Active but not alone: dietary and sleep patterns cluster with physical activity in adolescents

Activos, pero no solos: los patrones de alimentación y sueño se agrupan con la actividad física en adolescentes

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Abstract

Introduction: Adolescence is a period for establishing health behaviors that influence future health outcomes. This study aimed to examine the lifestyle-related correlates of moderate-to-vigorous physical activity (MVPA) among Portuguese adolescents.
Methods: A sample of 1117 students (489 boys; 628 girls), aged 12 to 18 years, from primary and secondary schools in northern Portugal, completed a self-administered online questionnaire. The questionnaire assessed socio-demographic factors, sedentary time, and perceived physical health. Binary logistic regression was used to estimate associations with sufficient MVPA (≥300 min/week).
Results: Greater sedentary time (OR: 0.999 [95%CI: 0.998 to 1.000]; p=0.047) and longer sleep duration (OR: 0.997 [95%CI: 0.995 to 1.000]; p=0.034) were weakly associated with lower odds of meeting MVPA recommendations, whereas higher vegetable and white meat consumption were positively associated with sufficient MVPA. In contrast, more frequent consumption of vegetables (OR: 1.132 [95%CI: 1.038 to 1.234]; p=0.005) and white meat (OR: 1.210 [95%CI: 1.075 to 1.362]; p=0.002) were positively associated with sufficient PA levels.
Conclusion: The study suggests that healthier dietary habits are associated with sufficient physical activity among Portuguese adolescents. These findings reinforce the need for integrated, school-based health promotion strategies that target multiple lifestyle domains to support adolescent well-being and reduce future health risks.

Keywords

Adolescent behavior, health and well-being, lifestyle factors, non-communicable diseases, public health policies.

Resumen

Introducción: La adolescencia representa un periodo para el establecimiento de conductas relacionadas con la salud que influyen en los resultados de salud futuros. Este estudio tuvo como objetivo examinar los correlatos relacionados con el estilo de vida de la actividad física moderada a vigorosa (AFMV) en adolescentes portugueses.
Métodos: Participaron 1117 estudiantes (489 varones; 628 mujeres), de entre 12 y 18 años, procedentes de escuelas primarias y secundarias del norte de Portugal, quienes completaron un cuestionario en línea autoadministrado. El cuestionario evaluó factores sociodemográficos, tiempo sedentario y percepción de la salud física. Se utilizó regresión logística binaria para estimar las asociaciones con niveles suficientes de AFMV (≥300 min/semana).
Resultados: Un mayor tiempo sedentario (OR: 0.999 [IC95%: 0.998–1.000]; p=0.047) y una mayor duración del sueño (OR: 0.997 [IC95%: 0.995–1.000]; p=0.034) se asociaron débilmente con menores probabilidades de cumplir las recomendaciones de AFMV, mientras que un mayor consumo de verduras (OR: 1.132 [IC95%: 1.038–1.234]; p=0.005) y de carne blanca (OR: 1.210 [IC95%: 1.075–1.362]; p=0.002) se asoció positivamente con niveles suficientes de AFMV.
Conclusión: El estudio sugiere que unos hábitos alimentarios más saludables se asocian con niveles suficientes de actividad física entre los adolescentes portugueses. Estos hallazgos refuerzan la necesidad de estrategias integradas de promoción de la salud en el ámbito escolar, dirigidas a múltiples dominios del estilo de vida, para apoyar el bienestar adolescente y reducir futuros riesgos para la salud.

Palabras clave

Comportamiento adolescente, enfermedades no transmisibles, factores del estilo de vida, políticas de salud pública.

Introduction

Adolescence is characterized by profound biological, psychological, and social changes that influence health behaviors (Al-Hazzaa et al. 2026). However, it is also a critical phase concerning Physical Activity (PA), with systematic reviews indicating a decline in PA levels, particularly during adolescence (Carvalho et al. 2023; Dumith et al. 2011).

