

Article

The Hidden Effects of Lockdown on Child Health: Evidence from Madrid's ASOMAD Study

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Abstract: COVID-19-related restrictions disrupted children's lifestyle habits, leading to significant changes in health behaviours. The ASOMAD study aimed to analyse the consequences of these restriction in lifestyle habits of children aged 8–12 in Madrid over three waves (three academic years). The results showed that approximately 20% of boys were overweight during and after the pandemic, with similar trends observed in girls (14.7% and 18.2%, respectively). Obesity rates for boys were high in the first wave (20.1%) but dropped to less than 10% in subsequent waves, while girls' rates remained stable. Physical activity levels decreased significantly, with 87.6% of girls failing to meet daily activity recommendations by the third wave. Boys exhibited worse adherence to recommended screen time limits than girls, particularly on weekends, where over 90% of boys exceeded guidelines. Adherence to the Mediterranean diet remained low, with over 50% of the sample categorized in medium- or low-adherence groups across all waves. In conclusion, lockdown may have increased sedentary behaviour, poor diet, and excessive screen time in children. The damage persistency, due to mobility restriction, affected some of the healthy lifestyle variables in our sample three years after.

Keywords: healthy habits; COVID-19; children; health risk; prevalence



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1. Introduction

According to the World Health Organization (WHO), in 2022, over 390 million children and adolescents aged 5 to 19 were classified as overweight, of whom 160 million were living with obesity [1]. Beyond the issue of excess weight, these conditions reflect broader challenges related to lifestyle habits and health determinants that are vital for children's physical, emotional, and social development [2–5]. Lifestyle patterns established during childhood often persist into adulthood, influencing long-term health and well-being [6–17]. The consequences of obesity and unhealthy lifestyles extend beyond physical health, facing higher risks of type 2 diabetes, hypertension, and cardiovascular diseases [18–22]. Addressing these issues early in life is essential not only for preventing chronic diseases but also for fostering overall development, including mental, social, and

emotional health [23–26]. In fact, unhealthy behaviours, such as insufficient physical activity, excessive screen time, poor dietary choices, and inadequate sleep, are associated with psychological risks, including low self-esteem, anxiety, and reduced academic performance [27–36]. This study highlights the critical need to address unhealthy lifestyles. Implementing structured physical activity programs in schools and communities is essential to combat declining activity levels, while promoting healthy diet, especially in disadvantaged groups. Educating families and schools on setting limits for recreational screen time, is equally important to mitigate its negative effects on physical and emotional well-being. Following Baldassano et al. [37], integrating mindfulness, exercise, and nutrition programs offers a comprehensive approach to improving overall well-being. Regular monitoring of children’s health behaviours is vital to adapt interventions and reduce the long-term impacts of COVID-19, fostering healthier habits from an early age.

The COVID-19 pandemic began in Wuhan, China, in December 2019, leading to its declaration as a global health emergency by the WHO on 30 January 2020, and a pandemic on 11 March 2020. In Spain, the first case was confirmed on 31 January 2020, and a state of alarm was declared on 14 March 2020, initiating a nationwide lockdown [38].

Countries around the world implemented different restrictions to avoid the spreading of the SARS-CoV2 virus, being Spain one of the most restrictive countries in Europe [38]. Before the pandemic, unhealthy patterns among children were already a focus of public health attention, but overweight and obesity rates seemed to be stabilising somewhat in recent years [39,40]. Lockdown measures of COVID-19 further disrupted routines, limiting physical activity opportunities and increasing sedentary behaviours [41–44]. These effects were particularly pronounced in the city of Madrid (Spain), a densely populated city with over 3.2 million residents [45], where strict lockdown measures were carried out [46,47]. This situation combined with the city’s socioeconomic diversity, created unique challenges for promoting healthy lifestyles, as limited resources in some areas compounded the impact of the pandemic [48]. The COVID-19 pandemic has significantly influenced children’s health and lifestyle habits, exacerbating pre-existing concerns while also impacting other vulnerable populations, such as adolescents and postpartum women. Increased screen time, reduced physical activity, and heightened anxiety and depression were common issues, with postpartum women additionally facing caregiving burdens, limited healthcare access, and isolation. These findings align with this study, highlighting the need for targeted interventions, such as mental health support, structured activity programs, and enhanced social support systems, to address the long-term effects of lockdowns. Including data on these groups would provide a broader understanding of the pandemic’s psychological impact [2–8].

The aim of this study is to describe and analyse the lifestyle habits of children living in Madrid after the lockdown and during the following years.

2. Materials and Methods

2.1. Study Design and Participants

The ASOMAD study represents a cross-sectional cohort study designed to assess lifestyle habits, sedentary behaviours, and health status among a representative sample of school-aged children (8 to 12 years old), in the city of Madrid, and their evolution over time. Through a descriptive, exploratory, and incidental approach, this study utilized a multi-stage and random allocation method to select the target population. Three waves’ data were collected during the academic years 2020–2021, 2021–2022, and 2022–2023 late fall-winter seasons.

The summary of data collection timetable is shown in Figure 1. Children in Spain were confined to their homes from 14 March 2020, when a state of alert was declared due

to COVID-19, until 26 April 2020, when they were allowed out for the first time for short trips [48]. During this total confinement of 43 days, they could only leave their homes for essential needs, such as medical care or food shopping. Initial actions included school closures, access to playground was forbidden, and a shift to remote learning, from March to May 2020. School classes re-started in September 2020 under strict security measures. As restrictions eased, protocols such as mandatory face masks for children aged six and above, increased ventilation in classrooms, and the introduction of classroom bubbles in early education and primary schools were enforced (ASOMAD 1 data collection, Figure 1). The restrictions coinciding with the second wave of measurements (ASOMAD 2, Figure 1) were medium restrictions in the playgrounds, keeping smaller groups in the classrooms, and the use of face masks [46,47]. By January 2022, quarantine policies were relaxed, limiting isolation to seven days and discontinuing full-class quarantines for single positive cases. In Spain, COVID-19 vaccination campaigns for children began in stages. Adolescents aged 12 and older started receiving vaccines in June 2021. During the measures in the third wave, playgrounds and public spaces reopening was phased, with limited capacity and regular disinfection protocols initially in place, that started in. Over time, these measures were eased to restore normal activities while addressing the emotional and social needs of children following prolonged restrictions [48].

