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POPULATION STUDY ARTICLE

Lifestyle behaviors clusters in a nationwide sample of Spanish children and adolescents: PASOS study

Augusto G. Zapico[1,2✉], Raquel Aparicio-Ugarriza[1,3], Carlos Quesada-González[1,4], Santiago Felipe Gómez[5,6,7,8], Julia Wärnberg[3,9], María Medrano[10], Narcís Gusi[11], Susana Aznar[12,13], Elena Marín-Cascales[14,15], Miguel A. González-Valeiro[16], Lluís Serra-Majem[3,17,18], Susana Pulgar[19], Josep A. Tur[3,20], Marta Segu[21], Montserrat Fíto[3,7], Clara Homs[5,22], Juan Carlos Benavente-Marín[9], Jesús Sánchez-Gómez[11], Fabio Jiménez-Zazo[12], Pedro E. Alcaraz[14,15], Marta Sevilla-Sánchez[15], Estefanía Herrera-Ramos[17], Cristina Bouzas[3,20], Clara Sistac[21], Helmut Schröder[6,7], Eva Gesteiro[1] and Marcela González-Gross[1,3]

BACKGROUND: Youth is a vulnerable period. To classify lifestyle behaviors and its relationship with health-related outcomes of Spanish children and adolescents.
METHODS: Cross-sectional study including 3261 children aged 7.5–17.5 y (52.8% females). Physical activity (PA), screen-time, sleep time, adherence to Mediterranean diet (MD), weight status (WS) by validated methods. Cluster analysis was run considering chronological age.
RESULTS: Six clusters were identified: C1: high screen time, low adherence to MD and sleep time ($n = 431$,13.20%); C2: high WS, medium adherence to MD,high sleep time, and low screen time ($n = 466$,14.30%); C3: young group with low screen time and high PA, adherence to MD and sleep ($n = 537$,16.40%); C4: worst profile regarding adherence to MD, PA, WS and sleep time ($n = 609$,18.70%); C5: low screen time and PA, high sleep time ($n = 804$,24.70%); C6: high PA and screen time, low WS ($n = 414$,12.70%). Mean absolute values were statistically different among PA levels, screen and sleep time, adherence to MD, age, and WS (all $p < 0.001$).
CONCLUSIONS: The most prevalent pattern was low levels of PA, MD, and screen time, and high sleep time. The second most prevalent was characterized by very low levels of PA, sleep time, and adherence to MD, and high screen time, and WS in adolescents.

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IMPACT STATEMENT:

- The main identified lifestyle behavior was poor physical activity, low adherence to Mediterranean Diet and high screen and sleep time.
- Children should increase physical activity levels, adherence to Mediterranean diet, decrease screen and sleep the appropriate hours per day.
- Families, schools, and medical communities must work together to gloss over present and future diseases.
- Sleep time had not been previously included in cluster analysis with physical activity, sedentary behaviors, obesity, and nutritional status, thus the present data open a new perspective in Spanish population.
- Health policies should focus on promoting physical activity, Mediterranean diet, adequate sleep and reducing screen time.

[1]ImFINE Research Group. Department of Health and Human Performance, Universidad Politécnica de Madrid, Madrid, Spain. [2]Department of Language, Arts and Physical Education, Universidad Complutense de Madrid, Madrid, Spain. [3]Biomedical Research Center on Physiopathology of Obesity and Nutrition (CIBEROBN), Institute of Health Carlos III, Madrid, Spain. [4]Departamento de Matemática Aplicada a las Tecnologías de la Información y la Comunicación, Universidad Politécnica de Madrid, 28031 Madrid, Spain. [5]Gasol Foundation, Sant Boi de Llobregat, Spain. [6]Biomedical Research Networking Center on Epidemiology and Public Health studies (CIBERESP), Institute of Health Carlos III, Madrid, Spain. [7]Hospital del Mar Medical Research Institute (IMIM), Barcelona, Spain. [8]Nursing and Physiotherapy Department, University of Lleida, Lleida, Spain. [9]EpiPHAAN Research Group. Faculty of Health Sciences, University of Málaga-Institute of Biomedical Research of Malaga (IBIMA), Málaga, Spain. [10]ELIKOS group, Institute for Innovation & Sustainable Development in Food Chain (IS-FOOD). CIBEROBN, ISCIII Navarra, Public University of Navarra, Navarra, Spain. [11]Physical Activity and Quality of Life Research Group (AFYCAV), Faculty of Sport Sciences, Universidad de Extremadura, Cáceres, Spain. [12]PAFS Research Group, Faculty of Sports Sciences, University of Castilla-La Mancha, Toledo, Spain. [13]Biomedical Research Networking Center on Frailty and Healthy Aging (CIBERFES). Institute of Health Carlos III, Madrid, Spain. [14]Research Center for High Performance Sport, Catholic University of Murcia, Murcia, Spain. [15]Faculty of Sport Sciences, UCAM, Catholic University of Murcia, Murcia, Spain. [16]Faculty of Sports Sciences and Physical Education, University of A Coruña, A Coruña, Spain. [17]Research Institute of Biomedical and Health Sciences (IUIBS), University of Las Palmas de Gran Canaria, Las Palmas, Spain. [18]Preventive Medicine Service, Centro Hospitalario Universitario Insular Materno Infantil (CHUIMI), Canarian Health Service, Las Palmas, Spain. [19]Regional Unit of Sports Medicine, Municipal Sports Foundation of Avilés, Asturias, Spain. [20]Research Group of Community Nutrition & Oxidative Stress, University of the Balearic Islands-IUNICS & Health Research Institute of the Balearic Islands (IDISBA), Palma de Mallorca, Spain. [21]Fundació FC Barcelona, Barcelona, Spain. [22]GRoW, Global Research on Wellbeing, Blanquerna School of Life Sciences, University Ramon Llull, Barcelona, Spain. ✉email: azapico@edu.ucm.es

