

# Risk of Obesity Among Children Aged 2–6 Years Who Had Prolonged Screen Time in Taiwan: A Nationwide Cross-Sectional Study

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**Objective:** To evaluate the risk of obesity in preschool children with prolonged screen time in Taiwan.

**Methods:** Using a nationwide survey with random sampling, we collected information on 8378 preschool children aged 2–6 years among 206 preschools in Taiwan from 2016 to 2019. Socioeconomic data, body mass index, and lifestyle of the preschool children and their caregivers were compared among the groups of preschool children who had moderate and prolonged daily screen time. We used multiple log-binomial regression models to calculate the adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of obesity associated with prolonged screen time.

**Results:** The prevalence of obesity in the preschool children was 13.1%, and the average screen time was 104.6 minutes. Children's age, sleep hours, outdoor play time, sugar intake, snack eating before dinner, sleep disturbance, and obesity, as well as caregiver's sex, age, education, screen time, exercise time and parent obesity were factors related to high screen time for preschool children. Compared with children with moderate screen time, children with prolonged screen time had a higher risk of obesity (PR, 1.45; 95% CI, 1.18–1.79). With a 60-minute increase in screen time, the risk of obesity increased, with an PR of 1.10 (95% CI, 1.03–1.17).

**Conclusion:** Preschool children with prolonged screen time had an increased risk of obesity in Taiwan. Interventions may be needed for this very susceptible population.

**Keywords:** digital media, obesity, preschool children, screen time, television

## Introduction

Prolonged screen time has become a crucial public health problem worldwide that is associated with poor health outcomes in young children, including obesity, sleep disturbance, and aggressive behavior,<sup>1–6</sup> as well as a risk of increasing depression,<sup>7</sup> exposure to violence and unsafe content and contacts,<sup>5</sup> and negative language development.<sup>8</sup> It also has immediate correlations with being sedentary.<sup>6,9</sup> The reported prevalence of screen time in children has widely varied because of differences in age, gender, socioeconomic status, lifestyle, and home education.<sup>4,10–13</sup> In Canada, a recommendation of screen time for young children claimed that no screen time is recommended for children under 2 years of age and that screen time should be limited to less than 1 hour to 2 hours a day for children aged 2 to 4 years;

parents should help their children to meet this goal.<sup>14</sup> The American Academy of Pediatrics also indicated that 2- to 5-year-old children should not use media over 2 hours per day;<sup>3,6</sup> in addition, some research suggests that preschool children should spend less than 2 hours per day engaging in screen time.<sup>15,16</sup>

However, the average daily screen time among preschool children varies by age and country, ranging from 71.3 minutes in Canada to 125.7 minutes in Switzerland.<sup>9,14,17,18</sup> In America, approximately 63.4% of obese preschool children spend over 2 hours per weekday in screen time.<sup>10</sup> Australian children aged 3–5 years spent 108.5 minutes per day in screen time.<sup>9</sup> In Asia, Japanese preschool children had an average of 118.6 minutes in screen time in 2018.<sup>19</sup> Among preschool children aged lower than 5 years in Bangladesh, the average of screen time is 160.9 minutes in 2019.<sup>20</sup> Preschool-aged children in Hong Kong had an average of 147 minutes in screen time in 2019–2020.<sup>21</sup> Although screen time showed little differences among countries, there still appears to be an increase in screen time in preschool children worldwide,<sup>22</sup> particularly during the COVID-19 pandemic period and we need to consider some solutions to seriously reduce and limit screen time.<sup>20,23</sup>

Because overweight or obesity starting at a young age commonly persists to old age, obesity prevention needs to be focused on the preschool stage.<sup>10,24</sup> Parents' practices and beliefs is one of factors related to children's lifestyles. It was suggested that making rules for screen time and controlling the home environment may be helpful to maintain children's health physical status, including normal body mass index.<sup>25,26</sup> If parents restricted the screen time of preschool children, they were more likely to achieve the Academy of Pediatrics recommendation of screen time.<sup>3,25</sup>

Although the problem of prolonged screen time in preschool children with overweight or obesity has been raised in previous studies,<sup>10,11,15,26–28</sup> the association between screen time and obesity risk in preschool children remains incompletely understood because of some study limitations, such as small sample sizes,<sup>15,26,28</sup> nonrandom sampling,<sup>15,26</sup> inadequate control for potential confounding factors,<sup>15,26–28</sup> and a lack of detailed information on screen time.<sup>10,27</sup>

In addition, limited information was available regarding the screen time in preschool children in Taiwan. The purpose of this study was to investigate the association between screen time and obesity status among preschool children in Taiwan using a nationwide survey with random sampling.

