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The association between sedentary behavior, physical activity, and body composition in public and private school students aged 9 to 12 years

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Abstract

The study investigates the BMI-PA relation through sedentary behavior assessment among 1,500 students distributed across public (970) and private (530) school populations. The study results showed that students in public schools averaged more sedentary behavior ($p = 0.027$, ES = 0.113) and fewer physical activities ($p < 0.001$, ES = 0.268) than their peers in private schools. Students enrolled in private educational institutions experienced more cases of overweight and obesity than public school students ($p = 0.041$, ES = 0.11). In public schools, BMI decreased by -0.088 units per increase in physical activity ($p < 0.001$), yet age ($p < 0.001$), video gaming ($p < 0.001$), and laptop use ($p = 0.064$) as specific sedentary behaviors both showed BMI elevation. The combination of physical activity and BMI had a positive relationship in private schools ($B = 0.029$, $p = 0.023$), and laptop use ($B = -0.112$ to -0.125, $p < 0.001$); together with video gaming ($B = -0.105$ to -0.142, $p < 0.001$), it produced critical results for BMI. The characteristics of age ($B = -0.008$, $p = 0.543$) and physical activity levels ($B = 0.004$, $p = 0.812$) demonstrated no meaningful relationships with BMI measurements in private school settings.

Keywords: Adolescents, Body Composition, Health Behaviors, School Environments.

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1. Introduction

Public health experts identify childhood and adolescent obesity as a worldwide concern, and Saudi Arabia has become a specific area of concern because boys' obesity rates range between 10% and 43.9%, while girls' rates vary from 8.4% to

34.3% [1]. The combination of inactive lifestyles and limited physical exercise, together with dietary changes resulting from rapid urbanization and societal economic changes [2, 3], serves as a key contributors to childhood obesity. Obesity generates various medical risks, which include type 2 diabetes, hypertension, and mental health conditions affecting both self-esteem and depression [2, 4]. Observations show that parental beliefs, along with cultural beliefs, significantly impact obesity management; therefore, healthcare professionals need to create adapted programs aimed at involving family units in behavioral change toward healthier choices [5]. The prevention and treatment of obesity within this group demand a combination of community-based initiatives and personal engagement, as this approach has proven successful in medical research [3, 4].

Childhood acts as a fundamental life stage for developing health behaviors that will last forever, and this includes body mass index (BMI), which results from multiple contributing elements such as dietary choices, exercise patterns, and social class standing. Studies show that children from households with highly educated parents typically have lower BMI because these parents promote healthy eating behaviors and encourage participation in physical activity [6]. The practice of using food to calm children results in higher BMI scores, and maternal weight status directly affects BMI-for-age z-scores in young children [7]. The relationship between overeating and childhood BMI exists in both directions because adverse childhood experiences (ACEs) and socioeconomic disadvantages make children more prone to weight gain [8, 9]. Studies show that early-life interventions should address these risk factors to prevent both short-term health problems associated with childhood obesity and psychiatric disorders that later develop from obesity [10]. It is essential to handle various environmental factors because they shape children's weight development pathways positively.

Educational institutions play an essential part in developing these behaviors because they provide an organized space that allows effective intervention implementation. The post-growth period demands a nutritious diet, which helps physical abilities and mental development, according to research from [11]. Data shows that adolescent BMI decreases with increased parental education levels because parents with higher education play a significant role in determining adolescent food decisions and physical activity routines [6]. Structured physical activity interventions at schools produce moderate results regarding BMI management, which shows that controlled programs minimize obesity risks, according to Tanous [12]. Research shows that multifactorial lifestyle interventions featuring educational content with physical activity achieve superior health quality outcomes beyond what exercise offers, yet struggle to impact body mass index values right away [13]. Fundamental strategies combining resources from schools, families, and community resources must undergo implementation to promote healthy adolescent behaviors [14].

Population-level differences between public and private institutions in Saudi Arabia strongly affect how adolescents practice physical activity as well as their BMI measurement statistics. Known limitations in government funding restrict public schools from providing sufficient sports facilities and organized physical education sessions, but private schools maintain better resources for athletics and sports programs, according to Aldukair et al. [15] and AlMarzooqi et al. [16]. Research suggests that insufficient physical activity exists in 79% of adolescents between 15 and 29, which raises obesity levels [15]. Female sports participation faces numerous challenges within Saudi sports initiatives despite the Saudi government dedicating its Vision 2030 to physical activity promotion [17]. Current research regarding the BMI impact of school settings needs more investigation to develop appropriate intervention strategies that can help Saudi adolescents achieve healthier lifestyles [15, 17].