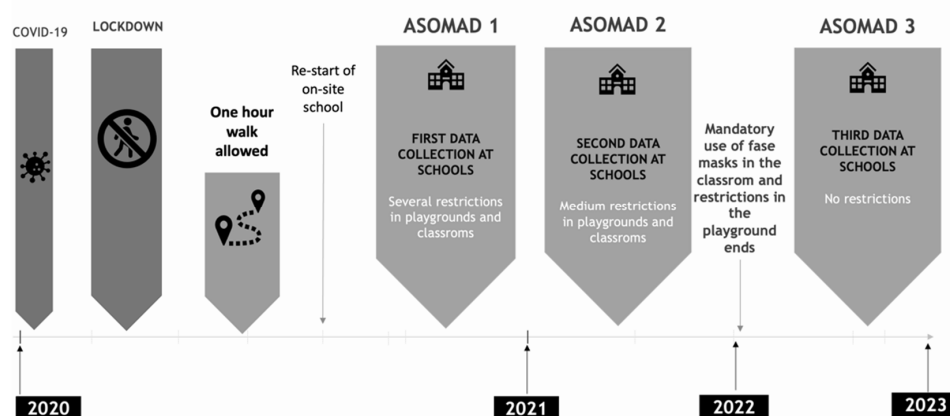


Figure 1. Data collection timetable ASOMAD Study.

2.2. Sample Size and School Selection

To fulfil the project objectives, a population sampling of 8-to-12-year-olds in Madrid was conducted by zones and/or districts. Figure 2 shows the process to get the target population. The 21 districts of Madrid city were considered as the first level of population grouping. From here, clusters of districts meeting the condition of being at a similar mid-level income (3 levels) and geographically close were formed (map explanation in Figure 2). These 21 districts were reduced to 10 clusters of homogeneous income and geographic proximity. A study of demographic data was conducted to gain knowledge of the total population and differences in the child/adult population ratio and other elements to consider for subsequent analyses according to the Institute of Statistics of the Madrid Community and Madrid City Council [45].

Upon this classification of 10 zones, the identification of the distribution of the school space in primary education corresponding to the study population was performed. This includes the number of schools that would form the target population and their classification by ownership.

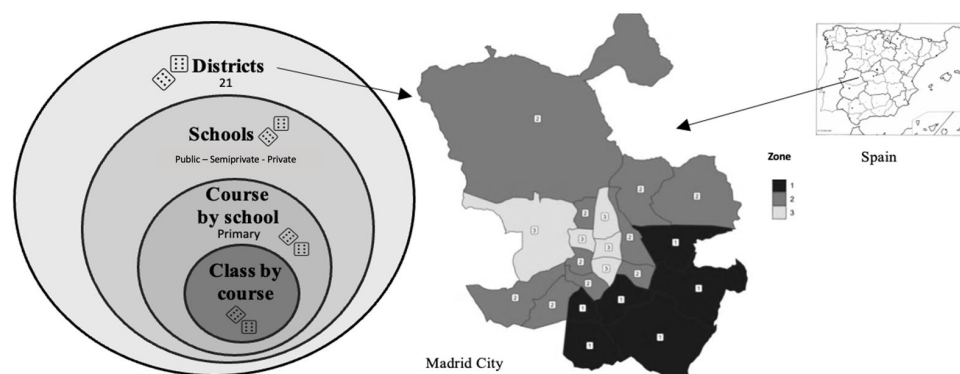


Figure 2. Multistage randomisation to obtain target sample.

The sample was estimated on classrooms of 25 pupils. This is the limit of students per classroom established by Spanish law at this educational stage [49]. A minimum of 70% response rate was considered, and an expected compliance of 360 final subjects, which has been achieved in all waves. The final sampling was affected by circumstances such as boosting the number of private or charter schools in some districts and having to use those from the district assigned to their area. In some schools, due to the low number of children in the selected course, it was decided to modify the course in which measurements were taken, always trying to balance the sample. The Income Indicator factor (3 levels) was taken as the most determining factor to identify homogeneous populations and for the sampling to be technically feasible with guarantees a population balance in terms of age and school ownership. In each of the 3 clusters of districts by Income, around 120 students were estimated to be necessary to complete the sample, to which 40 additional cases (10%) were added to ensure the sample in case of loss of estimated population.

Next, the distribution of courses (3rd, 4th, 5th, 6th) and school ownership (public, semiprivate, private) necessary for the sample to be representative of the population was calculated with the given size. Primary students in the city of Madrid presented the following distribution by school ownership: 40% public schools, 40% charter schools, and 20% private schools. It is considered similar across courses [45].

The census of schools in the city of Madrid characterized by their ownership and district group (categorization into 10 clusters) was considered, and a possible class to be interviewed was randomly assigned to them. Some were reserved for those guaranteeing their participation. This assignment was balanced by ownership and district group. Each of these participating schools belonged to a district of the city of Madrid (or in its adjoining district area, in those cases where there were no centres willing to participate in the district).

Once the school's administration approved participation, a senior researcher from the ImFINE research group delivered the documentation to the school to be passed on to the families, and once signed, the informed consent was returned to the school [49].

Researchers were vaccinated, and every 10 days, all researchers underwent serum IgG and IgM antibody COVID-19 testing, in addition to using PPE (Personal Protective Equipment), such as FFP2 masks and gloves. Additional safety measures, such as ventilating the rooms where the data was collected and measuring environmental CO₂, as well as the proper disinfection of measurement devices and computers after each subject's use, were also performed.