## Methods

### Source of Data

Taiwan is an island nation with a population of approximately 23 million people. This survey was conducted from October 2018 to March 2019 using mailed questionnaire interviews with preschool children's parents or caregivers. We randomly selected preschools from an official list, and these preschools were legal and regulated by Taiwan's Ministry of Education. We made telephone calls and queried the possibility of the school participating in this questionnaire-based survey. At the beginning of the telephone call, the interviewer explained the study purpose and asked if the person in charge of the preschool would participate in the interview. We mailed questionnaires to the preschools when obtaining the agreement to participate. We calculated the adequate number of preschools to include according to the populations of each city or county until the number of participating children reached appropriately six thousand per year. This study included three years of data; we collected each year of data from October to December through January to March of the next year. These cities or counties included northern areas (Taipei City, New Taipei City, Keelung City, Taoyuan City, Hsinchu City, Hsinchu County, and Yilan County), central areas (Miaoli County, Taichung City, Changhua County, Nantou County, and Yunlin County), southern areas (Chiayi City, Chiayi County, Tainan City, Kaohsiung City, and Pingtung County) and eastern areas (Hualien County, Taitung County) and outlying islands of Taiwan.

### Study Population

Before the formal investigation, we conducted a pilot study in 2016 to ensure the validity and reliability of the questionnaire.<sup>29</sup> To establish the surface validity and content validity of the questionnaire, we invited five professional experts to participate in the review and revision of the preliminary questionnaire (revising semantics of sentences or uncertain words). Then, a total of twenty-two main caregivers of preschool children who had been asked to complete the

same questionnaires twice within two weeks were asked to pretest the questionnaire to detect the test-retest reliability, with a coefficient of 0.891, which reached the acceptable range.

The formal questionnaires were sent to the preschools after a phone invitation to obtain agreement. After the questionnaires were sent to the preschools, teachers or administrative staff helped to give the questionnaires to parents or caregivers. After completing the questionnaire, the parents or caregivers returned them to preschool staff in two weeks; if they did not agree to participate in the survey, they could choose to not return the questionnaire or to return a blank questionnaire. When collection had finished, the preschool staff sent the returned questionnaires back to us. We invited the main caregivers to answer questions and complete the questionnaire including the information of preschool children's lifestyle habits, health status, height, weight, sleep patterns and other related factors of preschool children's daily life. In this study, we considered that preschools were registered in the official list of the Bureau of Education were eligible preschools. Children studied in the registered preschools were eligible study subjects.

The [Supplementary Figure S1](#) showed the selection process of study subjects. In the first study year (from October 2016 to January 2017), we randomly selected 122 preschools from the official list of Ministry of Education that included all preschools (6735 preschools) in Taiwan. With the contact by mail and telephone, we received the consent and approval from 75 preschools and 6120 questionnaires were mailed. Then, there were 67 preschools completed and returned 4327 questionnaires. After careful review, checkup, and evaluation of the content of questionnaires (excluding the missing data in age, sex, BMI, and screen time), there were 3075 eligible children were enrolled in this study. In the second study year (from December 2017 to March 2018), we randomly selected 142 preschools from the official list of Ministry of Education that included all preschools (6729 preschools) in Taiwan. With the contact by mail and telephone, we received the consent and approval from 97 preschools and 5789 questionnaires were mailed. Then, there were 70 preschools completed and returned 3409 questionnaires. After careful review, checkup, and evaluation of the content of questionnaires (excluding the missing data in age, sex, BMI, and screen time), there were 2443 eligible children were enrolled in this study. In the third study year (from November 2018 to January 2019), we randomly selected 137 preschools from the official list of Ministry of Education that included all preschools (6721 preschools) in Taiwan. With the contact by mail and telephone, we received the consent and approval from 94 preschools and 5908 questionnaires were mailed. Then, there were 69 preschools completed and returned 3746 questionnaires. After careful review, checkup, and evaluation of the content of questionnaires (excluding the missing data in age, sex, BMI, and screen time), there were 2860 eligible children were enrolled in this study. Finally, we collected adequate information from 8378 preschool children. Overall, the response rate of preschools was 51.3% (206/401) and the participation rate of children was 47% (8378/17817).