Physical activity (PA) and sedentary behavior (SB) are critical determinants of adolescent health and body composition, with regular exercise linked to improved cardiovascular health, muscle strength, and mental well-being, while excessive screen time correlates with increased body fat and metabolic risks [18, 19]. Unique Saudi Arabian cultural and environmental elements, including gender-educated schooling and scarce open-air workout areas, make analyzing the links between PA, SB, and body mass index (BMI) much more challenging [20, 21]. Research data shows that sedentary behaviors create a 30% increased obesity risk for adolescents, so interventions must account for cultural contexts [18]. Studies have demonstrated that physical activity elevation successfully counteracts the negative health effects of sitting time, which leads to better wellness results, particularly among people with elevated BMI [22]. Effective strategies for promoting adolescent health need to account for these factors in various cultural locations because of their importance [21].

This research examined how students in public and private educational institutions of Al-Hasa governorate within Saudi Arabia's eastern province reacted to their physical activity levels, together with their sedentary behavior scores regarding their Body Mass Index measurements. This research investigated three principal objectives, including how age, together with PA levels, as well as SB scores and BMI, relate; how these connections differ between public and private school students; and the impact of sedentary activities, including television viewing, laptop usage, gaming, and smartphone use, on BMI measurements. The study aimed to reach its goals by analyzing BMI change patterns with behavioral factors to establish preventive methods against obesity.

2. Material and Methods

2.1. Participants

The research employed random selection of ten public schools, along with private schools located within Al-Ahsa Governorate, Eastern Province, Saudi Arabia. The study divided its selected schools into five geographic regions named Eastern, Western, Central, Northern, and Southern regions, and chose two schools from each of these areas. The research selected two classrooms per grade level in every school through random processes and enrolled student populations ranging from 16 to 30 students per classroom. Participation in this project was encouraged for all students; however, certain exclusion criteria prevented specific students from joining, including those who were absent from physical education classes and those with medical conditions or who could not meet study requirements or obtain parental permission. The initial assessment of

1,525 students required parental consent approval. Initial screening eliminated 25 participants because they had obesity, chose not to join the study, or dropped out, thus leaving 1,500 students to complete all required tests. The study team delivered explicit, detailed information about the research to participants and their parents regarding its goals and methods, accompanied by possible risks and advantages. Prior to obtaining study participation from children aged 9 to 12, both parents provided consent for their child to participate. The Ethics Committee of the Deanship of Scientific Research at King Faisal University granted permission for the ethical implementation of the study under KFU-REC-2024-FEB-ETHICS1935.

2.2. Protocol

Physical education classes operated as the foundation from which students obtained data using assessment questionnaires and measurements of anthropometric characteristics. Student participation in physical activities and sedentary behaviors was evaluated throughout all segments of the survey. Primary data collection in the first stage obtained vital demographic statistics that included student gender, together with their grade levels and ages. The research utilized the PAQ-A that established itself through translation from the Physical Activity Questionnaire for Adolescents (PAQ-A), which Kowalski et al. [23] initially developed to gather data from fifth through seventh grade students. The NSW Schools Physical Activity and Nutrition Survey served as the measurement tool for determining SBs in the third part of this research [24]. The researchers provided detailed instructions about questionnaire protocol accuracy and guidelines that participants needed to follow a two-hour restriction on food and beverage consumption and twenty-four hours without vigorous physical activity. At first, students needed to empty their bladders. Physical education instructors implemented measurements in classrooms that maintained air-conditioner-controlled environmental temperatures.

2.3. Outcomes

2.3.1. Anthropometry

A Holtain stadiometer from Crymych, Wales, UK served for height measurements. The participants were positioned with straight-body postures while barefoot with feet touching each other and arms hanging naturally at their sides before being positioned with their heads aligned with the Frankfort horizontal plane. All height data obtained through measurements were recorded with a precision of 0.1 cm. The Omron Body Composition Monitor BF508 (Japan) used bioelectrical impedance analysis (BIA) to determine Body weight, Body Mass Index (BMI), and Percentage of Body Fat (PBF) through tests that included measurements with the handheld sensors and placement on the electrodes while participants stood barefoot. The participants performed impedance measurements by standing barefoot on the electrodes while using the handheld sensors under the supervision of the device. The measurements recorded weight with an accuracy of 0.1 kg, while BMI calculations divided weight by height squared (m^2). The methodology involved determining fat mass through the product of total body weight (kg) and PBF, followed by estimating fat-free mass by subtracting FM from total body weight to achieve specific and accurate measurements for anthropometric and body composition detections.