While adolescence is deemed healthy, many non-communicable diseases later in life stem from modifiable risk behaviors established during this period, such as smoking, unhealthy dietary patterns, and low PA levels (Aubert et al. 2018; Çal et al. 2026). Despite the known benefits, global trends indicate that most adolescents do not engage in sufficient levels of MVPA, as recommended by the WHO (at least 60 minutes per day) (Guthold et al. 2020). In Portugal, similar patterns have been observed, raising public health concerns regarding youth health behaviors and their determinants (Mota et al. 2008).

Several biological and environmental factors can influence MVPA in adolescents. These include age, sex, body mass index (BMI), biological maturation, eating habits, sleep duration, and sedentary time. These behaviors and characteristics may interact within broader lifestyle patterns rather than operate independently (Nilufar & Fazilat, 2024). For example, higher physical activity has been associated with healthier dietary choices and more favorable lifestyle profiles among adolescents, whereas sedentary behavior and sleep may compete with or coexist alongside daily movement behaviors (Al-Hazzaa et al. 2026). Considering these factors simultaneously may therefore provide a more comprehensive understanding of the characteristics associated with meeting MVPA recommendations.

The Lancet Commission (Patton et al. 2012) and the Global Accelerated Action for the Health of Adolescents (AA-HA!) (Aubert et al. 2018) highlighted that investing in adolescent health and well-being will yield a "triple benefit" – benefits for today, into adulthood, and for the next generation. Therefore, identifying factors associated with MVPA may help clarify the broader lifestyle context in which physical activity occurs and inform more comprehensive health-promotion strategies. Given these assumptions, this study aimed to examine biological and lifestyle factors associated with meeting MVPA recommendations among Portuguese adolescents.

Method

Sample

This cross-sectional study was conducted in 2021 and included adolescents aged 12 to 18 years (15.25 ± 1.57 years) from 22 primary and secondary public schools in northern Portugal. The convenience sample of 1117 students (489 boys; 628 girls) was recruited online with the assistance of Physical Education teachers. Because schools were recruited through collaborating Physical Education teachers, a convenience sampling strategy was adopted.

Inclusion criteria required participants to be students of Physical Education teachers enrolled in training at the University of Trás-os-Montes e Alto Douro (UTAD) and willing to participate voluntarily in the study.

Instruments/Procedures

Data were collected via a self-administered questionnaire, completed with guidance from a Physical Education teacher. The questionnaire assessed sociodemographic characteristics and self-reported information on health status and health-related behaviours.

The short form of the International Physical Activity Questionnaire (IPAQ) was used to measure physical activity (PA) levels in the previous seven days. The instrument captured MVPA and walking behaviors, whether related to routine activities (e.g., commuting, chores) or structured exercise (Craig et al. 2003).

PA frequency and duration were recorded for each intensity level (walking, moderate, and vigorous). Participants were asked, for example: “In a typical week, on how many days do you engage in vigorous physical activity for at least 10 minutes?” and “How much time do you usually spend in vigorous physical activities on one of these days?”

Responses were converted to minutes per week and categorized into three levels: 1) vigorous-intensity activity (e.g., aerobics), 2) moderate-intensity activity (e.g., leisure cycling), and 3) walking.

Based on World Health Organization (WHO) guidelines (World Health Organization 2022), adolescents should engage in at least 60 minutes of MVPA daily. In this study, 300 minutes per week was used as the threshold to define sufficient MVPA.

Health and well-being perception included self-related health, stress, duration, and quality of sleep, and physical fitness. Self-perceived health was rated on a 4-point scale from "Bad" (1) to "Very Good" (4). Stress and sleep quality were evaluated on 5-point scales ranging from "Never..." (1) to "Always..." (5).

Participants also reported their sleeping and time spent sitting (e.g., watching TV, playing video games), recorded in minutes per week. Physical self-perception was assessed as "Better," "Similar," "Worse," or "I do not know how to answer."