Among 8378 preschool children, informed consent was obtained from the main caregivers. Our study complies with the Declaration of Helsinki. This study was evaluated and approved by the Institutional Review Board of Fu-Jen University, Taiwan (C105002 and C105122).

## Exposure

Screen time was defined as time spent on screen-based media, such as watching television, DVDs, or videos or playing computer or video games,<sup>1</sup> as well as smart phone and tablet usage. Main caregivers (parents) responded to the questionnaire regarding their children's television time and digital devices time by their observation and memory. We calculated the daily screen time included daily television time plus daily digital devices time. According the international recommendations of screen time,<sup>30–32</sup> preschool children in this study were categorized into two groups as moderate screen time (1.0–4.9 years of age:  $\leq 60$  minutes per day; 5.0–6.9 years of age  $\leq 120$  minutes per day) and prolonged screen time (1.0–4.9 years of age:  $> 60$  minutes per day; 5.0–6.9 years of age:  $> 120$  minutes per day).

## Outcomes

Preschool children's height and weight were measured by caregivers or preschool teachers. The body mass index of preschool children was calculated according to the latest available growth curve standard of Taiwanese children and adolescents, which was announced by the Ministry of Health and Welfare of Taiwan,<sup>33</sup> to classify the body mass index standard of preschool children by age. The categories of body mass index include lean (the growth curve standard is

lower than the 5th percentile), normal (the growth curve standard is between the 5th and 85th percentile), overweight (the growth curve standard is higher than the 85th and lower than or equal to the 95th percentile), and obesity (the growth curve standard is >95th percentile).<sup>33</sup> Based on the above four growth curve categories, the preschool children in this study were divided into an obesity group (the growth curve > 95th percentile) and a non obesity group (the growth curve ≤ 95th percentile).<sup>33</sup>

## Covariates

The content of the questionnaire included basic characteristics of the preschool children, such as sex, age, height, weight, screen time (including time spent watching television, videos or DVDs and playing with computers, tablets, smartphones or video games),<sup>1,8,10,13</sup> sleep hours, sleep disturbance, outdoor play time, and other related lifestyle habits; information was also collected regarding the personal characteristics of the caregiver, such as sex, age, education, and other related lifestyle habits.

Eating snacks were defined as preschool children eating snacks before dinner frequently. Daily intake of sugar was categorized into three groups including seldom, sometimes, and frequently. We also collected the information of outdoor play time and it was divided into three groups included 0–60 minutes/day, 61–120 minutes/day, and >120 minutes/day.

We used the standards of sleep time duration recommendations of the National Sleep Foundation to distinguish sleep hours.<sup>34</sup> If the sleep hours of preschool children not meeting age-specific sleep recommendations (1.0–2.9 years: 11.0–14.9 hours/day; 3.0–4.9 years: 10.0–13.9 hours/day; 5.0–13.9 years: 9.0–11.9 hours/day), it meant preschool children had sleep deprivation. Sleep disturbance was defined as sleep problems occurred in the duration of sleep included sleep talking, primary snoring, sleep terrors, nightmares, obstructive sleep apnea, and sleep walking and excluded enuresis and bruxism which often happen at preschool children.