2.4. Physical Activity Levels

The Physical Activity Questionnaire for Adolescents (PAQ-A) Arabic version acted as the assessment tool for physical activity levels, while [25] adapted it for Saudi contexts. The self-administered PAQ-A questionnaire allows users to report on their physical activity participation across seven days. The instrument includes all activities occurring at various times, such as recesses and afterschool hours, and physical education classes, in addition to weekend functions. The survey contains nine questions measured through a five-point Likert scale from 1 (low activity) to 5 (high activity) for items 1 through 8. Descriptive Item 9 is excluded from the scoring process. The mean score computation from items 1 through 8 creates a comprehensive indicator for physical activity measurement. The study utilized mean scores to determine five activity levels: Extremely inactive (mean score < 1.8), Inactive (mean score between 1.8 – 2.6), Fairly active (mean score between 2.6 – 3.4), Active (mean score between 3.4 – less than 4.2) and highly active (mean score ≥ 4.2). The classifying system enables researchers to analyze adolescent physical activity behavior patterns comprehensively, which reveals the extent of inactive activities together with active behaviors in Saudi Arabia. The PAQ-A serves as a dependable tool for physical activity assessment because it provides a relevant measurement for cultural evaluations while matching global standards to specific local needs.

2.5. Sedentary Behaviors

The assessment of sedentary behavior (SB) utilized the New South Wales (NSW) Schools Physical Activity and Nutrition Survey [24] that Said et al. [25] modified for Saudi conditions and translation purposes. This study evaluated four major sedentary behaviors by measuring (1) screen time usage of mobile phones and laptops, and tablets, (2) television viewing or movie watching and (3) digital music listening, and (4) gaming activities on different devices. Each participant reported how they spent time on daily activities through a five-point scoring system that measured time allocation as follows: Less than thirty minutes received a score of 5, thirty to sixty minutes scored 4, and one to two hours received a score of 3, participants who spent two to four hours scored 2 points while spending more than four hours earned a score of 1. The composite sedentary behavior score evaluated four activities through an average calculation. Higher scores related to lower sedentary durations, while lower scores indicated greater sedentary activities. A score range from 1 to 5 showed a 1 ranking for maximal sedentary habits, yet 5 indicated minimum sedentary duration. The applied methodology establishes a precise and standardized measure of sedentary behavior to allow a complete assessment of sedentary activities in the Saudi population. Survey adaptations added cultural meaning to the assessment process without altering its research compatibility at the international level.

2.6. Statistical Analysis

The assessment of distribution normality included both the construction of histograms and measurements of absolute skewness and kurtosis values. The evaluation of non-normality considered values with |skewness| > 2 and |kurtosis| > 7. The study used descriptive statistics to analyze participant characteristics, which were represented by mean value plus or minus standard deviation (SD). Students' t-tests evaluated differences in public and private school participants through tests of homogeneity of variance and normality because their data met these critical assumptions. The research used Cohen's d-effect size calculations to interpret findings where small effects existed at 0.2 and medium and large effects warranted values above 0.5 and 0.8, respectively. The VIF values checked in at less than 5, thus verifying there is no multicollinearity between predictors. Tests for residual analysis, together with diagnostic methods, revealed heteroscedasticity within the gathered data. Specialized linear modeling structures that utilized the gamma distribution with Log transformation enabled precise analysis of different variables' effects on body mass index (BMI). A complete SB score was analyzed as an independent variable using Model 1, and Model 2 evaluated several distinct SB subcomponents. The research examined BMI determinants by using statistical models that managed potential influencing elements. The statistical significance threshold set at $p < 0.05$, accompanied by IBM SPSS Statistics Version 26 as the software tool to perform all analyses (IBM Corp., Armonk, NY, USA). The extensive analytical procedure strengthened both the reliability and robustness of the obtained results.

3. Results

3.1. Participants' Characteristics

Table 1 shows pronounced differences in physical measurements between public school students and their counterparts at private institutions as it presents complete data about their age and body sizes. The physical characteristics of public-school children contrasted sharply with private school students because public schoolers had greater height (p < 0.001, ES = 0.71), older age (p < 0.001, ES = 0.48) and higher anthropometric measures (p < 0.001, ES = 0.34). Public school students exceeded private school peers with mean ages of 11.01 years versus 10.02 years, and heights of 151.23 cm versus 142.10 cm and weights of 46.85 kg versus 41.30 kg, respectively. Private school students showed a slightly higher BMI than public school students based on the results (p = 0.041, ES = 0.11). Their BMI mean values were 20.48 kg/m² versus 19.85 kg/m² and revealed higher rates of overweight at 17% versus 10.9% and obesity at 28.4% versus 26%. Private school students showed higher percentage body fat measures (PBF) compared to their government school peers (p = 0.001, d = 0.25). Their average PBF stood at 15.70% while their counterparts measured 14.15% PBF. The groups exhibited similar levels of fat mass (p = 0.748, d = 0.02), indicating no statistical difference in total fat quantification despite observing different parameters. The research data indicates that social economics standing together with dietary routines along with life patterns affects how individuals develop physically, specifically through body structure and physical growth.

Table 1.
Evaluated participant populations of different school types based on their age and anthropometric measurements.