Dietary habits were measured by weekly frequency (0-7) of consuming fruits, vegetables, white meat, red meat, snacks, soda, and fish.

Preventive health behaviours related to blood pressure, cholesterol, and diabetes were assessed through four response options: ”No”,” Yes”, “I do not remember,” and “I have never measured”. A single yes/no item inquired whether the participants or someone in their household had contracted COVID-19.

Statistical analysis

Descriptive statistics included mean, standard deviation, and 95% confidence interval (95%CI). Normality was assessed visually using histograms (data not shown). Kruskal-Wallis test was performed to explore differences between each variable (BMI; seated time; sleep; fish; fruits; red meat; snack; soda; vegetables; white meat) in MVPA quartiles. A binary logistic regression with backward elimination was performed to examine the association with sufficient MVPA (≥300min/week). Variables included in the model ranged from continuous (e.g., age, BMI, maturity offset, eating habits, sleep, and sitting time) to categorical (e.g., sex and COVID-19 exposure). Odds Ratio (OR) with 95% CIs were reported, and a p-value threshold of <0.05 was used for statistical significance. All analyses were performed in SPSS version 20.

Results

Table 1 summarizes participant characteristics. The sample was composed of more girls (56.3%), 65.4% of the adolescents practiced MVPA ≥300min/week, 54.8% had good self-perceived health, 38.4% were sometimes stressed, 50.1% almost always slept well, and without diseases like high blood pressure, cholesterol, and diabetes. Most of the samples reported not having had COVID-19.

Table 1. Descriptive statistics of the sample.

Variables		Mean (SD)	95% CI
Sociodemographic characteristics			
Age	Years	15.25 (1.57)	15.17 to 15.37
Sex (%)	Girls		56.3
	Boys		43.7
Body mass	Kg	59.25 (13.94)	59.18 to 60.78
Stature	m	1.66 (0.13)	1.66 to 1.67
BMI	Kg/m^2	21.64 (3.76)	21.39 to 21.86
Maturity Offset	Years	2.17 (1.41)	2.09 to 2.27
Daily behavior			
MVPA	<300min/week		34.6
	≥300min/week		65.4
Sleep time	Minutes per/week	495.64 (67.01)	491.50 to 499.81
Seated time	Minutes per/week	400.79 (139.94)	391.92 to 409.37
Self-perceived health (%)	Bad		2.2
	Average		17.6
	Good		54.8
	Very good		25.4
Stress (%)	Never stressed		3.6
	Not stressed		10.5
	Rarely stressed		31.2

	Sometimes stressed		38.4
	Always stressed		16.4
	Never sleep well		0.6
	Rarely sleep well		7.3
Sleep Quality (%)	Sometimes sleep well		24.9
	Almost sleep well		50.1
	Sleep well		17
	Better		16.9
Physical self-perception (%)	Similar		50.6
	Worse		15.6
	I do not how to answer		16.9
Eating habits			
Fruits	Weekly frequency	4.53 (2.16)	4.45 to 4.72
Vegetables	Weekly frequency	4.11 (2.18)	4.01 to 4.29
White Meat	Weekly frequency	3.83 (1.49)	3.75 to 3.93
Red Meat	Weekly frequency	2.83 (1.62)	2.69 to 2.89
Snack	Weekly frequency	1.49 (1.33)	1.38 to 1.55
Soda	Weekly frequency	1.88 (2.10)	1.76 to 2.03
Fish	Weekly frequency	2.58 (1.44)	2.49 to 2.67
Diseases			
	No		66.0
	Yes		7.4
High Blood Pressure (%)	I do not remember		22.5
	I've never measured		4.1
	No		76.9
	Yes		6.3
High Cholesterol (%)	I do not remember		9.0
	I've never measured		7.8
	No		91.5
	Yes		0.7
Diabetes (%)	I do not remember		1.6
	I've never measured		6.1
	Yes. myself or my family		22.3
Did you have COVID-19?	No		77.7

Note: SD=standard deviation; CI=confidence interval; MVPA=moderate to vigorous physical activity.