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INTRODUCTION

Childhood and adolescence period is essential to establish healthy habits and to prevent the development of non-communicable diseases.[1] In this sense, screen time, lower levels of physical activity (PA), not accomplishing sleep time recommendations,[2] together with an unhealthy diet are recognized as main factors to develop non-communicable diseases and obesity.[1] Several programs have been performed aimed at reducing obesity, time spent in sedentary activities, and increasing PA levels; however, children and adolescents typically do not meet the recommendation about PA and sedentary time, dietary patterns have been moved towards western patterns, and effectiveness of school-based interventions are controversial.[3] Thus, promoting health policies addressed to young people should be a priority to prevent clinical indicators deterioration that occurs during adulthood.[4] In Spain, as in most of the countries in the world, many policy actions and education programs have been performed following the guidelines of the World Health Organization (WHO).[5] The Nutrition, Physical Activity and Prevention to Obesity (NAOS) initiative started in Spain in 2004 as an organizational umbrella to push private and public sector measures to reduce the impact of unhealthy behaviors on obesity.[6] A recent article has published an evolution of PA and time spend watching television (TV) in Spain between 1997 and 2017.[7] Authors conclude that there was a decrease of PA since sedentary activities are increasing, especially among girls and children aged from 12 to 14 years.[6] Likewise, the 2018 Spanish Report Card found that adherence to PA recommendations was low among Spanish children and adolescents aged from 5 to 17 years.[8] Increase of regular PA, and of consumption of fruit, vegetables, legumes, and whole-grain cereals,[9] together with a decrease in sedentary patterns such a screen time, and sleep a minimum of 8 h, have shown to be a protective lifestyle against obesity.[9] Previous research of the PASOS project found that a greater amount of screen time was related to worse adherence to the Mediterranean Diet (MD); concretely, a lower consumption of fruit, vegetables, fish, legumes, and nuts, and a higher consumption of fast food, sweets, and candies.[10] However, the study of the different health behaviors in youth has been performed mainly individually and not in combination. Moreover, research on clustering of lifestyle markers in adolescents is still scarce,[11–13] especially in Spanish children and adolescents.[14] This methodology offers a possibility to explore the association between several outcomes following a synergistic approach.[15] Thus, a holistic understanding how different lifestyle factors affect children's and adolescents' health through cluster approach would improve global knowledge and the design of future interventions.[16–18] Understanding the clustering of lifestyle indicators can inform strategies to better prevent, manage, and mitigate negative health consequences as behaviors are not studied in isolation.

Similarly, sleep patterns are not commonly included in clusters analysis, although an inadequate nocturnal sleep has been related to negative health factors.[16] Clustering children and adolescents for MD, PA, screen time, sleep time, and weight status (WS) could give us a better perspective of lifestyle patterns leading Spanish youth toward this condition that implicates higher health risks.

Therefore, the main aim of this research was to characterize lifestyle behaviors in clusters and to analyse its association with age, sex, WS, PA, screen time, sleep patterns, and adherence to MD in a representative sample of Spanish children and adolescents.

METHODS

Sample size and study design

This is a cross-sectional study part of the Physical Activity, Sedentarism and Obesity in Spanish Youth (PASOS) project", an observational, multicentric, and representative study of Spanish children and adolescents, led by the Gasol Foundation. The whole project protocol has been published elsewhere.[19] Baseline data were collected in 242 Spanish primary and secondary schools from March 2019 to February 2020.

Briefly, a formal request to conduct this survey was submitted and accepted by the boards of all participants' schools. Written informed consent was obtained from participants' parents/guardians. The study was approved by the Ethics Committee of the Fundació Sant Joan de Déu, Barcelona, Spain (PIC-179-18).[19] The trial was also registered in 2019 at the International Standard Randomized Controlled Trial (ISRCT; https://doi.org/10.1186/ISRCTN34251612) with the number 34251612.

The original sample randomization was performed by a multistage sampling procedure including four stages.[20,21] To obtain a sample of 4508 children/adolescents, assuming a mean of 18–20 pupils per classroom, 242 participating classrooms were required from the 17'autonomous communities' into which Spain is divided: 121 from primary schools (grades 3–6) and 121 from secondary schools (levels 1–4). In the first step, 121 municipalities were randomised across three population strata: 2000–30,000; 30,001–200,000; and more than 200,000 inhabitants. The total number of selected municipalities in each autonomous community was proportional to its share of the youth population of Spain aged 8–16 years.[22] In a second step, 242 schools were randomised from the selected municipalities, along with up to three replacements for each selected school to account for census data error or centers not willing to participate. In a third step, scholar-year per school was randomised. In the fourth and final step, a classroom for each scholar-year was randomised and invited to participate. A subsample of 23 classrooms (10%) was randomised for the objective measurement of PA by accelerometers. The software used for the sampling procedure was R, package mistage.

The calculation of the sample size was based on the prevalence of non-adherence to PA recommendations of at least 1 h of PA per day. According to the published data of the Spanish Report of Physical Activity,[8] we assumed 50% non-adherence among Spanish children and adolescents. Based on this assumption and considering a population increase of 8% as a relevant indicator, a total of 3994 participants were needed, 1997 in each of the two age groups (primary school: 8–11 years, and on secondary school: 12–16 years), to achieve a statistical power of greater than 80% to identify an increase of 8% as significant ($p \leq 0.05$). A dropout rate of 20% was anticipated. To consider the cluster effect, sample size was increased by 10%, leading to a sample size of 4394 participants. Finally, to ensure proportionality among the 17 autonomous communities studied, the number of municipalities was increased to 121 so the final expected sample was 4508 participants.

The final number of valid answers was 4092 which exceeds and therefore satisfies the initial requirement of 3994 participants.[19] This data set is the starting point of our study.