Variable	Group	N	Mean	SD	Public Vs. Private		
					t	**P**	**ES**
Age (years)	Public	970	11.01	1.8	4.56	<0.001	0.48
	Private	530	10.02	2.2			
	Total	1500	10.7	1.9			
Height (cm)	Public	970	151.23	15.20	12.12	<0.001	0.71
	Private	530	142.10	9.54			
	Total	1500	147.75	13.32			
Weight (kg)	Public	970	46.85	17.10	5.87	<0.001	0.34
	Private	530	41.30	12.60			
	Total	1500	44.58	14.75			
BMI (kg/m^2)	Public	970	19.85	4.85	2.05	0.041	0.11
	Private	530	20.48	5.40			
	Total	1500	20.12	5.08			
PBF (%)	Public	970	14.15	5.75	4.48	0.001	0.25
	Private	530	15.70	6.50			
	Total	1500	14.68	6.10			
Fat mass (kg)	Public	970	7.40	5.70	0.32	0.748	0.02
	Private	530	7.30	5.85			
	Total	1500	7.36	5.75			
Fat-free mass (kg)	Public	970	39.45	12.30	8.25	<0.001	0.50
	Private	530	34.00	7.65			
	Total	1500	37.55	11.20			

Note: SD, standard deviation; BMI, body mass index; PBF, percentage body fat; FF, Fat mass ; FFM, Fat-free mass ; ES, Effect Size.

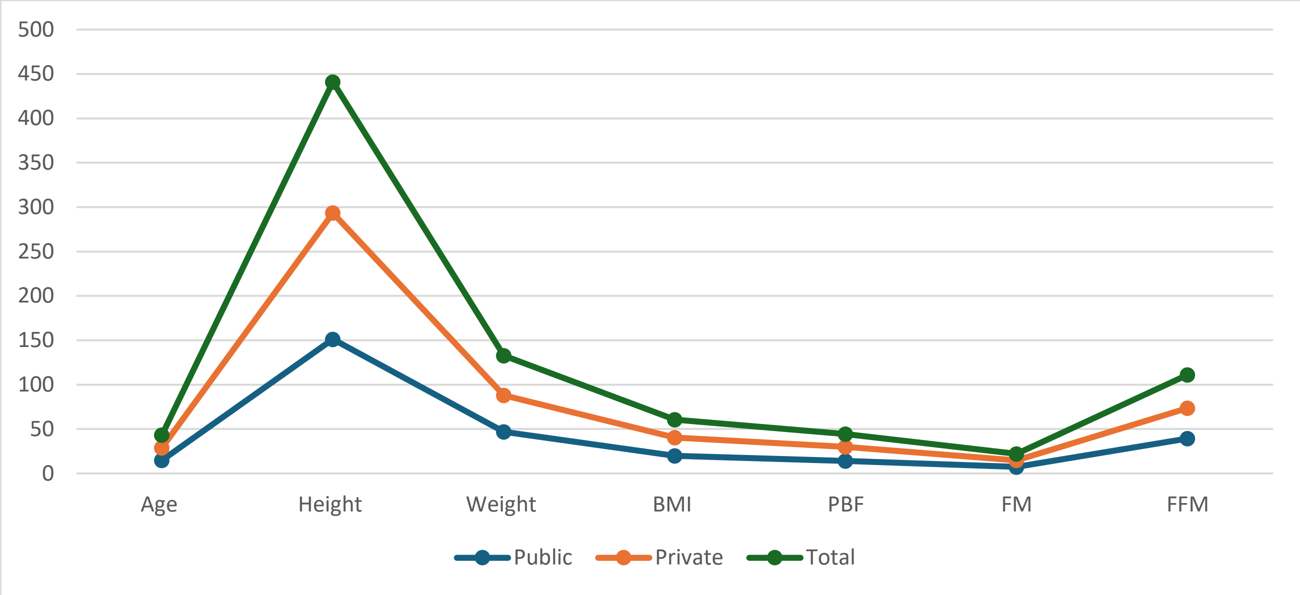

Figure 1.
Means of variables by school type.