Table 2 shows the comparison between independent variables in MVPA quartiles. The results revealed statistical differences in seated time, fruits, vegetables, and white meat consumption ($p<0.05$). No significant differences were observed regarding the remaining variables.

Table 2. Comparison between independent variables in moderate-to-vigorous physical activity quartiles.

Variable	Physical activity quartiles mean (min/week)				p-value
	1st (130.5)	2nd (315.5)	3rd (512.6)	4th (994.63)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
BMI (kg/m^2)	21. 23 (3.54)	21.50 (3.59)	21.86 (3.83)	21.70 (3.45)	0.666
Seated time (min/week)	403.02 (145.10)	401.93 (128.03)	395.72 (145.16)	363.82 (127.49)	0.02
Sleep (min/week)	501.95 (74.91)	504.35 (62.86)	497.50 (62.91)	487.99 (72.42)	0.359
Fish (Weekly frequency)	2.58 (1.56)	2.61 (1.17)	2.77 (1.41)	2.88 (1.50)	0.108
Fruits (Weekly frequency)	4.27 (2.07)	4.60 (2.12)	4.88 (1.96)	5.14 (2.08)	<0.001
Red Meat (Weekly frequency)	2.80 (1.64)	2.64 (1.49)	2.97 (1.55)	2.82 (1.59)	0.25
Snack (Weekly frequency)	1.74 (1.48)	1.49 (1.58)	1.44 (1.42)	1.33 (1.36)	0.8
Soda (Weekly frequency)	2.06 (2.15)	1.87 (2.04)	1.62 (1.79)	1.98 (2.20)	0.37
Vegetables (Weekly frequency)	3.67 (2.16)	3.92 (2.14)	4.34 (2.07)	4.73 (2.00)	<0.001
White Meat (Weekly frequency)	3.66 (1.42)	3.72 (1.46)	4.00 (1.51)	3.98 (1.44)	0.026

Table 3 shows the binary logistic regression model from the backward method, which identifies factors independently associated with sufficient MVPA. In the final model, boys had lower odds of meeting MVPA recommendations (OR: 0.653 [95%CI: 0.465 to 0.916]; p=0.014).

Greater sedentary time (OR: 0.999 [95% CI: 0.998–1.000]; p=0.047) and longer sleep duration (OR: 0.997 [95% CI: 0.995–1.000]; p=0.034) were associated with lower odds of meeting MVPA recommendations. However, the intake of vegetables (OR: 1.132 [95%CI: 1.038 to 1.234]; p=0.005) and white meat (OR: 1.210 [95%CI: 1.075 to 1.362]; p=0.002) were positively associated with the odds of being sufficient MVPA.

Table 3. Binary logistic regression models (backward method) to verify associations with sufficient moderate-to-vigorous physical activity.