2.3. Inclusion and Exclusion Criteria

Children who were enrolled in a participating school were eligible for inclusion. Pupils with a severe intellectual disability that would have prevented them from responding to

the lifestyle questionnaires would have been excluded from the study; however, no such cases were present.

2.4. Materials

Anthropometric measurements were carried out using validated instruments. For height: SECA 217 Stadiometer, and waist circumference measurements with the SECA 201 measuring tape, with a precision of 0.1 cm (SECA, Hamburg, Germany). Bioimpedance analysis (BIA): Using the Tanita DC-240MA system (TANITA, Tokyo, Japan) providing weight, and percentage of body fat and water. Subsequently, the BMI was calculated as body mass (kg) divided by height (m²), and the weight status of the children was classified according to the cut-off points established by the WHO [50].

Furthermore, in this study encompassed various aspects of lifestyle variables, utilizing self-reported questionnaires validated by scientific literature and completed by the children themselves on-site in schools, under controlled conditions with support from the research team and school staff at each centre. Without influencing their responses, the following data were collected:

Moderate to Vigorous Physical Activity (MVPA) was assessed using the PAU7-S questionnaire [51]. This instrument collects information on the duration of MVPA over a period of seven days, providing insight into participants' physical activity levels throughout the week. The children with a low level of physical activity would be those who do not meet the minimum recommendations of 60 min of MVPA per day according to the WHO for these ages [52].

Mediterranean diet adherence (MDA) was evaluated using the KidMED Index questionnaire. This tool is used to assess the quality of the diet in children and adolescents. It is based on a 16-item questionnaire that evaluates different aspects of diet, focusing on adherence to the Mediterranean diet. The standard classification of the KidMED Index defines three categories: low adherence (0–3 points), medium adherence (4–7 points), and high or optimal adherence (8–12 points) [53]. For this study, results were classified into two categories: optimal adherence (≥ 8) and suboptimal adherence (< 8).

Screen time on weekdays (WK) and weekends (WD) were examined using the SSBQ (Screen Sedentary Behaviour Questionnaire) [54]. This questionnaire captures participants' daily screen time habits, including time spent on activities such as watching TV, using computers, playing video games, and the use of smartphones, offering insights into sedentary behaviour patterns, according to the WHO [52].

Emotional well-being (EW) and self-perceived health were assessed using the Kidscreen-10 questionnaire. This questionnaire gauge participants' emotional well-being and self-perceived health status, respectively, providing valuable information on mental and physical health outcomes. The Kidscreen-10 is a self-report questionnaire used to assess health-related quality of life in children and adolescents. Scores close to 50 are considered within the average range, suggesting no significant issues related to quality of life. Scores below 50 (-1 SD or more) indicate a perceived quality of life lower than 16% of the normative population. This could serve as a warning sign to investigate potential problems in areas such as emotional state or physical well-being [55].

Sleep time on weekdays (WK) and weekends (WD) were analysed using the SHSA (Sleep Habits Survey for children) test. The sleep time was calculated based on the time of waking up and going to bed reported by each child for WK and WD [56]. Children aged 8 to 12 should aim for 9 to 12 h of sleep per night, with consistent sleep routines, a screen-free environment before going to bed, and a cool, dark room to support physical and cognitive development according to the AASM (American Academy of Sleep Medicine, Centers for Disease Control and Prevention, National Sleep Foundation) [57].

Handgrip strength was measured using the TAKEI T.K.K. 5001 GRIP A (Takei, Tokyo, Japan) analogue hand dynamometer (2018) with a measuring range of 0 to 100 kg. This device provides an objective assessment of participants' hand grip strength, a proxy for overall muscle strength and physical fitness. The risk of strength (HSR) in children was analysed based on strength test results, with children who fell into the 25th percentile or lower considered at risk [58].

2.5. Statistical Analysis

Exhaustive data analysis was conducted using IBM SPSS Statistics Software (Version 28.0, released by IBM Corp. in 2023, Armonk, NY, USA) and Python 3.12. Descriptive statistics were initially calculated to provide an overview of the sample across three cross-sectional waves, with data stratified by sex. This analysis included means, standard deviations (SD), and percentages to assess the adherence rates to health guidelines (sleep, screen time, Mediterranean diet and physical activity) and evaluated risk levels associated with strength (as measured by dynamometry). Descriptive statistics served to identify trends and variations within the sample, facilitating comparisons across different waves and between males and females.

For inferential analysis, an analysis of variance (ANOVA) was applied to continuous health-related variables to examine the effects of either sex or time (waves differences) on these variables. The aim was to detect significant changes across the three waves and to determine whether these changes differed between boys and girls. In those cases where significant effects were observed, Bonferroni post hoc analyses were conducted to identify specific differences between waves. For categorical variables, the Chi-Square test was employed to assess the associations between sex and health-related outcomes across the three waves. Post hoc comparisons were carried out to locate significant differences and clarify where the associations varied over time. A linear mixed model (LMM) was carried out to assess differences in the variables by sex in each of the waves of the study, focusing on the interaction term time \times sex. Using LMMs, instead of the more common repeated measures ANOVA, allowed us to handle imbalances in sample sizes across groups and to more accurately model unexplained variability by incorporating random effects associated with the data structure. Additionally, the LMM provides greater statistical robustness, making more reliable and generalizable estimates.

These analyses allowed for a comprehensive evaluation of trends and sex-specific differences in health-related outcomes across the study period.

3. Results

The final sample of the ASOMAD study comprised 384 subjects (51% girls) in the first wave (ASOMAD 1), a total of 468 children (49% girls) in the second wave (ASOMAD 2), and 385 subjects (46% girls) in the third wave (ASOMAD 3). Descriptives are shown in Table 1. The number of subjects varies according to the number of positive consents in each wave, independently of each other. The flow chart can be observed in Figure 3.

Table 1. Descriptive sample.