The raw dataset contained variables and observations with missing values, as part of the original variables in PASOS were obtained with parents' questionnaires that were filled voluntarily, adding up to more than 52% of missing values distributed among very specific variables and observations. A cleaning process was carried out in the spirit of obtaining a clean dataset ready for performing the cluster analysis.[23] The cleaning protocol included removing all observations with no information on either sex or age, as we considered both to be fundamental. Afterwards, if a variable included more than 1000 missing values it was discarded because it was considered to have a low answer rate. Then, all observations (rows) corresponding with respondents with more than 40 unanswered questions were also removed as they were unreliable. A second iteration of this filtering was performed, discarding variables with more than 50 missing values, and then observations with more than 20 unanswered questions. The reason to run this two-step pre-processing instead of a single removal of variables and observations was that if we had aimed directly to remove variables with more than 50 missings, most of the dataset would have been gone, due to the low-response observations. The remaining dataset was furthermore filtered to avoid misreporting, so conditions of plausibility were added. To be included in the present study, all observations had to satisfy:

- Age range 7.5 to 17.5 years.
- Sum of the daily hours spent on sleeping, screen time and PA < 18 h on a weekday and <23 h on a weekend day, as the remaining time was the minimum considered for school attendance and/or basic needs.
- Average sleep time between 5 and 15 h/day.
- Go-to-bed time from 19:00 to 3:00 in a weekday.
- Wake-up time from 5:00 to 9:30 in a weekday.

All observations not fulfilling any of these criteria were discarded, thus, the final sample was $n = 3261$ subjects and $k = 135$ variables. The final missing values account was less than a 0.1% and misreporting was remedied.

Outcomes

Physical activity. A 7-item self-reported questionnaire (PAU-7S) was performed to assess PA. PAU-7S questionnaire has been validated in a randomized sample of 321 participants from the PASOS study that completed the PAU-7S twice and wore an accelerometer (gold standard) for at least 7 consecutive days.[24] This questionnaire showed a good internal consistency (Cronbach's alpha: 0.76), a fair correlation with data measured with an accelerometer (Spearman's correlation coefficient: 0.62), and a fair concordance (kappa value: 0.24).[24]

In this questionnaire, six questions were asked about PA frequency and duration in the previous week: (1) How many days did you go for a walk?; (2) How many days did you participate in movement play during recess time?; (3) How many days did you participate in movement play during free time after school or during the weekend?; (4) How many days did you have physical education (PE) class at school?; (5) How many days did you play a team sport?; (6) How many days did you play an individual sport?. The response options for these questions were ranged from 0 to 5 for each day of the week: (1) 0 min (no activity); (2) less than 30 min; (3) between 30 min and 1 hour; (4) between 1 h and 1.5 h; and (5) more than 1.5 h. The final question asked about health status with a Yes/No response option: Were you sick last week or did anything prevent you from performing your usual PA?.[23] For this study, total moderate to vigorous activity (MVPA) was considered for the statistical analyses as average minutes per day. Children and adolescents were categorized into achieving the MVPA daily recommendations (≥60 min/day) or not achieving the MVPA daily guidelines (<60 min/day) according to the WHO PA guidelines.[5]

Screen time. Screen time, as part of the sedentary behavior (SB), was assessed using the Screen-time Sedentary Behavior Questionnaire,[25] and was based on questions about the time that youths spend in 4 activities: (1) watching TV; (2) playing computer games (3) playing console (video) games; and (4) using a mobile phone, separately for weekdays and weekends.[25] This questionnaire was previously validated in adolescents in the HELENA study.[25] Screen mean time was calculated for weekdays (Monday to Friday) and weekends (Saturday and Sunday).[10] Achievements of screen time recommendations has been considered when participants used screen time less than 2 h/day.[5]

Sleep time. The Sleep Habits Survey for Adolescents was performed to assess sleep quality and rest time during weekdays and weekend.[26] Total sleep time during weekdays and weekend days has been calculated, as well as if participants achieved sleep recommendations (from 9 h to 11 h of sleep for children under 14 years old, and from 8 h to 10 h for those with at least that age).[27]

Adherence to Mediterranean Diet. Adherence to the MD, a healthy dietary pattern, was assessed by means of the validated 16-item "Kids level of adherence to the Mediterranean diet, KIDMED".[28,29] This questionnaire used dichotomous response options (Yes/No), based on the principles that sustain MD patterns and those that undermine it. The KIDMED index has been designed to estimate adherence to the MD in children and adolescents. Thus, an affirmative answer to items denoting lower adherence is assigned a value of −1 (4 items) and those related to higher adherence are scored +1 (12 items). Participants were categorized into 3 groups: low adherence to the MD (3 or fewer points), medium adherence to the MD (4–7 points), and high adherence to the MD (8 or more points).[10]

Anthropometric variables. Weight, height, and waist circumference (WC) were evaluated through an electronic SECA 899 scale (Seca, Hamburg, Germany) (recorded to the nearest 100 g), a portable SECA 217 stadiometer (Seca, Hamburg, Germany) (to the nearest 1 mm) and a flexible, non-stretch SECA 201 metric tape (WC, Seca, Hamburg, Germany) (to the nearest 1 mm). Body weight and height were evaluated with the participants in light clothing, without shoes. Body mass index (BMI) was calculated using the following formula: (weight (kg)/ height (m)^2). BMI Z-score was calculated according to the WHO 2007 growth standards and reference for children and adolescents aged 5 to 19 years.[30] Furthermore, WS has been categorized by age and sex according to the following BMI Z-score cutoffs: severe obesity >3 standard deviation (SD); obesity >2 SD and ≤3 SD; overweight >1 SD and ≤ 2 SD; normal-weight (NW) ≥−2SD and ≤1 SD; underweight < −2SD and ≥−3SD; and severe underweight <−3SD.[31]