Variables	Model 1			Model 2			Model 3			Model 4			Model 5			Model 6			Model 7			Model 8		
	OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI	
		LL	UL		LL	UL		LL	UL		LL	UL		LL	UL		LL	UL		LL	UL		LL	UL
Soda (Weekly frequency)	1.009	.925	1.100																					
Fish (Weekly frequency)	1.019	.894	1.161	1.020	.895	1.162																		
Age (Years)	.956	.745	1.226	.956	.745	1.226	.956	.745	1.226															
Maturity Offset (Years)	1.083	.788	1.488	1.083	.788	1.488	1.082	.787	1.487	1.027	.895	1.179												
COVID-19 (yes/no)	1.224	.828	1.809	1.225	.829	1.812	1.226	.830	1.813	1.227	.830	1.813	1.225	.829	1.811									
BMI (kg/m²)	1.026	.978	1.075	1.025	.978	1.075	1.025	.978	1.074	1.025	.978	1.074	1.026	.979	1.075	1.026	.979	1.075						
Red Meat (Weekly frequency)	1.068	.949	1.203	1.069	.950	1.204	1.069	.949	1.204	1.071	.952	1.205	1.072	.953	1.207	1.070	.951	1.204	1.073	.954	1.207			
Sex (girls/boys)	.606	.364	1.008	.604	.363	1.003	.606	.365	1.006	.644	.438	.945	.666	.474	.936	.667	.474	.937	.664	.472	.932	.653	.465	.916
Sleep (min/week)	.998	.995	1.000	.998	.995	1.000	.998	.995	1.000	.998	.995	1.000	.998	.995	1.000	.997	.995	1.000	.997	.995	1.000	.997	.995	1.000
Seated time (min/week)	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000
Fruits (Weekly frequency)	1.069	.977	1.169	1.068	.977	1.168	1.069	.978	1.169	1.071	.980	1.170	1.071	.980	1.171	1.070	.979	1.169	1.070	.980	1.169	1.070	.980	1.169
Vegetables (Weekly frequency)	1.125	1.028	1.232	1.124	1.027	1.229	1.128	1.034	1.230	1.128	1.034	1.231	1.129	1.035	1.231	1.130	1.037	1.233	1.133	1.039	1.235	1.132	1.038	1.234
White Meat (Weekly frequency)	1.189	1.052	1.345	1.189	1.052	1.345	1.194	1.059	1.346	1.193	1.059	1.345	1.194	1.060	1.346	1.196	1.061	1.348	1.200	1.065	1.352	1.210	1.075	1.362
Snack (Weekly frequency)	.896	.775	1.035	.899	.780	1.035	.901	.783	1.036	.901	.783	1.036	.898	.782	1.032	.899	.783	1.033	.887	.774	1.017	.913	.803	1.037

Note: OR= odds ratio; CI=confidence interval; LL=lower limit; UL=upper limit; bold values meaning that the p-value of OR was <0.05.

Discussion

The study aimed to identify factors associated with MVPA among Portuguese students. More frequent consumption of vegetables and white meat was positively associated with meeting MVPA recommendations, whereas greater sedentary time and longer sleep duration showed weak inverse associations. Boys also had lower adjusted odds of meeting MVPA recommendations. Given the small magnitude of the associations observed for sedentary time and sleep duration, these findings should be interpreted cautiously.

The magnitude of the associations involving sedentary time and sleep duration warrants careful consideration. Although both associations reached statistical significance, the corresponding ORs were very close to the null value (0.999 and 0.997, respectively), indicating relatively small changes in the odds of meeting MVPA recommendations for each unit increase in these continuous variables. Because sedentary time and sleep duration were entered into the model in minutes, a one-unit increase represents only a small change in exposure, which can result in ORs numerically close to 1.00. Thus, the proximity of the estimates to the null value should not be interpreted as evidence of a strong association. Rather, the findings suggest relatively small associations whose practical relevance remains uncertain.

The confidence intervals also approached the null value of 1.00, with the upper limit reaching 1.000 for both associations. This indicates limited separation from the null and reinforces the need for cautious interpretation. Statistical significance at the conventional $p<0.05$ threshold does not necessarily imply

a meaningful effect size. The combination of ORs close to 1.00 and confidence intervals approaching the null suggests that these associations should be regarded as weak statistical relationships rather than strong determinants of MVPA.