Sex	ASOMAD 1			ASOMAD 2			ASOMAD 3			p Value		
	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	% N			
Boys	BMI (kg/m ²)	18.8 ± 3.9 (14–38)			18.6 ± 4.0 (10–38)			17.7 ± 2.8 (13–26)			<0.001 ↔ <0.001 ϕ <0.001 Ψ	
	BMI Group	Normal weight	96	51.3		152	63.9		153	75		0.002 ↔ 0.001 ϕ
		Overweight	53	28.3		48	20.2		30	14.7		
		Obesity	38	20.3		38	16.0		21	10.3		
	Strength Risk	0	162	86.6		210	88.2		186	89.4		<0.001 ϕ
		1	25	13.4		28	11.8		22	10.6		
	Handgrip Strength (kg)	16.1 ± 3.7 (7–34)			17.3 ± 4.0 (8–37)			18 ± 3.4 (9–30)				
	MDA	6.9 ± 2.5 (0–12)			7.2 ± 2 (0–12)			7.2 ± 2.4 (0–12)				0.039 ↔ 0.001 ϕ
	MDA Group	Low	19	10.1		18	7.6		17	8.2		0.047 ↔ 0.013 ϕ
		Medium	92	48.9		109	45.8		89	42.8		
		Optimal	77	41.0		111	46.6		102	49		
	Screen Time WK (min)	147.7 ± 162.6 (0–720)			125.7 ± 138 (0–660)			119.4 ± 131.2 (0–660)				0.012 ϕ
	Meets Screen Time WK	0	69	63.3		103	56.5		83	60.1		0.022 ↔
		1	119	36.7		134	43.5		125	39.9		<0.001 ϕ
	Screen Time WD (min)	282.9 ± 175.6 (15–720)			285.4 ± 186 (0–720)			257.8 ± 167.7 (0–720)				<0.001 ϕ
Meets Screen Time WD	0	14	92.6		16	93.2		11	94.7		<0.001 ϕ	
	1	174	7.4		221	6.8		197	5.3			
MVPA diary (min)	110.7 ± 65.7 (6–354)			139.5 ± 76.4 (4–396)			144.5 ± 72.2 (13–332)				<0.001 ↔ <0.001 ϕ <0.001 Ψ	

Table 1. Cont.

Sex	ASOMAD 1			ASOMAD 2			ASOMAD 3			p Value
	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	% N	
Boys	Meets MVPA 7 days per Week	0	132	70.2	141	59.2	128	61.5	<0.028 ↔	
		1	56	29.8	97	40.8	80	38.5	<0.001 ϕ	
	Sleep Time WK (hour)	9.8 ± 1.0 (6–12)		9.9 ± 1 (7–13)		9.8 ± 1.1 (5–12)		ns		
	Meets Sleep Time WK	0	25	13.3	32	13.4	29	13.9	0.003 ↔	
		1	163	86.7	206	86.6	179	86.1		
	Sleep Time WD (hour)	10 ± 1.7 (5–14)		10.2 ± 1.6 (6–16)		9.8 ± 1.7 (6–17)		<0.003 ↔		
	Meets Sleep Time WD	0	40	21.3	46	19.3	56	26.9	<0.001 ϕ	
		1	148	78.7	192	80.7	152	73.1		
	EW	40.8 ± 5.9 (20–50)		41.5 ± 5 (12–50)		41.6 ± 5.5 (20–50)		ns		
	BMI	18.2 ± 3.4 (13–33)		17.9 ± 2.9 (13–27)		17.9 ± 3.1 (1132)		<0.001 ↔ <0.001 ϕ <0.001 Ψ		
Girls	BMI (kg/m ²)	Normal weight	134	68.7	159	69.4	133	73.5	0.002 ↔	
		Overweight	44	22.6	49	21.4	33	18.2	0.001 ϕ	
		Obesity	17	8.7	21	9.2	15	8.3		
	Strength Risk	0	181	92.3	219	95.2	166	93.3	<0.001 ϕ	
		1	15	7.7	11	4.8	12	6.7		
	Handgrip Strength (kg)	15.6 ± 3.7 (3–28)		16.3 ± 3.8 (9–30)		17.4 ± 3.8 (9–26)				
	MDA	7.3 ± 2.3 (0–12)		7.6 ± 2 (0–12)		7.7 ± 2.2 (0–12)		0.039 ↔ 0.001 ϕ		
	MDA Group	Low	15	7.7	9	3.9	6	3.4	0.047 ↔	
Medium		93	47.4	96	41.7	71	39.9	0.013 ϕ		
Optimal		88	44.9	125	54.3	101	56.7			

Table 1. Cont.

Sex	ASOMAD 1			ASOMAD 2			ASOMAD 3			p Value	
	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	N%	M ± SD (MIN, MAX)	N	% N		
Girls	Screen Time WK (min)	103.5 ± 129 (0–720)			86.8 ± 101 (0–600)			83.6 ± 101.4 (0–720)			0.012 φ
	Meets Screen Time WK	0	94	52.0		109	52.6		83	53.4	0.022 ↔
		1	102	48.0		121	47.4		95	46.6	<0.001 φ
	Screen Time WD (min)	191 ± 170.6 (0–720)			182.7 ± 138 (0–690)			180.4 ± 138.6 (15–720)			<0.001 φ
	Meets Screen Time WD	0	38	80.6		39	83.0		22	87.6	<0.001 φ
		1	158	19.4		191	17.0		156	12.4	
	MVPA diary (min)	94.4 ± 55.2 (6–345)			102.9 ± 56.7 (15–358)			107.1 ± 58 (11–394)			<0.001 ↔ < 0.001 φ 0.003 Ψ
	Meets MVPA 7 days per Week	0	158	80.6		179	77.8		133	74.7	<0.028 ↔
		1	38	19.4		51	22.2		45	25.3	<0.001 φ
	Sleep Time WK (hour)	9.9 ± 1 (6–13)			10 ± 0.8 (7–12)			9.8 ± 0.9 (6–12)			ns
	Meets Sleep Time WK	0	26	13.3		21	29.1		25	14	0.003 ↔
		1	170	86.7		209	90.9		153	86	
	Sleep Time WD (hour)	10.5 ± 1.5 (6–14)			10.6 ± 1.6 (6–16)			10.4 ± 1.4 (6–17)			<0.003 ↔
	Meets Sleep Time WD	0	22	11.2		25	10.9		19	10.7	<0.001 φ
1		174	88.8		205	89.1		159	89.3		
EW	40.9 ± 5.8 (23–50)			41.2 ± 6 (22–50)			40.8 ± 5.4 (22–50)			ns	