Caregivers are the main person responsible for taking care of the daily routine of preschool children at home, and caregivers are usually the parents of the preschool children. In this study, caregivers included mothers (85.49%), fathers (6.46%), grandmothers (5.74%), grandfathers (1.41%) and other relatives (0.90%). Caregiver education was divided into four groups: high school (caregiver education lower than and equal to high school), college, university, and graduate school (caregiver education higher than and equal to graduate school). According to the criteria from the Ministry of Health and Welfare in Taiwan, caregiver's obesity was defined as body mass index  $\geq 27$  kg/m<sup>2</sup> in this study.<sup>35,36</sup>

## Statistical Analysis

We used chi-square tests and t tests to compare the distribution of the characteristics among preschool children with low, moderate and high screen times. The characteristics of caregivers were also examined by chi-square tests and t tests among children with low, moderate and high screen times. Multiple log-binomial regression models were used to calculate adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) of screen time associated with obesity. Stratified analyses by age, sex, and other characteristics were also performed by calculating adjusted PRs and 95% CIs to investigate the association between prolonged screen time and obesity in preschool children. We also calculated the risk of obesity in children with prolonged screen time compared with children had zero screen time (caregivers reported their children had no) in the [Supplementary Table S1](#). All analyses were performed with SAS software, version 9.4 (SAS Institute Inc., Carey, NC).

## Results

Among 8378 preschool children with a mean age of 4.91±0.95 years ([Table 1](#)), the prevalence of obesity was 13.1%. Preschool children spent an average of 104.6±81.1 minutes per day on screen time, and 46.6% of them had prolonged screen time. A higher proportion of prolonged screen time existed among children with (versus without) the following characteristics: boys, aged 4 years, sleep deprivation, outdoor play time >120 minutes, frequent sugar intake, snack eating before dinner frequently, and obesity.

**Table 1** Characteristics of Preschool Children by Screen Time (N=8378)\*

Children's Characteristics	Daily Screen Time	
	Moderate (n=4475)	Prolonged (n=3903)
	n(%)	n(%)
Screen time, minutes	54.9±31.3	161.6±83.3
Sex		
Girl	2190(54.6)	1819(45.4)
Boy	2285(52.3)	2084(47.7)
Age, years		
2	118(53.4)	103(46.6)
3	516(44.8)	636(55.2)
4	899(35.2)	1658(64.8)
5	2157(67.3)	1046(32.7)
6	785(63.1)	460(36.9)
Mean±SD	5.1±0.9	4.7±0.9
Sleep deprivation* (hour/day)		
No	3226(60.8)	2078(39.2)
Yes	1249(40.6)	1825(59.4)
Mean±SD	9.6±0.7	9.5±0.7
Daily outdoor play time		
0–60 minutes	2045(55.7)	1629(44.3)
61–120 minutes	1071(48.3)	1146(51.7)
>120 minutes	304(37.2)	513(62.8)
Mean±SD	65.7±45.8	79.9±60.7
Daily intake of sugar		
Seldom	201(74.7)	68(25.3)
Sometimes	2009(61.4)	1265(38.6)
Frequently	736(42.9)	981(57.1)
Snack eating before dinner		
Seldom	1026(69.8)	444(30.2)
Sometimes	2896(53.2)	2547(46.8)
Frequently	527(37.5)	877(62.5)
Sleep disturbance		
No	2310(53.1)	2043(46.9)
Yes	2091(53.6)	1811(46.4)
Obesity		
No	3984(54.8)	3293(45.3)
Yes	491(44.6)	610(55.4)
BMI (kg/m <sup>2</sup> ), mean±SD	15.6±2.1	16.0±2.4

**Notes:** \*Missing data: 1670 in outdoor play time; 3118 in sugar intake; 61 in snack eating before dinner; 123 in sleep disturbance.

**Abbreviation:** BMI, body mass index.

Table 2 shows that the children whose main caregivers were male, 45–59 years old, with a junior high school level of education, screen time > 240 minutes, exercise time >60 minutes, and obesity had higher proportion of prolonged screen time than those without these characteristics.

In the multiple log-binomial regression models (Table 3), children with prolonged screen time had an increased risk of obesity compared with children with moderate screen time (PR, 1.45; 95% CI, 1.18–1.79). The adjusted PRs of obesity risk in preschool children with prolonged television time (>120 minutes) was 1.46 (95% CI, 1.18–1.80).

