students	1.47 (0.97 – 2.23)	0.070	1.23 (0.80 – 1.91)	0.342
Receiving physical education in school	0.61 (0.40 – 0.91)	0.017	0.62 (0.38 – 1.01)	0.056
Very good or excellent academic performance	2.31 (1.55 – 3.44)	0.000	2.25 (1.48 – 3.43)	0.000
Living with both parents	0.83 (0.50 – 1.37)	0.461	0.85 (0.51 – 1.43)	0.546
Saudi citizens	1.94 (1.19 – 3.18)	0.008	1.95 (1.17 – 3.22)	0.010
Fathers have bachelor or higher education	1.17 (0.84 – 1.63)	0.359	1.16 (0.80 – 1.66)	0.435
Mother have bachelor or higher education	1.13 (0.80 – 1.58)	0.493	0.94 (0.65 – 1.37)	0.753

OR: odds ratio, CI: confidence interval

do insufficient vigorous-intensity PA compared to the non-Saudi adolescents but after adjusting for the effect of other sociodemographic variables no such association was evident (Table 4).

Regarding excessive recreational screen time (>2 hours daily), we found that adolescents living in HCPs were 1.51 (95% CI: 1.03-2.20) times likely to have excessive recreational screen time than adolescents living in NHCPs. Excessive recreational screen time was also significantly associated with academic performance and nationality in both bivariate and multivariable logistic regression analyses. Adolescents with a very good or excellent academic performance were 2.25 (95% CI: 1.48-3.43) times likely to spend more than 2 hours on screen daily compared to adolescents with lower academic performance. The odds of excessive recreational screen time in Saudi adolescents were 1.95 (95% CI: 1.17-3.22) times the odds of excessive recreational screen time in non-Saudi adolescents, provided that the effect of all other variables included in the model was held constant. This outcome implies that Saudi adolescents spend significantly more time on watching screens compared to non-Saudi adolescents. However, we did not observe any significant association between excessive screen time and other sociodemographic variables such as age, parents' education, and whether the adolescent lives with both parents (Table 5).

Discussion. This study employed a cross-sectional survey among school-going adolescents in the Qassim region of KSA, to determine the prevalence and determinants of insufficient PA and excessive recreational screen time. Furthermore, we compared these behaviors of the adolescents between HCPs and NHCPs.

We found that most of the school-going adolescents in the Qassim region, KSA perform insufficient levels of PA, with 82.4% doing insufficient amount (<60 minutes) of moderate- to vigorous-intensity PA daily and 59% doing insufficient amount (<3 days) of weekly vigorous-intensity PA. Previous studies in the KSA have also suggested that most of the adolescents in this country perform insufficient levels of PA. However, different studies have reported varying proportions. This is perhaps because different studies have used different definitions of insufficient PA. In our study, to define insufficient PA, we used the minimum activity threshold recommended by the WHO for the adolescents.² Al-Hazza et al¹⁵ reported that the proportion of minimally active (210-419 minutes per week) Saudi youths was 20.7%, while highly active adolescents (420 minutes

or more per week) were 31.5%. While another study by Alsubaie et al¹⁶ reported findings similar to ours with only 15.5% of the participants reported performing PA per the recommended rate (5 days and more per week) and 20.1% were physically inactive. Another study¹⁷ of 1249 Saudi male adolescents reported that 25.7% of them do not perform any PA. A cross-sectional study of 1257 health college students reported that more than half of the students are physically inactive and only 12.1% can be considered highly active.¹⁸ Other countries in the Gulf region have also reported a high proportion of physical inactivity. For instance, a study carried out among Kuwait university students revealed that the prevalence of physical inactivity was 34% among male and 55% among female.¹⁹ In a study of 600 university students in a governmental university in Egypt, approximately one-third of the participants were considered physically inactive.²⁰ In another study among Lebanese university students, approximately a quarter of the participants reported involvement in PA.²¹ The practice patterns of PA may differ in the West. In 2013, the Centers for Disease Control and Prevention in the United States reported that 15.2% of secondary school students were not involved in any PA during the week, while 36% of secondary school boys were found to practice daily PA.²² Furthermore, in a study carried out in Finland among adolescents aged 15-16 years, 23% of males and 10% of females reported receiving the recommended 60 minutes of daily moderate- to vigorous-intensity PA.²³

The high percentages of physical inactivity among Saudi students express a serious situation for Saudi adolescents' health and the overall quality of life, which should raise healthcare concerns among policymakers.

Our analysis also revealed that most adolescents (84.6%) in the Qassim region, KSA spend more than 2 hours a day watching screens such as television, computers, smartphones, and tablets for recreation. A recent survey in the United States and Thailand college students found that the excessive use of smartphones may be a reason for receiving inadequate levels of PA.²⁴

We found that state school adolescents have slightly higher odds of doing insufficient PA and having excessive recreational screen time compared to private school adolescents. However, these findings were not statistically significant. It should be noted that we had only 15% of our participants from private schools. In contrary, Al-Hazza et al¹⁵ revealed that males studying in state schools were more physically active than their counterparts in private schools. However, females in private schools were more active than those in state

schools. The study attributed these findings to the higher prevalence of overweight and obesity detected in private school students compared to their peers in state schools. In addition, adolescents who attend private schools usually belong to families with a higher socioeconomic level, which may facilitate their access to smart electronic devices such as laptops and tablets and their lack of sufficient PA. Some reports have revealed that a low socioeconomic level was associated with inadequate levels of PA.²⁵ In other studies, higher socioeconomic status has been found to be correlated with a high level of physical inactivity and a sedentary lifestyle.^{26,27}