WC was measured in the narrowest zone between the lower costal rib and iliac crest, in the supine decubitus and horizontal positions. Furthermore, Waist-to-Height ratio (WHtR) was calculated as follows: (WC (m)/height (m)). The cut-off value of 0.50 was used for WHtR to classify abdominal obesity in our study.[32] Every measure has been performed by trained personnel following the WHO standardized protocol.[33]

Statistical Analysis. Baseline characteristics for the whole sample are presented as frequency (percentage) for categorical variables or mean ± standard deviations (±SD) for lineal variables. The descriptive characteristics are also shown by age groups (children, below 12 years old; and adolescents, at least 12 years old),[34] by sex, and by both age group and sex at the same time. We highlight the effect of adolescence in several variables for both males and females. The statistical significance is tested measuring the interaction term. For categorical variables, the significance of the interaction is measured through logistic regression and for quantitative variables, ANCOVA tests were conducted, taking into account the p value of the interaction term. All calculations and tests have been done using only observations with no missing values for each of the tested variables, as losing some observations did not decrease the sample enough to affect the statistical power ($n = 3261$) and so, no bias was introduced due to imputation.

Clustering. The cluster analysis consisted of three main classical steps: (i) reduction of dimensionality (reducing number of variables by creating new variables that condense all the information), (ii) clusterization itself (creating the groups with common properties) and (iii) post-hoc analysis (identifying the patterns in each cluster).

First of all, in order to do the clustering we took into account all variables that are directly related to the subjects but without including treats that were not of their own (such as education of their parents). Since most of the variables were categorical, it would seem reasonable to consider clustering algorithms that work naturally with those kind variables, such as k-Prototypes,[35] ROCK, Chameleon or Squeezer,[36] or to reduce dimensionality with algorithms that work with categorical data such as Multiple Correspondence Analysis, CATPCA, or Factor Analysis with Mixed Data. However, all of these rely on hypotheses that do not hold for our dataset, such as sphericity or linearity. Indeed, after several tries with these algorithms no good results were at hand. Following the advice of Rousseeuw,[37] ordered variables can be simply considered as quantitative, and thus quantitative dimensionality reduction algorithms such as Principal Component Analysis (PCA) and quantitative clustering algorithms (such k-means or hierarchical clustering) can be used. The first step then, was to standardize all variables and missing values were imputed with the median. The highly dimensional dataset presents a Hopkins statistic[38] of 0.32 which indicates bad chances for clusterization. Dimensionality reduction algorithms such as PCA, Multidimensional Scaling (MDS), ISOMAP, or Locally Linear Embeddings did not improve the situation either (as an example, using PCA, the first 40 components just captured around 75% of the variance of the whole set leaving the Hopkins statistic still at 0.26).

A more refined way to reduce dimensionality is using autoencoders, a type of neural network designed specifically for this purpose. Similarly, to other methods, the idea behind autoencoders was to find fewer features that keep most of the information of the whole dataset, but they performed it using neural networks instead of linear methods such as a PCA or nonlinear methods with very rigid structures (as MDS or ISOMAP).

We used an autoencoder with the following architecture: three dense sigmoid layers of 64, 48 and 24 features, followed by a dropout layer of 30% dropout and a final ReLU encoding layer of 16 features. It was trained using RMSProp for 200 epochs, with a learning rate of 0.01 and a batch size of 112. The encoded dataset with 16 features had a Hopkins statistic of 0.041, suggesting a very clusterizable structure. Several cluster algorithms were computed for a setting ranging from 3 to 20 clusters. The best configuration was found using k-means for 6 clusters.

Finally, a post-hoc analysis was carried out to find differences between clusters. This was done only for certain variables, as the interest is on describing the clusters in terms of the most relevant information rather than stating all significant differences between clusters. We test the differences by means of chi-squared and ANOVA tests (with Welch's correction when needed), setting cluster as the independent categorical variable. Normality is not an issue, as all clusters have over 400 observations.

Software. The raw database was received in .sav format, from SPSS (Statistical Package for the Social Sciences version 21.0 IBM, Chicago, IL). All the pre-processing, visualization, descriptive statistics and post-hoc analysis for the clusters was performed in R 4.1.2 under the frontend RStudio 1.4.1717. The dimensionality reduction and clusterization was computed in Python 3.9.10 with the frontend Visual Studio Code 1.62.

RESULTS

Table 1 shows the descriptive characteristics of the study population divided by age groups (children and adolescents) and sex. A total of 3261 children and adolescents were included in the analysis. Regarding anthropometric outcomes, we focused on analyzing whether the changes in certain measures are different for males and females when entering in the adolescent group. Significant differences were observed between age and sex groups for weight, height (both $p < 0.001$), BMI Z-score ($p = 0.04$), and WC ($p = 0.004$). Adolescent males group presented a higher increase in height, weight, and WC than females although BMI z-score is reduced more in boys entering the adolescent group than in girls; meaning that even though the increase is larger in absolute terms, the z-score suggest the male population comes closer to $z = 0$.

Concerning PA, there were significant differences between sex groups in the daily MVPA ($p = 0.002$) both children and adolescent males' groups performed higher levels of MVPA compared to children and adolescent female groups, but the decrease is clearly larger in females. Similar results were displayed for the achievement of MVPA in average minutes per day and every day between; in both cases the reduction is significant $p < 0.001$ but the interaction is not so significant ($p = 0.065$), although it is close. The highest and lowest achievement were met, respectively for children male and adolescent female groups.

With respect to screen time exposure, adolescents showed significantly higher values than children ($p < 0.001$) during the week, and with a larger increase for females ($p = 0.026$). During the weekend, screen time increased in all age and sex groups. There were significant differences between age and sex groups, of which, adolescent male group presented the highest screen time. In this sense, only 7.1% and 10.7% of adolescent males and females, respectively, met screen time recommendations.