Previous research indicates that adolescents who engage in higher levels of physical activity are also more likely to adopt other health-promoting habits (Lodovica et al. 2024; Shao e Zhou 2023), including healthier eating (Mora et al. 2025) and better sleep hygiene (Guedes, Zuppa, e Yamaji 2023). Studies across diverse populations have shown similar trends, reinforcing the idea that lifestyle behaviors do not occur in isolation but often co-exist in synergistic patterns that reflect broader health profiles (Arafa et al. 2024; Guedes et al. 2023; Telford, Meiring, e Gusso 2025). Contrary to previous studies, the finding that boys were less likely to meet MVPA recommendations contradicts the prevailing literature, which typically shows higher physical activity levels among male adolescents (Telford et al. 2025). This discrepancy may reflect adjustment for dietary and sedentary behaviors included in the multivariable model. This finding should therefore be interpreted cautiously and may reflect differences in the distribution or combination of lifestyle behaviors captured in the multivariable model.

From a behavioral perspective, the association of PA, reduced sedentary time, better dietary quality, and sleep behaviors reflects broader health profiles of the lifestyle framework. Longitudinal studies and systematic reviews support this view (Fournier et al. 2023), suggesting that targeting one health behavior may positively influence others, particularly in the adolescent period characterized by identity formation and increasing autonomy. Therefore, interventions aiming to increase PA should not operate in isolation but should incorporate nutritional education and sleep hygiene promotion to maximize impact. Regardless of sex, higher MVPA was associated with greater vegetable and white meat consumption. This finding is consistent with studies conducted in the United States and Europe, which showed positive associations between higher physical activity levels and the consumption of fruits, vegetables, and other healthy foods (Moradell et al. 2023; Çal et al. 2026).

Practical applications

School-based interventions should integrate physical activity promotion with nutritional education and healthy sleep practices. Addressing multiple lifestyle behaviors simultaneously may represent a useful approach for school-based health promotion, although intervention studies are needed to determine whether integrated strategies are more effective than single-behavior approaches (Schmidt et al. 2020). For a comprehensive prevention approach, it is important to understand and consider that these health behaviours may interact with each other. Although non-communicable diseases such as hypertension, diabetes, and hypercholesterolemia did not show significant associations with MVPA in this study, physical activity remains a key preventive factor. Embedding movement into adolescents' daily routines continues to be a cornerstone of public health strategy to reduce long-term morbidity. Thus, integrating physical activity into daily routines remains a critical component of public health strategies to improve overall health outcomes.

Strengths and limitations

One significant strength of our study is the large sample recruited from 22 public primary and secondary schools in northern Portugal. Additionally, the study examines a wide range of factors, including sedentary behavior, sleep duration, dietary choices, and gender differences, offering a multifaceted understanding of the influences on adolescents' PA.

Our analysis has some limitations that should be considered. The relatively marginal p-values (p=0.047 and p=0.034) should be interpreted in conjunction with the effect estimates and confidence intervals. Statistical significance is influenced not only by sample size but also by effect magnitude, variability, and measurement precision. Therefore, the observed p-values do not, by themselves, establish that these associations are substantively important. The assessment of PA and food intake was based on self-reports, which are subject to recall and social desirability bias. This may lead to overreporting of healthy behaviours and underreporting of unhealthy behaviours. The use of objective methods, such as activity monitors, may help to reduce such bias for PA. However, bias might still be present since the measurement of specific PA by activity monitors is only possible in combination with a self-reported diary, and the consciousness of the activity being measured may also alter actual behaviour. In a free-living population setting, it is hardly possible to measure dietary intake objectively. The food frequency instrument

used in this survey is not comprehensive and detailed enough to give a complete and precise overview of food consumption and energy intake.

Conclusions

This study suggests that Portuguese adolescents who met the recommended levels of moderate-to-vigorous physical activity were more likely to report healthier dietary habits, particularly more frequent consumption of vegetables and white meat. These findings reinforce the concept that health-related behaviors may coexist during adolescence and support the adoption of integrated health promotion strategies in school settings.

Given the cross-sectional design, the observed associations should not be interpreted as causal relationships. Future longitudinal studies using objective measures of physical activity, sedentary behavior, sleep, and dietary intake are warranted to clarify the direction and mechanisms underlying these associations and to inform more effective interventions for promoting healthy lifestyles among adolescents.

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