Notes: No risk of strength 0; risk of strength 1. Did not meet recommendations 0; met recommendations 1. ↔: Differences between the 3 waves (ASOMAD 1, 2 and 3). φ: Differences by sex (whole sample). Ψ: intersection sex * time. ns: No significance marked as ns for all variables or blank if there are one or two significant interactions in the variable. M: Mean. SD: Standard Deviation. MIN: Minimum. MAX: Maximum. N: Sample size. BMI: Body Mass Index. MDA: Mediterranean Diet Adherence. WK: Weekdays. WD: Weekend. MVPA: Moderate to Vigorous Physical Activity. EW: Emotional Well-being.

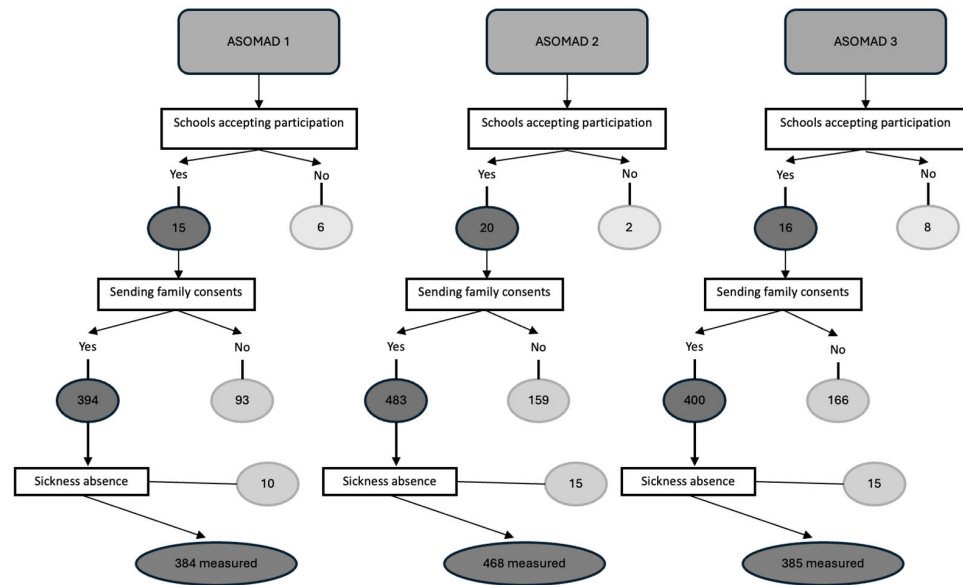


Figure 3. Flow chart on sample collection ASOMAD 1,2,3.

BMI: Significant differences were found in BMI categories across the three waves ($\chi^2(4) = 17.356, p = 0.002$), showing a trend toward increased overweight prevalence and stabilization in obesity cases (Table 1). Boys exhibited higher rates of overweight and obesity compared to girls, particularly in the first wave, where 20% of boys were classified as obese versus 8.7% of girls ($p < 0.001$). Post hoc analysis revealed a significant increase in overweight prevalence in the second wave, with time and sex having a significant influence on BMI variation ($p < 0.001$).

Strength Risk (HSR): Chi-square analysis was used to examine the effect of time and sex on the HSR variable. Regarding the wave, no significant differences were observed in the distribution of HSR ($\chi^2(2) = 1.202, p = 0.548$). This suggests that the percentage of boys and girls with and without risk remained constant over the three waves of evaluation, with no relevant changes. In terms of sex, significant differences were identified in the HSR variable ($\chi^2(1) = 11.498, p < 0.001$). Boys showed a significantly higher percentage of risk compared to girls in all waves (Table 1). The likelihood ratio test ($p < 0.001$) and the linear-by-linear association ($p < 0.001$) confirmed these differences. Additionally, Fisher’s exact test also yielded significant results ($p < 0.001$), reinforcing the robustness of the association between sex and the presence of HSR.

MDA: The analysis of MDA revealed significant results in relation to the three waves and sex (Table 1). The mean KIDMED index for both sexes across all measurement waves indicated suboptimal adherence (<8 points in the index). In the first wave, 59% of boys and 55.4% of girls were classified as having suboptimal adherence (KIDMED groups 1 and 2; Table 1). Although the percentages of suboptimal MDA decreased in subsequent waves, they remained above 50%: for boys, 53.4% in the second wave and 51% in the third wave, while for girls, these percentages were 45.6% in the second wave and 43.3% in the third wave. This yields a significant effect of time ($p = 0.039$) and sex ($p = 0.001$), evidencing those girls consistently scored higher on the KIDMED index compared to boys across all analysed waves. The interaction between time and sex was not significant ($p = 0.339$). Although, as shown in Figure 4, the adherence trend among girls has been consistently better across all waves, with steady progress nearing the optimal score compared to boys.