In terms of sleep time, significant differences (all $p < 0.001$) were observed between age and sex groups for sleep time during weekdays, with a decrease of sleep time. This decrease is particularly larger for females ($p < 0.001$). On weekends, however, the sleep time increases in the adolescent group ($p < 0.001$) with no difference between males and females.

Figure 1 depicts the main variables from the 6 clusters displayed from the minimum to the maximum value of health/lifestyle behavior patterns each variable. Clusters included a total of 10 outcomes which were: KIDMED score, WS by WHO, sleep time during the weekdays and weekends, screen time during weekdays and weekends, MVPA (weekdays and total week), age, and number of participants.

Cluster 1 (C1, $n = 431$) was characterized by high screen time, but also low scores on KIDMED, and sleep time. Cluster 2 (C2, $n = 466$) showed low screen time and medium KIDMED score and high sleep time. However, this cluster presented high level of WS. Cluster 3 (C3, $n = 537$) displayed the best health-related results, and it was distinguished to be part of the younger and healthiest group. C3 performed high levels of MVPA, KIDMED, and sleep time as well as low and medium scores on screen time. Cluster 4 (C4, $n = 609$) showed the worst score on KIDMED, sleep time, MVPA, and WS. Moreover, it displayed high and medium scores on screen time. Cluster 5 (C5, $n = 804$) presented low screen time and MVPA, but high sleep time. Finally, cluster 6 (C6, $n = 414$) performed high levels of MVPA and low WS, while dedicating a lot of time to screen activities. Following the results, older participants obtained the worst results while younger participants showed better behavioral patterns.

Table 2 displays the mean absolute values of several outcomes by cluster groups. Mean absolute values for daily MVPA and MVPA during the weekend, screen, and sleep time (both weekdays and weekend), KIDMED score, and age were statistically different among clusters (all $p < 0.001$ except for sleep time on weekdays; $p = 0.015$). Moreover, pairwise comparisons are displayed, in order to show which clusters, have similar values to which others for each of the variables.

DISCUSSION

The current study aimed to classify Spanish children and adolescents according to their lifestyle patterns and to investigate the differences between cluster groups among the following variables: age, sex, PA, screen and sleep time, adherence to MD and WS. A total of six clusters were detected and they were consistent with previous studies where two or three predominant lifestyle behaviors have been identified.[13]

In our study, there is no tendency for participants who are engaged into a specific lifestyle behavior to be also involved in another one. This fact suggests that there could be a compensation between different behaviors. This means that some participants performed more PA, ate well but spent a lot of time using screens, while others slept well, did not meet PA recommendations or their screen time was little.

Despite all the benefits from being physically active, only 36.2% of PASOS participants met WHO PA recommendations every day; however, non-compliance with PA recommendations was greater in adolescent females (78.4%) than in adolescent males (62.4%); and a total of 48.3% child females did not meet PA recommendations every day compared to males (62.7%).[39]

We observed an age influence on the composition of clusters, being stronger in older participants, especially regarding low levels of PA and sleep time, and high levels of screen time. However, maturation test was not performed in this study and could have an effect on theis parameter. Unhealthy behavioral habits also generally concurred and increased with age from nearly one-third of younger children to nearly three-quarters of older adolescents.[16] C3 reported the highest amount of time spent on PA and, at the same time, presented the lowest prevalence of WS and intermedium time spent on screen activities. This finding supports that meeting current recommendations for PA could avoid the excess of body fat in children. In this line, there are several studies in the literature which found similar results.[40–43] Nevertheless, evidence regarding that PA is associated with the management of a healthy WS is still scare and more research is needed[44] as well as the evidence of an association between the indicators of adiposity and PA.[45]

Low PA and high screen time were also frequently detected together.[15] In fact, active children typically did more MVPA and spent less time in front of a screen.[1,46] Moreover, D'Souza et al. found that males performed more PA, and screen time, while low levels of PA and high SB activities were more commonly seen in females.[15,47] However, our study found that males were more physically active but spent also more time on screens than females.

In our cluster analysis, C1 showed the highest amount of time spent on screens, followed by C6 and C4. Moreover, C1 showed one of the lowest scores on sleep time suggesting they sleep less because probably they spend too much time on screens before falling asleep.[48] Screen time is related to obesity in youth

Table 1. Descriptive characteristics in children and adolescents by sex.