We found no evidence of an association between academic performance and levels of PA but evidence of a significant association between adolescents' academic performance and having excessive recreational screen time, with adolescents with a very good/excellent academic performance are 2.25 times likely to spend an excessive amount of time (>2 hours daily) on any screen. In contrast, a large study among Korean adolescent students (n=75,066) revealed that boys who regularly participate in vigorous exercise 2-4 times weekly had higher odds of reaching an average or above-average academic score.²⁸ A recent study of 601 primary school students in New Zealand also showed a positive correlation between PA and academic performance among students.²⁹ Perhaps the use of devices in academic purposes leads adolescents to use the same devices for recreational purposes and they might develop dependency on these devices. However, we recommend further studies to explore this issue.

Our study found that the odds of engaging in an insufficient amount of weekly PA were higher among older adolescents. Other studies have also reported similar findings.^{15-18,30} For example, Alsubaie et al¹⁶ examined the independent predictors of PA and reported that level on PA decreased as the students' age increased. Different hypotheses were suggested to explain this correlation. For example, the high school period represents a vital stage in adolescents' lives, as they must perform well and attain high scores to get into their desired university; thus, they may tend to reduce their time spent of PA to be able to spend more time focusing on grade improvement. Another explanation is that as adolescents' age increases, their interests and lifestyle may change due to social, emotional, and psychological changes.¹⁶

Our study suggests lack of association between parents' educational attainment, adolescents' level of PA, and recreational screen time. This outcome is supported by Alsubaie et al¹⁶ and Awadalla et al¹⁸ who reported

no association between parents' education levels and the adolescents' levels of PA. Nonetheless, many studies have reported a positive association between parents' education level and the extent of adolescent PA.^{26,31-33}

Although it was expected that adolescents living in HCPs would show better PA status than those living in NHCPs, the study showed no significant differences between the 2 groups, which could be due to the nationwide implementation of PA programs that can take place in both HCPs and NHCPs. This lack of effectiveness of the HCP could also be due to the challenges it faces. In the Eastern Mediterranean region, the HCP faces various challenges despite its widespread acceptance. Challenges includes lack of institutionalization of the concepts and methodologies; lack of documentation and evidence building at the local level; and poor partnership with nongovernmental organizations, donors, UN agencies, academic and research institutions.³⁴ Nevertheless, our study findings warrant an in-depth evaluation of the process and outcomes of the HCP in the KSA. A descriptive analysis of PA initiatives in the KSA found that most of these initiatives lack objective evaluations of their outcomes.⁵

Study limitations. The main limitation of this study is that the sample population was composed of adolescents in the Qassim region high schools aged between 15 and 19 years and was not inclusive of adolescents living in other regions in KSA and those studying at different educational levels and those who aged less than 15 years or above 19 years. The study also did not consider any adolescents who were not attending school. Hence, for a thorough understanding of the PA practices of Saudi Arabian adolescents, future research should involve all adolescent groups irrespective of their schooling status.

In conclusion, the present study sheds light on the high prevalence of physical inactivity and sedentary behaviors in KSA. Based on the mounting evidence of high levels of physical inactivity and the sedentary lifestyles of Saudi adolescents, prompt interventions and novel solutions from relevant policymakers are warranted. Undoubtedly, a lack of PA has a positive association with coronary artery disease, breast tumors, premature death, type-2 diabetes mellitus, and colon cancer.¹ Schools should work closely with the Ministry of Health and the Ministry of Education to increase adolescents' awareness of the importance of physical exercise and the serious risks of being inactive. Schools should extensively involve PA in their daily routines.

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Appendix 1 - Sampling frame and sample size by city, type of school and gender.

Cities	Number of schools		Sampling frame				Sample size			
	Type	Gender	n	Total	State vs private	Total	n	Total	State vs private	Total
Onaiza	State	M	17	2786	6579	7499	4	84	198	226
		F	20	3793			4	114		
	Private	M	2	630	920	1	19	28		
		F	1	290		1	9			
Almedh nab	State	M	7	1220	2520	2755	2	37	76	
		F	7	1300			2	39		
	Private	M	1	112	235	1	3	7		
		F	1	123		1	4			
Albukayriah	State	M	5	750	1650	1818	2	23	50	
		F	6	900			2	27		
	Private	M	1	75	168	1	2	5		
		F	1	93		1	3			
Buraydah	State	M	32	6596	15857	19239	5	199	478	
		F	44	9261			5	279		
	Private	M	9	1929	3382	1	58	102		
		F	10	1453		1	44			
Alrass	State	M	8	1187	3020	3754	2	36	91	
		F	11	1833			2	55		
	Private	M	2	479	734	1	14	22		
		F	2	255		1	8			
Albadea	State	M	7	1170	2397	2532	2	35	72	
		F	7	1227			2	37		
	Private	M	1	70	135	1	2	4		
		F	1	65		1	2			
Total			203		37597		46		1133	