The average physical activity level of public-school students amounted to 2.43 (SD = 0.78). Private school students showed a nearly average physical activity level of 2.65 (SD = 0.70) above their public-school counterparts. PA measurements between public and private school students showed a meaningful difference to the extent that private school students displayed increased physical activity levels ($p < 0.001$, Cohen's d = 0.268). The average score for school-based physical activity among public school students equated to 2.92 (SD = 0.88). Private school students registered an average score of 2.81 (SD = 0.92) when measuring their sedentary behavior status. Public school students demonstrated greater sedentary behavior participation according to a significant statistical evaluation ($p = 0.027$, Cohen's d = 0.113). Television Viewing (TV): Public school students: M = 2.75 (SD = 1.49). Private school students: M = 3.01 (SD = 1.35). Private school students television viewing exceeded that of public school students television viewing based on statistical analysis ($p = 0.004$, Cohen's d = 0.147). Laptop Use: Public school students: M = 2.61 (SD = 1.52). Private school students: M = 2.80 (SD = 1.43). Differences between public and private school use of laptops proved significant at $p = 0.015$ and displayed Cohen's d = 0.135. Video Gaming: Public school students: M = 2.98 (SD = 1.55). Private school students: M = 2.78 (SD = 1.36). The time public school students dedicated to video gaming differed substantially from private school students ($p = 0.012$, Cohen's d = 0.129). Mobile Phone Use: Public school students: M = 3.35 (SD = 1.47). Private school students: M = 2.75 (SD = 1.39). Results established a strongly meaningful relationship ($p < 0.001$, Cohen's d = 0.425), which revealed that public school students used mobile phones to a significantly great extent.

Table 2.
The mean value and standard deviation measurements from participants about physical activity levels and sedentary behavior split by school type.

Variable	Group	N	Mean	SD	Public Vs. Private		
					T	P	Cohen's D
Physical activity level	Public	970	2.43	0.78	5.28	<0.001	0.268
	Private	530	2.65	0.70			
	Total	1500	2.50	0.75			
Sedentary behaviors score	Public	970	2.92	0.88	2.21	0.027	0.113
	Private	530	2.81	0.92			
	Total	1500	2.88	0.90			
TV score	Public	970	2.75	1.49	2.89	0.004	0.147
	Private	530	3.01	1.35			
	Total	1500	2.88	1.46			
Laptop score	Public	970	2.61	1.52	2.45	0.015	0.135
	Private	530	2.80	1.43			
	Total	1500	2.71	1.49			
Video-games score	Public	970	2.98	1.55	2.52	0.012	0.129
	Private	530	2.78	1.36			
	Total	1500	2.89	1.48			
Mobile score	Public	970	3.35	1.47	8.12	<0.001	0.425
	Private	530	2.75	1.39			
	Total	1500	3.12	1.44			

Note: SD, standard deviation.

3.2. Influencing Participants' BMI Based on School Type

3.2.1. Public school

The GLM analyses produced results which showed both physical activity (PA) levels and sedentary behavior (SB), and student age and BMI were linked statistically to public school student populations. The models fit well with values of deviance and Pearson Chi-Square being close to their corresponding degrees of freedom (Model 1: Deviance = 38.456, df = 950, Pearson Chi-Square = 41.289, df = 950; Model 2: Deviance = 36.789, df = 930, Pearson Chi-Square = 39.456, df = 930). The fitted models achieved superior performance than the intercept-only model according to likelihood ratio chi-square tests (Model 1: Chi-Square = 145.345, df = 3, $p < .001$, Model 2: Chi-Square = 190.456, df = 20, $p < .001$). Statistically speaking, information criteria from both models reinforced their appropriateness (Model 1: AIC = 4415.912, BIC = 4432.456, Model 2: AIC = 4423.356, BIC = 4528.765).

According to Model 1, both PA levels (B = -0.088, $p < .001$) and older age (B = 0.030, $p < .001$) and higher SB scores (B = 0.038, $p < .001$) correlated with BMI changes. The substitution of the overall SB score with specific sedentary activities in Model 2 did not reduce the relation between physical activity levels and BMI (B = -0.085, $p < .001$). The use of video games yielded the most robust connection to BMI among SB activities since players who spent more than 4 hours daily recorded higher BMI results (Not at all: B = -0.110, $p < .001$; 30 min–1 h/day: B = -0.115, $p < .001$). Student BMI decreased when laptop usage reached 1–2 hours per day ([Laptop use = 1–2 h/day]: B = -0.052, $p = .064$). The research observed that students who spent fewer than thirty minutes watching TV possessed lower BMIs in comparison to students spending more than four hours (B = -0.048, $p = .108$). Results show that BMI management through PA enhancement and screen time regulation, specifically at 1 to 4 hours, is becoming important for public school student weight control (Table 3).

Table 3.
parameter values associated with BMI predictors for public schools.