	Children 8–11 years		**Adolescents 12–17.5 years**		**Total N = 3261 (100%)**	***p* value**
	Males N = 705 (21.6%)	**Females N = 767 (23.5%)**	**Males N = 834 (25.8%)**	**Females N = 955 (29.4%)**		
Age (y)	10.37 ± 1.00 4.00 (7.99–11.90)	10.36 ± 1.04 4.02 (7.96–11.98)	14.34 ± 1.38 5.45 (12.00–17.45)	14.34 ± 1.35 5.42 (12.00–17.42)	12.55 ± 2.32 9.48 (7.96–17.45)	0.935
Weight (kg)	38.65 ± 9.78 72.9 (21.40–94.30)	38.80 ± 10.32 66.10 (19.70–85.80)	58.84 ± 14.67 94.8 (28.20–123.0)	55.21 ± 11.76 77.0 (28.40–105.4)	48.70 ± 15.00 103.3 (19.70–123.0)	<0.001***
Height (cm)	142.23 ± 8.61 72.20 (99.30–171.50)	142.72 ± 9.35 62.0 (117.20–179.20)	165.25 ± .10.65 58.50 (134.90–193.40)	159.08 ± 6.79 50.90 (131.90–182.80)	153.20 ± 13.35 94.10 (99.30–193.40)	<0.001***
BMI (kg/m2)	18.90 ± 3.43 21.77 (13.15–34.93)	18.80 ± 3.43 22.02 (11.61–33.64)	21.32 ± 3.96 23.82 (13.59–37.41)	21.72 ± 3.98 27.34 (13.47–40.81)	20.31 ± 3.97 29.19 (11.61–40.81)	0.072·
BMI z score	0.76 ± 1.26 6.81 (−2.76–4.05)	0.55 ± 1.16 7.26 (−3.54–3.72)	0.51 ± 1.19 6.74 (−2.97–3.77)	0.47 ± 1.07 6.80 (−2.94–3.86)	0.56 ± 1.17 7.59 (−3.54–4.05)	0.040*
WC (cm)	67.37 ± 9.99 60.8 (49.20–110.0)	65.44 ± 9.19 59.40 (48.0–107.40)	76.32 ± 10.85 66.55 (53.0–119.55)	72.45 ± 9.49 58.20 (52.0–110.20)	70.67 ± 10.77 71.55 (48.0–119.55)	0.004**
WHtR	0.47 ± 0.06 0.30 (0.36–0.67)	0.46 ± 0.05 0.31 (0.35–0.67)	0.45 ± 0.06 0.41 (0.34–0.75)	0.45 ± 0.05 0.33 (0.34–0.68)	0.46 ± 0.05 0.41 (0.34–0.75)	0.060
AO = Yes (n, %)	200 (28.4)	159 (20.7)	189 (22.6)	189 (19.8)	737 (22.6)	0.142·
WS (WHO) (n, %)						0.222
Undernutrition	14 (2.0)	16 (2.1)	20 (2.4)	13 (1.4)	63 (1.9)	
Underweight	33 (4.7)	48 (6.3)	59 (7.1)	61 (6.4)	201 (6.2)	
Healthy Weight	354 (50.3)	425 (55.4)	468 (56.0)	606 (63.5)	1853 (56.8)	
Overweight	157 (22.3)	170 (22.2)	170 (20.4)	176 (18.4)	673 (20.8)	
Obesity	143 (20.3)	102 (13.3)	115 (13.8)	95 (9.9)	455 (14.0)	
MVPA (min/day)	149.36 ± 77.68 394.28 (0–394.28)	127.30 ± 79.37 392.14 (2.14–392.14)	134.54 ± 69.18 394.28 (0–394.28)	96.64 ± 75.70 372.85 (0–372.85)	124.98 ± 77.67 394.28 (0–394.28)	0.002**
MVPA (min/week)	1045 ± 532.89 2760 (0–2760)	941.82 ± 493.97 2745 (15.0–2760)	891.10 ± 554.94 2760 (0–2760)	676.43 ± 518.87 2610 (0–2610)	874.83 ± 543.66 2760 (0–2760)	
Achieve PA recommendations (min/day)	642 (91.2)	654 (85.3)	682 (81.7)	603 (63.1)	2581 (79.2)	0.065·
Achieve PA recommendations (every day) (n = , %)	364 (51.7)	286 (37.3)	314 (37.6)	206 (21.6)	1170 (36.2)	0.205
Screen time (min wk/day)	135.16 ± 125.85 720 (0–720)	98.40 ± 94.87 585 (0–585)	217.90 ± 139.52 690 (0–690)	202.89 ± 121.82 720 (0–720)	167.65 ± 131.30 720 (0–720)	0.026*
Screen time (min wknd/day)	254.02 ± 161.17 720 (0–720)	171.55 ± 134.65 720 (0–720)	360.96 ± 160.30 720 (0–720)	287.29 ± 139.87 720 (0–720)	271.97 ± 163.45 720 (0–720)	0.463
Achieve Screen time (min wk/day)	436 (61.9)	546 (71.2)	256 (30.7)	280 (29.3)	1518 (46.5)	0.001**
Achieve Screen time (min wknd/day)	175 (24.9)	359 (53.2)	59 (7.1)	102 (10.7)	695 (21.3)	0.010**
Total sleep time (wk/day)	9.59 ± 1.01 7.25 (5.25–12.50)	9.66 ± 0.98 7.34 (5.91–13.25)	8.45 ± 1.15 7.25 (5.0–12.25)	8.19 ± 1.07 7.58 (5.08–12.66)	8.90 ± 1.25 8.25 (5.0–13.25)	<0.001***
Total sleep time (wknd/day)	10.02 ± 1.66 9.75 (5.0–14.75)	10.42 ± 1.58 10.0 (5.0–15.0)	9.50 ± 1.53 9.90 (5.0–14.91)	9.79 ± 1.46 10.0 (5.0–15.00)	9.91 ± 1.59 10.0 (5.0–15.0)	0.292
Achieve sleep recommendations (wk/day) (n, %)	557 (79.1)	621 (81.0)	487 (58.3)	466 (48.8)	2131 (65.3)	0.002**
Achieve sleep recommendations (wknd/day) (n, %)	542 (77.0)	643 (83.8)	671 (80.4)	826 (86.5)	2682 (82.2)	0.944
KIDMED index (n, %)						0.019*
Low	63 (8.9)	61 (8.0)	70 (8.4)	120 (12.6)	314 (9.6)	
Medium	320 (45.5)	349 (45.5)	442 (52.9)	514 (53.8)	1625 (49.8)	
High	321 (45.6)	357 (46.5)	323 (38.7)	321 (33.6)	1322 (40.5)	
KIDMED score	2.36 ± 2.44 13 (−1–12)	2.38 ± 2.31 12 (0–12)	2.29 ± 2.46 15 (−3–12)	2.21 ± 2.49 14 (−2–12)	6.79 ± 2.4 15 (−3–12)	0.008**

AO abdominal obesity, *BMI* body mass index, *KIDMED* the Kids' level of adherence to the Mediterranean diet, *MVPA* moderate to vigorous physical activity, *WC* waist circumference, *WhtR* waist to hip ratio.

The table focuses on interaction between group and sex. For categorical variables, the significance of the interaction is measured through logistic regression and for quantitative variables, ANCOVA tests were conducted, displaying the *p* value of the interaction term. Significant differences are displayed as ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; :$p < 0.10$.