In the stratified analysis (Table 4), the association between prolonged screen time (reference group: children without prolonged screen time) and obesity was significant in preschool children who were: girls (PR, 1.72; 95% CI, 1.21–2.45), boys (PR, 1.32; 95% CI, 1.01–1.71), 3 years of age (PR, 1.85; 95% CI, 1.02–3.37), who had no sleep deprivation (PR, 1.72; 95%

**Table 2** Baseline Characteristics of Caregiver by Preschool Children's Screen Time\*

Caregiver's Information	Daily Screen Time of Preschool Children	
	Moderate (n=4475)	Prolonged (n=3903)
	n(%)	n(%)
Sex		
Female	3833(53.8)	3288(46.2)
Male	550(50.1)	548(49.9)
Age, years		
17–29	463(50.4)	455(49.6)
30–44	3566(54.1)	3026(45.9)
45–59	256(50.2)	254(49.8)
60–83	185(52.9)	165(47.1)
Mean±SD	38.0±7.8	37.6±8.2
Education		
Junior high school	159(44.7)	197(55.3)
High school	1076(45.0)	1317(55.0)
College	736(51.6)	690(48.4)
University	1915(57.6)	1412(42.4)
Graduate school	535(69.4)	236(30.6)
Daily screen time, minutes		
0–120	1532(66.7)	766(33.3)
121–240	1494(52.8)	1338(47.3)
241–360	547(41.1)	785(58.9)
>360	819(45.9)	965(54.0)
Mean±SD	240.6±183.8	301.6±198.2
Daily exercise time, minutes		
0–30	3050(55.1)	2483(44.9)
31–60	858(50.9)	829(49.1)
>60	290(44.4)	363(55.6)
Mean±SD	36.3±63.7	40.6±70.3
Obesity		
No	3768(54.5)	3143(45.5)
Yes	397(44.0)	506(56.0)
BMI (kg/m <sup>2</sup> ), mean±SD	22.6±3.6	23.3±3.9

**Notes:** \*Missing data: 159 in sex; 8 in age; 105 in education; 132 in screen time; 505 in exercise time; 564 in parent obesity.

**Abbreviation:** BMI, body mass index.

CI, 1.32–2.23), outdoor play time >120 minutes (PR, 2.26; 95% CI, 1.15–4.46), sometimes sugar intake (PR, 1.55; 95% CI, 1.18–2.02), sometimes eating snacks before dinner (PR, 1.47; 95% CI, 1.13–1.91), and sleep disturbance (PR, 1.60; 95% CI, 1.22–2.09). The risk of obesity in association with high screen time was also significant in children's caregivers with the following characteristics (Table 5): female sex (PR, 1.46; 95% CI, 1.17–1.82), 30–44 years of age (PR, 1.45; 95% CI, 1.15–1.84), college level of education (PR, 1.84; 95% CI, 1.10–3.11), 241–360 minutes of screen time (PR, 3.20; 95% CI, 1.61–6.35), exercise time 31–60 minutes (PR, 1.56; 95% CI, 1.00–2.45), and obesity (PR, 1.71; 95% CI, 1.03–2.83).

In the Table S1, compared to children with zero screen time, children with prolonged screen time had increased risk of obesity (PR, 3.36; 95% CI, 1.07–10.6). The characteristics of children (Table S2) and caregivers (Table S3) among children with female caregivers was showed in the Supplementary Files. Among children with female caregivers (Table S4), children's prolonged screen time was associated with risk of obesity (PR, 1.46; 95% CI, 1.16–1.82).



**Table 3** Adjusted Prevalence Ratios and 95% Confidence Intervals of Obesity Associated with Preschool Children's Daily Screen Time, Television Time, and Digital Media Time

	Risk of Obesity			
	n	Obese Children	Rate, %	PR(95% CI)*
Screen time, minutes/day				
Moderate	4475	491	11.0	1.00(Reference)
Prolonged	3903	610	15.6	1.45(1.18–1.79)
Per 30 increase				1.05(1.02–1.08)
Per 60 increase				1.10(1.03–1.17)
Television time, minutes/day				
≤60	6042	717	11.9	1.00(Reference)
61–120	2336	384	16.4	1.46(1.18–1.80)
Per 30 increase				1.07(1.02–1.12)
Per 60 increase				1.14(1.04–1.25)
Digital media time, minutes/day				
0–30	7638	980	12.8	1.00(Reference)
31–60	740	121	16.4	1.02(0.74–1.41)
Per 30 increase	5418	616	11.4	1.05(0.99–1.11)
Per 60 increase	1757	272	15.5	1.10(0.98–1.23)

**Notes:** \*Adjusted for children's information (included age, sex, daily sleep hours, daily outdoor play time, daily intake of sugar, snack eating before dinner, and sleep disturbance) and caregiver's information (included age, sex, education, screen time, exercise time, and obesity).