Model 1				
Metric	**Value**	**df**	**Value/df**	**Sig.**
Goodness of Fit				
Deviance	38.456	950	0.040	-
Scaled Deviance	895.342	-	-	-
Pearson Chi-Square	41.289	950	0.043	-
Scaled Pearson Chi-Square	987.654	-	-	-
Log Likelihood	-2201.456	-	-	-
AIC	4415.912	-	-	-
BIC	4432.456	-	-	-
Omnibus Test				
Likelihood Ratio Chi-Square	145.345	3		<0.001
Parameter Estimates	B	Std. Error	95% Wald CI	Sig.
(Intercept)	2.680	0.082	[2.519, 2.841]	<0.001
Age (years)	0.030	0.006	[0.018, 0.042]	<0.001
PA levels	-0.088	0.011	[-0.110, -0.066]	<0.001
SB score	0.038	0.009	[0.020, 0.056]	<0.001
(Scale)	0.042a	0.003	[0.036, 0.048]	-
Model 2				
Metric	Value	df	Value/df	Sig.
Goodness of Fit				
Deviance	36.789	930	0.039	-
Scaled Deviance	898.765	-	-	-
Pearson Chi-Square	39.456	930	0.042	-
Scaled Pearson Chi-Square	985.345	-	-	-
Log Likelihood	-2185.678	-	-	-
AIC	4423.356	-	-	-
BIC	4528.765	-	-	-
Omnibus Test				
Likelihood Ratio Chi-Square	190.456	20	-	<0.001
Parameter Estimates	B	Std. Error	95% Wald CI	Sig.
(Intercept)	3.150	0.042	[3.068, 3.232]	<0.001
Age (years)	0.033	0.007	[0.019, 0.047]	<0.001
PA levels	-0.085	0.012	[-0.109, -0.061]	<0.001
[TV viewing = <30 min/day]	-0.048	0.030	[-0.107, 0.011]	0.108
[TV viewing = > 4 h/day]	0a			
[Laptop use = 1–2 h/day]	-0.052	0.028	[-0.107, 0.003]	0.064
[Laptop use = >4 h/day]	0a			
[Video games = Not at all]	-0.110	0.035	[-0.179, -0.041]	<0.001

[Video games = <30 min/day]	-0.120	0.030	[-0.179, -0.061]	<0.001
[Video games = 30 min–1 h/day]	-0.115	0.027	[-0.168, -0.062]	<0.001
[Video games = 1–2 h/day]	-0.065	0.025	[-0.114, -0.016]	0.009
[Video games = 2–4 h/day]	-0.060	0.024	[-0.107, -0.013]	0.012
[Video games = >4 h/day]	0a			
(Scale)	0.040b	0.003	[0.034, 0.046]	-

Note: CI, confidence interval; PA, physical activity; SB, sedentary behavior. [a], set to zero because this parameter is redundant; [b], maximum likelihood estimate.

3.3. Private School

The satisfactory model fit for both conceptual models emerged when analyzing private school students because their deviance and Pearson Chi-Square results corresponded closely to their corresponding degrees of freedom (Model 1: Deviance = 22.457, df = 518, Value/df = 0.043; Pearson Chi-Square = 24.678, df = 518, Value/df = 0.048; Model 2: Deviance = 20.345, df = 500, Value/df = 0.041; Pearson Chi-Square = 22.123, df = 500, Value/df The results of likelihood ratio chi-square tests indicated both proposed models beat the intercept-only model (Model 1: Chi-Square = 10.456, df = 3, p = 0.015; Model 2: Chi-Square = 65.456, df = 18, p < 0.001) and information criteria validated the examined models (Model 1: AIC = 2418.690, BIC = 2435.456; Model 2: AIC = 2426.912, BIC = 2502.345).

The relationship between BMI and age, along with physical activity levels, proved insignificant using the data collected (Age: B = -0.012, p = 0.312; PA Levels: B = -0.015, p = 0.354). Research showed that BMI scores bore a significant positive statistical link with sedentary behavior scores (B = 0.029, p = 0.023). The substitution of the whole SB score with individual sedentary activities in Model 2 showed that age was still insignificant (B = -0.008, p = 0.543) and physical activity levels maintained their non-significance (B = 0.004, p = 0.812). BMI demonstrated important relationships with two specific sedentary activities, including laptop use and video gaming. The use of laptops for less than thirty minutes per day (B = -0.112, p = 0.003) and for half an hour to one hour per day (B = -0.087, p = 0.015) and one to two hours per day (B = -0.125, p < 0.001) all had negative relationships with BMI measurements. The duration spent on video gaming showed parallel negative associations at various points (Not at all: B = -0.105, p = 0.008; <30 min/day: B = -0.118, p = 0.002; 30 min–1 h/day: B = -0.142, p < 0.001; 1–2 h/day: B = -0.085, p = 0.024). Analysis of BMI measurements through both TV viewing and mobile phone use was not significant. Research data confirms that BMI management requires focused intervention on laptop usage and video gaming behaviors in order to help private school students (see Table 4).

Table 4.
Parameter estimates for predictors of private schools' BMI.