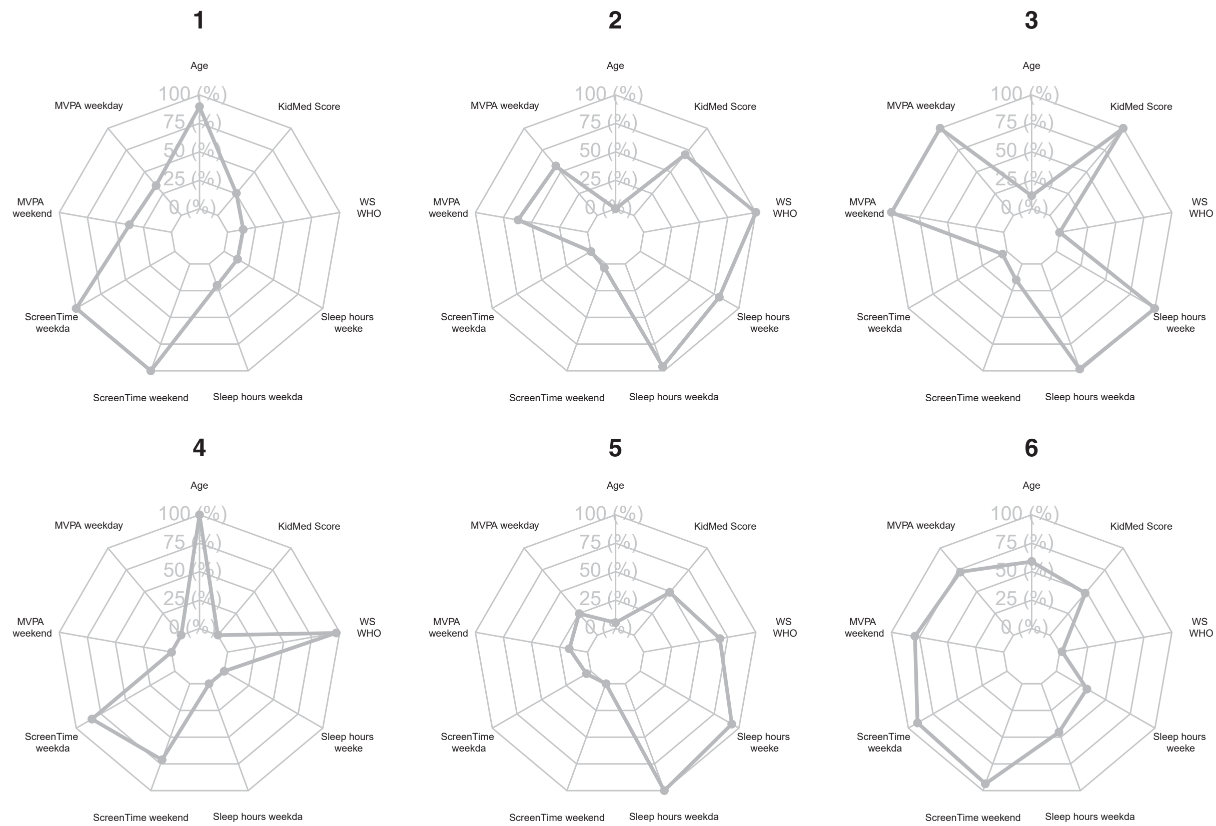

Fig. 1 Variable distributions for each cluster. Radar plots numbered 1 to 6 represent, for each cluster, the distribution of the main variables; Age, KidMed Score, WS WHO (Weight Status), Sleep hours, Screen time and MVPA (Moderate to Vigorous Physical Activity). Last three variables for weekday and weekends.

participants independent of PA.[16,49] Likewise, the high incidence of excessive time on screen of SB together with low score dietary quality is consistent with our study and others.[16,50,51] Contrary to our results, other studies observed a better cardiovascular profile with low SB and low sugar sweetened beverages consumption than higher intake of fruits and vegetables or doing PA.[4,16,50–52] It is necessary to consider that a certain amount of time spent in SB that comprehend studying and reading, playing family games or any other kind of game and activity that requires pause, reflection and thinking are inevitable and even necessary.[53] Therefore, we identify a need to use specific tools which allow researchers to differentiate between these activities.

Optimal adherence to MD was related to meet PA recommendations and screen time in another research of the PASOS Study.[54] In the current study, adherence to MD was mainly high and all clusters showed a ranged score from 9 to 12 in the KIDMED score. Clusters composed of younger children (C2 and C3) reported higher KIDMED score, probably due to parents influence in their dietary decisions, as suggested by Pedersen et al.[55], even though eating behaviors and social cognitive factors may influence fruit and vegetable consumption.[56] When analyzing the combination of screen time and eating behaviors, in our study, participants who had low MD adherence, spent more time on screens. These results are aligned with other studies.[10,57]

In recent years, sleep quality and duration have been associated with obesity, as sleep plays a fundamental role in hormonal and metabolic functioning and regulation.[2,58] Thus, dysregulation of ghrelin and leptin interferes with the mechanism underlying the regulation of hunger and satiety which are related to poor sleep time.[58] In the present study, the average amount of sleep in every cluster was ≥8 hours, (sleep pattern previously observed in a Spanish sample[14]). Moreover, sleep patterns have been not previously included in most clusters' studies in children and adolescents.

The strengths of this study were that it analyses a nationwide sample of children and adolescents in Spain as well as the use of clusters, which is an optimal technique that can help to obtain a holistic overview of the results. This type of analysis allows formulating some hypothesis about associations between a certain pattern of lifestyle, identified in the different groups during the analysis, and a defined outcome. Another strength is the harmonization between all the centers for the field work and the centralized data collection and processing. This research also has several limitations. First, the PASOS project is a cross-sectional study and, thus, authors cannot establish causality for the significant relationships identified. However, the large number of participants with complete data support the results and a representative dataset has been used for the analysis. Second, most of the variables were obtained using questionnaires and the results are based on self-reported data. Nevertheless, the conclusions have extensive clinical implications and incite forthcoming studies.