**Abbreviations:** CI, confidence interval; PR, prevalence ratio.

**Table 4** Stratified Analysis by Preschool Children's Characteristics for the Risk of Obesity Associated with Daily Screen Time

	Daily Screen Time of Preschool Children	
	Moderate (n=4475)	Prolonged (n=3903)
	PR (95% CI)	PR (95% CI)*
Sex		
Girl	1.00(reference)	1.72(1.21–2.45)
Boy	1.00(reference)	1.32(1.01–1.71)
Age, children, years		
2	1.00(reference)	1.39(0.30–6.44)
3	1.00(reference)	1.85(1.02–3.37)
4	1.00(reference)	1.55(0.98–2.44)
5	1.00(reference)	1.71(1.23–2.39)
6	1.00(reference)	0.91(0.53–1.57)
Sleep deprivation		
No	1.00(reference)	1.72(1.32–2.23)
Yes	1.00(reference)	1.08(0.77–1.52)
Daily Outdoor play time		
0–60 minutes	1.00(reference)	1.28(0.96–1.70)
61–120 minutes	1.00(reference)	1.54(1.08–2.20)
>120 minutes	1.00(reference)	2.26(1.15–4.46)
Daily intake of sugar		
Seldom	1.00(reference)	1.28(0.48–3.43)
Sometimes	1.00(reference)	1.55(1.18–2.02)
Frequently	1.00(reference)	1.29(0.90–1.85)

(Continued)

**Table 4** (Continued).

	Daily Screen Time of Preschool Children	
	Moderate (n=4475)	Prolonged (n=3903)
	PR (95% CI)	PR (95% CI)*
Eating snack before dinner		
Seldom	1.00(reference)	1.44(0.88–2.36)
Sometimes	1.00(reference)	1.47(1.13–1.91)
Frequently	1.00(reference)	1.44(0.87–2.37)
Sleep disturbance		
No	1.00(reference)	1.27(0.91–1.78)
Yes	1.00(reference)	1.60(1.22–2.09)

**Notes:** \*Adjusted for children's information (included age, sex, daily sleep hours, daily outdoor play time, daily intake of sugar, snack eating before dinner, and sleep disturbance) and caregiver's information (included age, sex, education, screen time, exercise time, and obesity).

**Abbreviations:** CI, confidence interval; PR, prevalence ratio.

**Table 5** Stratified Analysis by Caregiver's Characteristics for the Risk of Obesity Associated with Prolonged Screen Time in Preschool Children

Caregiver's Characteristics	Daily Screen Time of Preschool Children	
	Moderate (n=4475)	Prolonged (n=3903)
	PR (95% CI)	PR (95% CI)*
Sex		
Female	1.00(reference)	1.46(1.17–1.82)
Male	1.00(reference)	1.25(0.68–2.32)
Age, years		
<30	1.00(reference)	1.40(0.68–2.88)
30–44	1.00(reference)	1.45(1.15–1.84)
45–59	1.00(reference)	1.70(0.83–3.48)
≥60	1.00(reference)	0.83(0.28–2.47)
Education		
Junior high school	1.00(reference)	0.93(0.31–2.82)
High school	1.00(reference)	1.18(0.79–1.76)
College	1.00(reference)	1.84(1.10–3.11)
University	1.00(reference)	1.58(1.16–2.17)
Graduate school	1.00(reference)	1.46(0.67–3.19)
Screen time of caregivers		
0–120 minutes/day	1.00(reference)	1.10(0.74–1.63)
121–240 minutes/day	1.00(reference)	1.29(0.91–1.83)
241–360 minutes/day	1.00(reference)	3.20(1.61–6.35)
>360 minutes/day	1.00(reference)	1.80(1.10–2.94)
Exercise time of caregiver		
0–30 minutes/day	1.00(reference)	1.43(1.11–1.83)
31–60 minutes/day	1.00(reference)	1.56(1.00–2.45)
>60 minutes/day	1.00(reference)	1.43(0.67–3.04)
Caregiver's obesity		
No	1.00(reference)	1.40(1.11–1.76)
Yes	1.00(reference)	1.71(1.03–2.83)

**Notes:** \*Adjusted for children's information (included age, sex, daily sleep hours, daily outdoor play time, daily intake of sugar, snack eating before dinner, and sleep disturbance) and caregiver's information (included age, sex, education, screen time, exercise time, and obesity).