Model 1				
Metric	**Value**	**df**	**Value/df**	**Sig.**
Goodness of Fit				
Deviance	22.457	518	0.043	-
Scaled Deviance	498.321	-	-	-
Pearson Chi-Square	24.678	518	0.048	-
Scaled Pearson Chi-Square	512.456	-	-	-
Log Likelihood	-1205.345	-	-	-
AIC	2418.690	-	-	-
BIC	2435.456	-	-	-
Omnibus Test				
Likelihood Ratio Chi-Square	10.456	3	-	0.015
Parameter Estimates	B	Std. Error	95% Wald CI	Sig.
(Intercept)	3.012	0.050	[2.914, 3.110]	<0.001
Age (years)	-0.012	0.012	[-0.035, 0.011]	0.312
PA levels	-0.015	0.016	[-0.046, 0.016]	0.354
SB score	0.029	0.013	[0.004, 0.054]	0.023
(Scale)	0.045a	0.004	[0.037, 0.053]	-
Model 2				
Metric	Value	df	Value/df	Sig.
Goodness of Fit				
Deviance	20.345	500	0.041	-
Scaled Deviance	497.654	-	-	-
Pearson Chi-Square	22.123	500	0.044	-
Scaled Pearson Chi-Square	505.345	-	-	-
Log Likelihood	-1189.456	-	-	-
AIC	2426.912	-	-	-
BIC	2502.345	-	-	-
Omnibus Test				
Likelihood Ratio Chi-Square	65.456	18	-	<0.001

Parameter Estimates	B	Std. Error	95% Wald CI	Sig.
(Intercept)	3.189	0.052	[3.087, 3.291]	<0.001
Age (years)	-0.008	0.013	[-0.033, 0.017]	0.543
PA levels	0.004	0.017	[-0.029, 0.037]	0.812
[Laptop use = <30 min/day]	-0.112	0.038	[-0.186, -0.038]	0.003
[Laptop use = 30 min–1 h/day]	-0.087	0.036	[-0.157, -0.017]	0.015
[Laptop use = 1–2 h/day]	-0.125	0.039	[-0.201, -0.049]	<0.001
[Laptop use = >4 h/day]	0a			
[Video games = Not at all]	-0.105	0.040	[-0.183, -0.027]	0.008
[Video games = <30 min/day]	-0.118	0.038	[-0.192, -0.044]	0.002
[Video games = 30 min–1 h/day]	-0.142	0.037	[-0.214, -0.070]	<0.001
[Video games = 1–2 h/day]	-0.085	0.038	[-0.159, -0.011]	0.024
[Video games = >4 h/day]	0a			
(Scale)	0.041b	0.004	[0.033, 0.049]	-

Note: CI, confidence interval; PA, physical activity; SB, sedentary behavior. [a], set to zero because this parameter is redundant; [b], maximum likelihood estimate.

4. Discussion

The study on Body Mass Index (BMI) among students in Al-Hasa, Saudi Arabia, highlights the significant impact of physical activity levels and sedentary behaviors on BMI across different educational settings. Studies show higher BMI results from people who watch TV and use laptops since these screen activities lead to physical inactivity and excessive calorie intake [26]. The BMI changes of both students and boys in secondary school demonstrate higher values than other educational levels or gender demographics [27, 28]. The study shows that weight-related interventions ought to focus on reducing sedentary lifestyle while boosting physical activity because these factors primarily affect health results across public school environments versus private institutions [25, 29].

Research findings show that physical activity and sedentary behavior, alongside body mass index, vary based on school-age children's ages within different educational institutions. According to research public school students demonstrate a positive relationship between higher sedentary behavior scores and increased BMI numbers as children grow older [6]. Excessive television screen time above four hours per day commonly leads to higher BMI, but monitoring television for less than half an hour results in lower BMI [30]. Research shows that increased physical activity, particularly through longer physical education classes, helps lower BMI, which indicates organized physical activity helps prevent weight gain according to Ługowska et al. [30]. Research demonstrates that BMI levels rise when children spend long periods of time playing video games or using laptops, but findings about smartphone usage effects produce conflicting results [31, 32]. Increased physical activity together with decreased sedentary behavior represent essential methods for controlling BMI in children.

School-aged children demonstrate different connections between physical activity (PA), sedentary behavior (SB), and body mass index (BMI) based on their attendance at private or public institutions. The relationship between moderate-to-vigorous physical activity and BMI differs between public and private schools because private school students lack this significant correlation [33, 34]. Research demonstrates that private school students face higher risks of overweight and obesity since 27.5% of boys and 18.4% of girls in these institutions meet the criteria for being overweight [34]. An increase in screen usage involving laptops and video games tends to raise BMI levels, similarly to what public school statistics show [33]. BMI values of private school students are heavily influenced by their dietary practices and recreational options, and academic demands, which transcend the impact of physical activity [35, 36].