CONCLUSIONS

According to the clusters, among youngest participants, a high number was classified with low levels of PA and screen time, and high sleep time. Among adolescent group, the most prevalent behaviors characterized by clusters were very low levels of PA, sleep time, low adherence to MD, and high screen time and high prevalence of overweight and obesity. Our study included the analysis of typical behavioral patterns as PA, screen time, and adherence to MD but also some novel determinants like sleep

Table 2. Mean absolute values of cluster analysis in Spanish children and adolescents.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	F	*p* value
n (%)	431 (13.20%)	466 (14.30%)	537 (16.40%)	609 (18.70%)	804 (24.70%)	414 (12.70%)	–	–
Age	13.85 (2.31)^{2,3,5,6}	11.44 (2.14)^{1,4,6}	11.75 (2.03)^{1,4,6}	14.13 (2.36)^{2,3,5,6}	11.58 (2.25)^{1,4,6}	13.02 (2.20)$^{1-5}$	190.75	<0.001
WS WHO (%)	^{2,4}	^{1,3,6}	^{2,4,5}	^{1,3,6}	^{3,6}	^{2,4,5}	–	<0.001
Undernutrition	2.09%	1.51%	2.44%	0.83%	2.24%	2.67%		
Underweight	9.07%	4.54%	6%	6.28%	5.11%	7.28%		
Healthy Weight	58.84%	51.4%	64.17%	52.4%	55.24%	63.11%		
Overweight	17.91%	25.92%	18.76%	22.31%	22.07%	15.53%		
Obesity	12.09%	16.63%	8.63%	18.18%	15.34%	11.41%		
MVPA (min/day)	105.13 (35.72)$^{2-6}$	148.41 (39.83)$^{1,3-6}$	233.28 (59.48)$^{1,2,4-6}$	37.95 (28.58)$^{1-3,5,6}$	86.37 (35.09)$^{1-4,6}$	179.88 (52.53)$^{1-5}$	1541	<0.001
MVPA (min/wknd)	49.24 (36.18)$^{2-6}$	71.57 (35.57)$^{1,3-6}$	106.0 (39.56)$^{1,2,4-6}$	15.38 (22.03)$^{1-3,5,6}$	30.02 (27.51)$^{1-4,6}$	87.06 (36.04)$^{1-5}$	648.07	<0.001
Screen time (min wk/day)	280.58 (127.55)$^{2-5}$	83.33 (67.29)^{1,4,6}	92.54 (73.88)^{1,4,6}	249.18 (120.47)$^{1-3,5}$	92.22 (71.14)^{1,4,6}	262.31 (120.30)^{2,3,5}	508.32	<0.001
Screen time (min wknd/_day)	408.89 (142.05)$^{2-6}$	183.09 (118.60)^{1,3,4,6}	209.83 (132.00)$^{1,2,4-6}$	341.45 (138.44)$^{1-3,5,6}$	174.66 (116.41)^{1,3,4,6}	393.85 (145.92)$^{1-5}$	355.01	<0.001
Sleep time (min wk/day)	8.33 (1.18)$^{2-6}$	9.35 (1.14)^{1,4,6}	9.38 (1.05)^{1,4,6}	8.06 (1.12)$^{1-3,5,6}$	9.40 (1.12)^{1,4,6}	8.67 (1.08)$^{1-5}$	160.48	0.015
Sleep time (min wknd/day)	9.60 (1.66)^{2,3,5}	10.09 (1.68)^{1,4,6}	10.24 (1.48)^{1,4,6}	9.50 (1.48)^{2,3,5}	10.18 (1.54)^{1,4,6}	9.72 (1.57)^{2,3,5}	23.97	<0.001
KIDMED score	10.06 (2.31)$^{2-6}$	11.50 (2.14)$^{1,3-6}$	12.48 (2.00)$^{1,2,4-6}$	9.24 (2.36)$^{1-3,5,6}$	10.83 (2.25)$^{1-4}$	10.80 (2.20)$^{1-4}$	139.35	<0.001

Data are means and SD, unless otherwise indicated.

KIDMED the Kids' level of adherence to the Mediterranean diet, *MVPA* moderate to vigorous physical activity, *WS by WHO* categories of BMI according to the WHO classification.

*Analysis of variance for quantitative variables,$^{1-6}$ Superscripts indicate significant differences between clusters ($p < 0.05$). Pairwise comparisons were performed with Bonferroni's adjustment. Chi-squared tests for categorical variables. Superscripts indicate significant differences between clusters ($p < 0.05$).

time and WS. Furthermore, it has been done in a nationwide sample of Spanish children and adolescents. According to our results, health policies should be focused principally on promoting PA, MD, and sleep recommendations and reducing screen time for preserving youth health.

DATA AVAILABILITY

Data available under request.

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AUTHOR CONTRIBUTIONS

A.G.Z. and M.G.G. conceptualized and designed the study, R.A.U. and C.Q.G. run statistical analyses, A.G.Z., R.A.U. and M.G.G. drafted the initial manuscript and incorporated the suggestions of all the consortium authors, A.G.Z., R.A.U., C.Q.G., E.G., and M.G.G. wrote the manuscript. S.G. and H.S. are the coordinators of the PASOS study. All authors contributed to the methodology and data acquisition and reviewed the final version of the manuscript.

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COMPETING INTERESTS

The authors declare no competing interests.

PATIENT CONSENT

The parents and legal tutors of participant children received and signed an informed consent before the data collection.

ADDITIONAL INFORMATION

Correspondence and requests for materials should be addressed to Augusto G. Zapico.

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