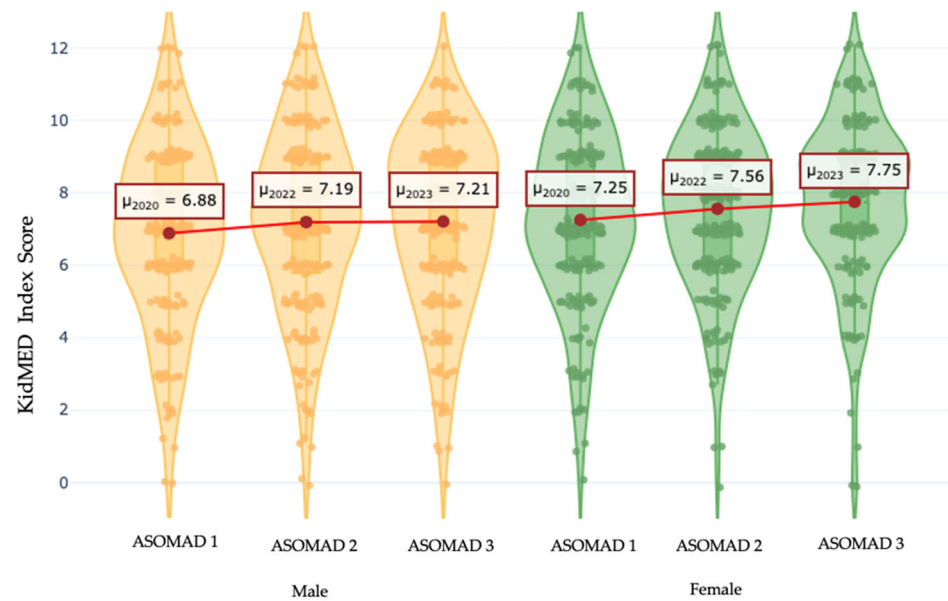


Figure 4. Distribution of adherence to Mediterranean diet by sex and time (2020–2023). Means (μ) are highlighted in red for each group and wave. A linear mixed model analysis was conducted, indicating no statistically significant differences between groups ($F = 0.38$, $p = 0.537$). Data for males are shown in orange, and data for females are shown in green.

Screen and Sleep Time WD and WK: The analysis of screen time during WD revealed a decreasing trend over the three waves of study. The two-way ANOVA indicated a significant effect of both wave ($p = 0.022$) and sex ($p < 0.001$). However, no significant interaction was observed between these factors ($p = 0.903$), suggesting that the variation in screen use was not dependent on the combination of wave and sex. The post hoc analysis showed a marginally significant difference between the first and third waves ($p = 0.050$), indicating a change in screen usage patterns over time. Despite these trends, over half of the sample did not comply with screen time recommendations in any of the analysed waves. Boys exhibited a higher percentage of non-compliance compared to girls, with a mean difference of approximately 10% in all waves (Table 1). Regarding WK, no significant differences in usage time were identified over the time ($p = 0.265$), although marked differences between sexes were observed ($p < 0.001$). Boys consistently exhibited higher screen use compared to girls in all evaluated waves, with no significant interaction between time and sex ($p = 0.533$). Over the three waves, more than 90% of boys did not comply with screen time recommendations during WK, a significantly higher percentage compared to girls, who showed around 80% non-compliance (Table 1), being exceptionally high in both sexes.

The sleep results were positive, generally meeting the recommendations. There was a low percentage of children, both boys and girls (Table 1), who did not meet the recommendations across all three waves of measurement.

MVPA: Significant differences were found in the ANOVA. Weekly MVPA levels were influenced by time, sex, and the interaction between both factors ($p < 0.001$). The post hoc analysis revealed a significant decrease in MVPA between wave 1 and both waves 2 and 3 ($p < 0.001$ in both cases), while no significant differences were observed between waves 2 and 3. Regarding the influence of sex, girls showed a greater increase in minutes per day of MVPA during the evaluated period ($p < 0.05$).

The significant interaction between time and sex ($p = 0.003$) suggests that the evolution of physical activity over time varies according to sex (Figure 5). Table 1 shows high percentages of non-compliance with MVPA recommendations over the 7-day week for both

sexes throughout the study period. For boys, 70.2% did not meet the recommendations in the first wave, decreasing to 59.2% in the second wave, only to slightly increase again to 61.5% in the third one. In contrast, girls exhibited an upward trend in non-compliance, with 80.6% in the first wave, 83.0% in the second wave, and 87.6% in the third wave. These results reflect a decreasing trend at weekly MVPA over time, particularly in the female population, leading to an increase in the percentage of girls not meeting MVPA recommendations during the week. Despite the slight improvement observed in boys during the second wave, the percentage of non-compliance remains high.

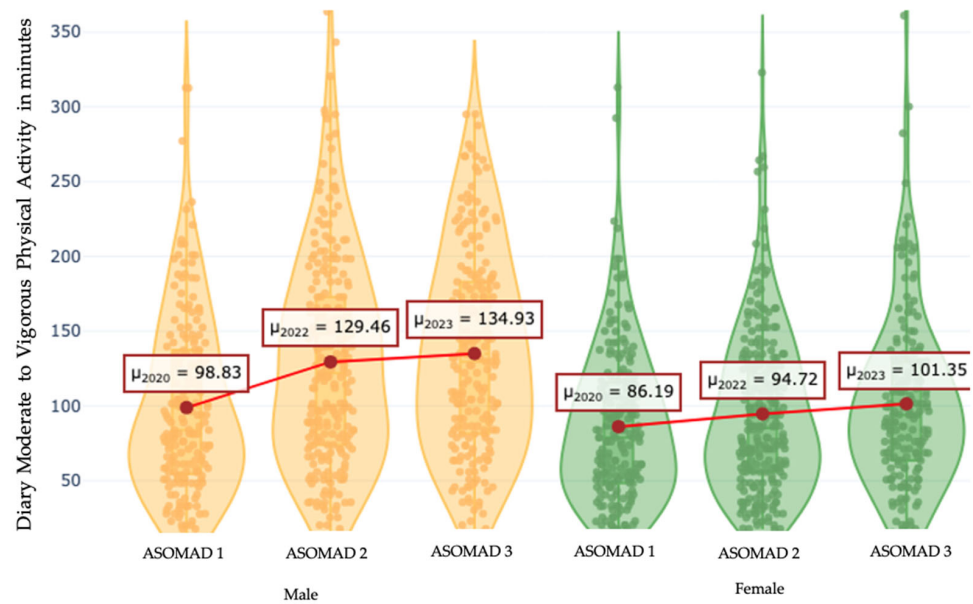


Figure 5. Distribution of daily moderate to vigorous physical activity in minutes by sex and time (2020–2023). Means (μ) are highlighted in red for each group and wave. A linear mixed model analysis was conducted, indicating statistically significant differences between groups ($F = 8.57$, $p = 0.00348$). Data for males are shown in orange, and data for females are shown in green.