The physical activity situations in educational settings directly shape adolescent obesity levels alongside their opportunities for exercise because public and private school environments show different outcomes. The poor resources, insufficient food programming, and limited physical education access at public schools drive public school students towards obesity and overweight [37, 38]. Research studies, including Saudi Arabian surveys, show that youth obesity increases due to improper nutrition habits and deficient physical activity [37]. Children from lower socioeconomic backgrounds face limited access to sports and physical activity, which causes health inequality to become worse [39]. Research demonstrates the urgent requirement for specific programs that promote both health-promoting settings and impartial access to physical activity facilities in academic institutions [40, 41].

BMI changes according to different sedentary behaviors because each behavior brings unique activity characteristics together with specific behavioral traits. Watching television with smartphone use generates double effects that lead to both longer inactive intervals and greater food advertisement exposure, which then triggers unhealthy eating patterns and reduced energy output for obesity risk [42, 43]. Video game players spend more time in the game, but their inactive state while doing demanding mental work causes their BMI to remain mostly unaffected. Science confirms that teenage obesity develops from excessive smartphone use, yet suggests that video gaming leads to fewer obesity cases, specifically in young users [43]. Targeted interventions that reduce screen time usage, together with physical activity promotion programs, help minimize the obesity risks experienced by young people [44, 45]

Several environments along with social elements, affect how people exercise and eat in urban areas, particularly in the Al-Ahsa region. The rise in urbanization has made high-calorie foods more obtainable, which contributes to the increase of obesity statistics because cities primarily support sedentary living through screen entertainment and vehicle-dependent mobility systems [46, 47]. The weather of Al-Ahsa poses severe challenges for outside activities and these limitations worsen due to poor access to exercise facilities and public parks, according to Ruel et al. [46]. Residents of rural areas face steep academic pressure together with strong cultural traditions which push them to place intellectual studies before physical exercise, according to Ruel et al. [46 and Congdon [47]. Mandatory policies combining ecological and economic variables with cultural elements are essential to improve health through proper nutrition and exercise because these factors shape well-being [48, 49].

Many challenges exist that limit the success of school-based programs that aim to increase physical activity among students. The implementation of physical education in Saudi Arabian schools faces obstacles from conservative opponents and optional enrollment which reduces its effectiveness [50, 51]. Studies show the school environment maintains substantial impact on child health because elements like building designs and green spaces impact physical activity rates [50, 52]. The lack of suitable facilities as well as unsafe outdoor areas during extreme weather conditions, makes it difficult for people to participate in physical activity [52]. The failure of evidence-based interventions occurs from poor execution strategies despite their demonstrated effectiveness in increasing physical activity and reducing obesity, according to Lee et al. [51]. PA engagement decreases because schools fail to establish sports programs or extracurricular activities that provide comprehensive sporting opportunities for every student [53]. Students' physical and mental well-being substantially depends on the school environment, which operates as a community yet faces continuous barriers from systemic factors [54]. Creating an active and supportive school environment demands a holistic strategy that unites environmental development with students' perceptions along with their behaviors [52, 54].

4.1. Study Limitations

The findings generate vital knowledge, which aids healthy lifestyle promotion and body composition factor comprehension among teenage populations. The research contains various constraints that must be noted. The cross-sectional design restricts researchers from making conclusions about the causal relationships among physical activity levels and SB scores, and BMI. Future research using longitudinal techniques will establish temporal sequencing and establish causal connections. An inherent problem exists in this study because students may make inaccurate reports about their activities and screen-based behaviors when using self-report methods. Accurate measurements would become possible through the adoption of objective instruments such as accelerometers. The study failed to implement confounding factor control methods for dietary intake alongside social status and genetic personal risk factors that influence BMI measurements. The specific region included in the study restricts how widely the research findings can be used to understand physical activity levels among the larger student population.

5. Conclusions

The research examines how students from public and private schools relate body mass index to their physical activity levels, subject-based barometers, and their chronological age. The study analysis demonstrates that public school students' age-related BMI increases because older students log higher BMI measurements. This group needs effective BMI management through increased physical activity and decreased sedentary behavior due to the proven BMI relationship with long television viewing time, laptop use, and video games. The examination revealed no meaningful relationship among private school students between age, physical activity levels, and body mass index. Additional screen-based activities did not signal a uniform change in BMI results; yet, overall screen-based activity ratings predicted BMI increase, while increased laptop and gaming time produced more significant BMI results. The present research data shows that schools must implement specific intervention programs to decrease screen time inside their premises. Research on this student population reveals that age, physical activity levels, and BMI do not create meaningful correlations, thus demonstrating that other societal elements, such as dietary choices, need consideration when analyzing these relationships. The data demonstrates that intervention strategies need to develop approaches specified for each unique set of student behaviors based on their educational environments. Schools provide essential obesity prevention through targeted policies that support physical activity, control sedentary behavior, and manage dietary components alongside socioeconomic variables. The attainment of enduring success depends on strengthening initiatives by enhancing infrastructure along with community participation.

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