**Abbreviations:** CI, confidence interval; PR, prevalence ratio.



## Discussion

We found that there was a high prevalence of obesity and prolonged screen time among preschool children in Taiwan. Preschool children with prolonged screen time had an increased risk of obesity, and this association existed significantly in many subgroups. High television time and high digital media time were also associated with obesity risk. Our study is a large population-based study that raised the influence of screen time on obesity risk among preschool children in Asian countries.

In this study, the average daily screen time among preschool children in Taiwan was approximately 2 hours, which was lower than that in the United States, Switzerland, Australia, Finland and Japan<sup>9–11,17,18</sup> but higher than that in Canada.<sup>14</sup> Information regarding screen time in Taiwan's preschool children was limited. According to the recommendation by the American Academy of Pediatrics, the daily screen time should be less than 2 hours.<sup>3,15,16</sup> However, we found that 27% of preschool children in Taiwan had a screen time of more than 2 hours per day in this study.

A high prevalence of obesity was observed in preschool children with prolonged screen time and lower physical activity.<sup>11</sup> Some studies reported that age, sex, family background, diet, physical activity, sleep duration and lifestyle habits of preschool children were factors associated with prolonged screen time and the risk of obesity.<sup>11,15,37–46</sup> These factors were considered potential confounding factors of obesity and should be controlled for when investigating the association between screen time and obesity, as in the present study. Our results reveal that preschool children who spent more time on screens had an increased obesity risk, which is the same outcome as previous research.<sup>6,11,12,38</sup>

Age was associated with screen time in preschool children,<sup>38</sup> particularly older preschool children who spent a lot of time watching television.<sup>38,39</sup> This phenomenon was also found in our study. Moreover, our study showed that the time spent viewing television and digital media were both important predictive factors of childhood obesity, and television time had a more significant association with childhood obesity than digital media time did. Our findings were similar to the results of the National Health and Nutrition Examination Survey (1999–2014), which showed that children aged 2–5 years had a significantly increased risk of obesity if their television time or screen time was over 2 hours/day; especially when television time and screen time exceeded 3 hours/day, children had an increased risk of severe obesity,<sup>6</sup> and other studies revealed that television time was more positively associated with adiposity than other forms of screen-based media.<sup>12,14</sup>

Many studies demonstrated that eating a meal while watching television was positively associated with being overweight.<sup>47</sup> Moreover, junk food, such as snacks, fried foods, sweets, and beverages, were often consumed when children watched television;<sup>45</sup> therefore, when children used the tablet or smartphone, their fingers were usually less involved in consuming food. In general, a television is often set in a place, eg, a living room or bedroom, and is not easy to move. However, like a smartphone, digital media is usually mobile, which means that the user could have more physical activity and energy consumption.

In the past two decades, our society and research have focused on television, considering how to influence childhood obesity and setting the recommendation that an excessive amount of television hours should be limited. However, recently, numerous screen-based media, eg, smartphones, tablets, and computers, have become common and frequently used devices in our daily home environment. This means that young children have enhanced opportunities to see, touch or use them, so currently, children not only watch television but also interact with various digital media. Although digital media time has a lower predictive power than television time, it is a screen-based medium and still has a negative influence on childhood obesity.

Shorter sleep is also a problem in children with high screen time.<sup>15,40,41</sup> Our results revealed that preschool children with high screen time had fewer sleep hours than those with low screen time. It has been suggested that excessive use of television and computers may result in shorter sleep hours and overweight.<sup>42</sup> Delayed bedtime and sleep deprivation are risk factors for poor sleep quality in preschool children.<sup>40</sup> Deprivation of sleep hours was identified to be associated with a lack of physical activity, weight gain, insulin resistance, and unhealthy dietary patterns.<sup>42</sup> High screen time and shorter sleep hours were independent factors contributing to childhood overweight and obesity.<sup>11,43</sup> In our results, higher screen time was related to lower sleep hours; thus, limiting preschool children's screen time might be another way to enhance their sleep health.