EW: In the ANOVA conducted for the Kidscreen-10 variable, differences in the subjective well-being of children were examined based on the wave of evaluation and the sex of the participants. The ANOVA indicated no statistically significant differences in Kidscreen-10 scores between the different waves ($p = 0.501$), nor between sexes ($p = 0.295$). Additionally, no significant interaction between time and sex was found in the LMM ($p = 0.339$).

4. Discussion

According to the MAPFRE study [59], during the COVID-19 pandemic, Spain presented a relatively low restriction index compared to other European countries. Italy imposed much stricter restrictions, as did Greece, which recorded some of the highest restriction indices. In contrast, countries such as the United Kingdom and Spain showed similar levels of restriction, as did Chile in South America. Some Asian countries, New Zealand and Iceland, however, had much lower indices. Nevertheless, in the specific case of Madrid city, the restrictions were more stringent than in other regions of Spain, which could have had a differentiated impact on children’s lifestyle habits. Comparing these data with those from other countries allows for a better understanding of the possible similarities and differences in observed lifestyle changes, with the policies of restriction likely playing a significant role in shaping children’s behaviour.

The findings in our study reveal a notable increase in overweight prevalence, particularly among boys, and a stabilisation in obesity rates. Sex and the timing of evaluations influenced patterns in the different variables measured.

In relation to BMI, our results align with national findings from PASOS 2019 [60], ALADINO 2019 [39,61], and PESCA studies [62], which previously documented gender-specific trends in overweight and obesity among Spanish children (in the PESCA study, overweight is considered both overweight and obesity for data; results are shown according to the International Obesity Task Force). PASOS 2019 reported normal-weight prevalence at 65.1%, with overweight at 20.7% and obesity at 14.2% (children aged 6–12 years), particularly among boys [60]. Similarly, ALADINO 2019 indicated 24.7% overweight in girls and 21.9% in boys, aligning with our findings in which girls retained similar overweight and obesity rates as those reported before the pandemic [39]. Conversely, boys showed a significant rise in overweight immediately post-lockdown, reaching 28.3% overweight and 20.3% obesity in the first post-lockdown wave. Similarly, PESCA (2018–2021) showed a progressive increase in overweight (from 17.8% in 2018 to 26.57% in 2021) [62].

This increase underscores the distinct impact of the lockdown, leading to nearly 50% of boys in our sample presenting excess weight, which was notably higher than data reported pre-pandemic and in the PESCA study [62,63]. In relation to European data, a study performed in Italy (similar cross-sectional study with a similar children age) evidenced a similar increase from 10.8% to 17.6% in the first wave, with a slight reduction to 15% in the second [41]. However, obesity in this study increased significantly, from 7.8% to 20.5% over two waves (2019 to 2021) [41]. The WHO's COSI 2018–2020 data illustrate a heightened prevalence of overweight and obesity in Mediterranean countries, with countries like Cyprus and Greece reporting overweight and obesity rates of 48% and 44% in boys, respectively [64]. By comparison, ASOMAD study data showed post-lockdown prevalence (overweight and obesity together) for boys at 48.6%, with a stabilisation to 36.2% in the second wave. This trend suggests a significant yet temporary increase following lockdown, with gradual improvement as restrictions lifted. When compared to England's data [64], where combined overweight and obesity reached 35.2% pre-pandemic and rose to 37.8% post-lockdown, the Madrid child population appears to have experienced a more pronounced BMI increase post-lockdown, particularly among boys [64].

Our findings on MVPA and screen time raise significant concerns [60]. The post-lockdown period showed a continued decline in MVPA, particularly among girls (8–16 years), with 87.6% non-meeting physical activity guidelines by the third wave. The PESCA study reported data of physical activity defined as the percentage of participants who report engaging in physical activity, excluding the teaching hours of the physical education subject at school. A significant increase in those non-meeting the recommendations has been observed between the second and the third-wave data collection (14.5 to 28.10%) [62], while in Italy, MVPA compliance dropped from 8.6% before COVID-19 to 29.4% during the pandemic [41]. The COSI study also highlights varied compliance with MVPA recommendations, with higher MVPA observed in Croatia (10%) compared to lower rates in Greece (19% boys, 30% girls) [64]. These declines coincide with the restrictions imposed during lockdown and the challenges in returning to previous activity levels, particularly among girls, as reflected in both PESCA and ASOMAD studies [62]. Our non-compliance rates are significantly higher compared to other studies; however, it is important to note that our criteria for compliance require adherence across all seven days of the week. These trends suggest a potential long-term reduction in physical activity levels, possibly influenced by limited opportunities for structured physical activity post-lockdown. In regard to the screen time, boys showed elevated on both WD and WK, with 90% exceeding screen time recommendations on WK. This pattern is consistent with PASOS 2019 [60], where

56.5% of boys did not meet screen time recommendations on WD, rising to 85.3% on WK (8–12 years). Screen use, extensively documented in PESCA study [62], also emerges as a relevant factor. Although there were improvements in screen time among younger children in the third year of [62], the overall increase when including those over 10 years old highlights a shared problem between studies from Italy and ASOMAD [41], where screen-related sedentary behaviour seemed to have significantly impacted children's health. For screen time, data show moderate compliance, with countries like Croatia reporting 45% of boys not meeting screen time recommendations [64], contrasting sharply with our findings in Madrid, where non-compliance was much higher, particularly in boys. However, Italy, a Mediterranean country with similar lockdown stringency, revealed an alarming increase in screen time during the pandemic. One study showed that 75% of children exceeded screen time recommendations, with boys reporting higher usage than girls, similarly, in Greece, pre-pandemic estimates of non-compliance with screen time limits (approximately 60%) rose to nearly 85% during the lockdowns, emphasizing how pandemic restrictions amplified sedentary behaviours across the Mediterranean region [41,43,64].