It has been reported that high screen time is significantly associated with low physical activity and more sedentary behaviors in children.<sup>44</sup> Too much sedentary behavior and screen time increased the risk of obesity.<sup>9,11,44</sup> Greater physical activity time was positively associated with decreasing obesity<sup>11</sup> because adding outdoor activity time could decrease the sedentary behaviors of preschool children.<sup>9,11</sup> Our study showed a lower time of outdoor activity of preschool children who had a higher ratio of screen time. This result might reveal the increased risks faced by preschool children in Taiwan, so reducing screen time and adding active physical activity time for them is required.

A review study suggested that children who spent more time using screen-based media would have more behaviors with food intake or snack consumption.<sup>45</sup> Undoubtedly, snack consumption was an important risk factor for childhood obesity.<sup>37,45</sup> Overeating snacks in preschool children was associated with high screen time, which was also observed in our findings. To improve preschool children's health, we suggest that caregivers pay attention to children's snack consumption during screen time.

Additionally, the family environment and socioeconomic status of caregivers were factors associated with screen time in preschool children.<sup>4,25,48</sup> In the current results, we have similar findings that caregivers' sex, age, education, and physical activity (eg, screen time and exercise time) were associated with preschool children's screen time. Parenting style and the family environment were important mediators for enhancing the lifestyle and health status of preschool children, such as limiting their screen time or other behaviors and arranging their daily routine schedule.<sup>25</sup> Maternal caregivers with lower education or younger age were more likely to allow longer screen time for their preschool children.<sup>48</sup> As a result, to effectively reduce the screen time of preschool children, we should consider how to educate caregivers about behaviors in the home environment and how to teach a healthy lifestyle to their children. Another interesting result of this study was that caregivers' obesity (85% of caregivers were mothers) was also an important factor associated with preschool children's high screen time. Many studies have shown that parenting is one of the crucial influential factors in child health and obesity.<sup>4,10,11,49</sup> Obesity in adults is a multifactorial issue that is frequently caused by lifestyle. In particular, inadequate physical activity increased the risk for adult obesity, and an association was shown between physical inactivity from youth.<sup>50</sup> Thus, it can be seen that parenting has a powerful influence on young children's health and development. A parent's obesity and unhealthy behaviors might influence a young child in daily routines. To efficiently reduce preschool children's screen time in Taiwan, caregivers or parents need to stringently limit their television time.

In the subgroup analysis of this study, high screen time was not significantly associated with obesity risk in some subgroups. This phenomenon revealed that the association between screen time and obesity was mediated by socio-demographic and lifestyle factors. More comprehensively designed studies are needed to prove this relationship.

Interpretations of the current findings should be made with caution because some limitations existed in this study. First, recall bias may occur in surveys, and all data were based on main caregivers' reports by observation. Second, the unavailable information on body mass index and detailed lifestyle habits of the main caregivers may confound the findings of this study. Third, inadequate physical activity was associated with sedentary behavior and obesity, but we have no corresponding data in preschool children. Fourth, caregiver sex as an important limitation of this study because fathers are very underrepresented (less than 7%). In addition, some confounding factors potentially affected our study, although we adjusted for all available information. Finally, our study was a cross-sectional survey that could not demonstrate a causal relationship between screen time and obesity. We could not exclude the possibility of the potential reverse causation that obesity may be a risk factor for prolonged screen time among preschool children.

## Conclusion

We observed a high prevalence of obesity and prolonged screen time among preschool children in Taiwan. Preschool children with prolonged screen time may have increased risk of obesity, and this association was mediated by socio-demographic and lifestyle factors. Our observations are of considerable public health interest, and future high-quality studies, such as randomized controlled trials, are needed to demonstrate causality.

## Abbreviations

SD, standard deviation; CI, confidence interval; PR, prevalence ratio.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no conflicts of interest in this work.

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