In the same way, MDA in our sample showed suboptimal levels, with an average score on the KIDMED index below 8 for both sexes throughout the evaluated waves. These results are consistent with previous studies, such as ALADINO 2019 and MUGI Project [61,65], which found that more than 75% of children presented insufficient MDA, highlighting an ongoing issue in children's dietary habits in Spain even before the lockdown. While some studies reported a slight improvement in MDA during the lockdown [65], in our research, the percentage of children with optimal MDA remained below 15% in the third wave, suggesting that post-pandemic challenges, such as limited access to fresh foods and changes in eating patterns, may have negatively affected adherence to a healthy diet. At the national level, the PASOS study [60] indicated an average MDA of 6.86 for boys and 6.68 for girls, with values ranging between 6.5 and 7 points for both sexes, demonstrating that no group achieved the optimal average of 8 points at any stage [3]. In this context, 41.9% of boys and 38.8% of girls were classified as having a low level of adherence (<8 points on the KIDMED index). When differentiated by waves, the percentage of boys and girls reaching a high level in PASOS study was only 45.7% [60], which aligns with the low levels observed in our sample and reinforces the notion that adherence to healthy dietary patterns was low even before the pandemic. At the European level, Palermi et al., reported an increase in the consumption of unhealthy foods during the pandemic compared to previous periods [41]. Also, the COSI study by the WHO reported low adherence to healthy diets in children aged 6 to 9 years, with less than 50% of children consuming fruit daily and only 22.6% consuming fresh vegetables regularly before the COVID-19 [64]. The data regarding adherence to healthy diets reflect notable variations between countries, being higher in the Mediterranean area like San Marino (80.8%) and Italy (72.6%) [64], compared to regions in Central Asia, where daily fruit consumption is significantly lower, such as in Kyrgyzstan (18.1%) [64]. These differences are also observed between sexes, with a greater tendency for girls to consume fruit daily compared to boys, a pattern also seen in our sample.

Regarding EW, our findings show a general stability in emotional health levels over the evaluation period, suggesting a notable resilience in children despite lifestyle changes brought about by the pandemic. However, studies such as PASOS have presented data broken down by specific items [60], offering a more detailed view of emotional aspects like sadness and loneliness. This focused analysis by PASOS identified a worrying increase in feelings of sadness and loneliness over time, showing that a high percentage of children felt lonely and sad as the post-lockdown period progressed [60]. This rise in negative emotions is significant, as it suggests that, while general well-being data may appear stable,

a more granular breakdown could reveal substantial emotional challenges that warrant attention [3,60]. Our findings, by not addressing these specific items, may underestimate emotional health aspects that require targeted interventions. Future studies should take a closer look at the details of EW, especially when it comes to understanding how the pandemic has affected children's mental health over time [1,3,60]. Conversely, HSR analysis indicated that boys exhibited a higher risk compared to girls across all evaluation waves, consistent with existing literature that identified biological factors contributing to greater muscular strength in boys [58]. Notably, there were no significant changes in HSR over the three waves, implying that pandemic-related restrictions did not significantly impact this area of health [27,66–68].

5. Conclusions

In conclusion, this study suggests that COVID-19 mobility restrictions may have negatively impacted the health habits and lifestyles of children in the city of Madrid, with a possible increase in the prevalence of overweight, and a potential decline in physical activity levels, especially in girls. There may also have been suboptimal MDA and excessive screen time, particularly among boys. While HSR showed no significant changes, the results suggest that unhealthy habits may have persisted even three years after the lockdown, especially for boys. These findings highlight the need for public health interventions that promote physical activity, improve dietary habits, and regulate screen time, with a particular focus on boys.

The behavioural risks identified in this study highlight the need for long-term public policies that promote sustainable habit changes. Given the time required to modify behaviours, interventions must reach as many people as possible and be tailored to gender-specific needs. Reducing screen time, particularly in boys, requires coordinated efforts through education, structured leisure activities, and school regulations. In contrast, increasing MVPA in girls calls for targeted initiatives, such as inclusive physical activity programmes and team-based sports. Additionally, improving adherence to the MDA, especially in boys, necessitates school-based nutrition education and enhanced access to fresh foods. These policies are essential to fostering lifelong healthy habits and mitigating the negative effects identified.

One limitation of this study is the lack of pre-pandemic data specific to the study area, which prevents a direct comparison of trends before and after COVID-19. Instead, we rely on findings from national studies such as PASOS and ALADINO, which reported similar behavioural patterns in Spanish children prior to the pandemic. While our results suggest that the pandemic may have exacerbated sedentary lifestyles and unhealthy behaviours, these trends were already present, making it difficult to attribute them exclusively to COVID-19. Future research should consider longitudinal designs that include pre-pandemic data to better isolate the effects of the pandemic on children's health and lifestyles.

Another limitation of this study is that the questionnaires administered in some cases may suffer from a certain bias, despite explanations and attention from the researchers, the questionnaire is self-reported by young children who may not have fully understood some of the questions.

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Institutional Review Board Statement: ASOMAD protocol meets the criteria of the Declaration of Helsinki of the World Medical Association (64th General Assembly, Fortaleza, Brazil, October 2013) for research on human beings, of the Oviedo Convention on Human Rights Man and Biomedicine (Council of Europe, 1997). And was approved by the Ethics Committee of the Universidad Politécnica de Madrid (number 20200727-1).

Informed Consent Statement: Informed consent was obtained from all subjects' parents or legal guardians involved in the study.

Data Availability Statement: The ASOMAD study is now complete, and data collection has ceased. The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions, as they include sensitive information derived from medical records and clinical examinations.

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