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The Temporal Trend of Screen-Based Exposure among Chinese Younger Generation from 2004-2015

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Abstract

Background: Media equipment is infiltrating into all areas of daily life, and its potential health outcomes have been a focus. However, the long-time trend of screen exposure among Chinese young generation is unclear. **Objective:** To examine the changing trend of screen exposure among Chinese young generation from 2004 to 2015. **Methods:** The temporal trends in screen exposure were examined among participants aged 6 - 24 years who came from five cross-sectional surveys through 2004 (n = 2435), 2006 (n = 1971), 2009 (n = 1934), 2011 (n = 2318) and 2015 (n = 2461) of China Health and Nutrition Survey. **Results:** Across five surveys from 2004 to 2015, screen time continued to grow from 2004 to 2011, while in 2015, it declined significantly (1.45 hrs/day in 2004, 1.99 in 2006, 2.35 in 2009, 2.47 in 2011, and 1.95 in 2015). The stratification analyses by age, gender, and residential area got the same patterns in most cases. During the same period, the prevalence of overweight/obesity kept increasing from 11.4% to 24.4%. **Conclusions:** The secular upward trend in young generation's screen exposure since 2004 reached its apex in 2011, and then there was a fall-off in 2015. By contrast, the prevalence of overweight/obesity kept increasing from 2011 to 2015.

Keywords

China Health and Nutrition Survey, Screen Time, Overweight, Obesity, Long-Term Trend, Younger Generation

1. Introduction

Media devices, such as television, smartphones, tablets, computers, are playing a

growing role in daily life, particularly for children, adolescents and youths (American Academy of Pediatrics, 2016; Strasburger et al., 2013). Media exposure related sedentary behavior has been a pervasive concern all around the world (American Academy of Pediatrics, 2016; Strasburger et al., 2013). Accumulating studies provided evidence that too much screen time was implicated in an increased risk of overweight/obesity, as well as a wide spectrum of other negative impacts, including higher cardiometabolic risk, myopia, unfavorable behavioral conduct, lower fitness, and poor self-esteem (Cai et al., 2017; Carson et al., 2016; Tremblay et al., 2011; Tremblay et al., 2016; Wu et al., 2016; Zhu et al., 2019). When considering all of these consequences, recommendation for screen time has been proposed that no more than 2 hours per day for children and adolescents (American Academy of Pediatrics, 2016). Back on the ground, it is critically important to monitor the changing trend of screen exposure, and to examine if it has similar trajectory track with overweight/obesity over the same time.

Media use is a lifestyle choice, which is closely related to social economic level and public awareness of health care. Data from a nationally representative sample of 34,605 children and adolescents in the US examined the secular trend of screen-based sedentary behaviors, including television/videos/DVDs viewing, video game playing, and computer using over the period from 2001 to 2010 (Iannotti & Wang, 2013). In contrast with earlier findings, this study found that, although most adolescents still exposed to screen more than 2 hours per day, a decreasing trend in overall screen time was observed (Adams, 2006; Iannotti & Wang, 2013).

Benefiting from the reform policy, China has achieved rapid development covering an extensive range, including improved economic condition, increased access to health care and strengthened public health promotion. To date the insight regarding the change of screen exposure over time among Chinese young people is limited. To our knowledge, only one early study, using national wide data, described the secular trend, which demonstrated that the prevalence of screen time more than 2 hours per day increased from approximately 10% in 1997 to approximately 40% in 2006 (Cui et al., 2011). However, updated data following the trend with time goes on is scare, and most of recent studies were based on small sample, single center or only one cross-section survey (Duan et al., 2015; McBride, 2018; Ye et al., 2018; Zhu et al., 2018). Two newly published studies reported the prevalence of screen viewing more than 2 hours per day among Chinese children and adolescents based on a nationally representative sample in 2016 and 2017, and the data were 36.8% and 34.6%, respectively (Cai et al., 2017; Zhu et al., 2019). It seemed that, similar to their peers in the US, a stabilizing or even a declining trend of screen time emerged among Chinese children and adolescents in recent years. However, only study in the basis of longer span observation could provide solid evidence.

Except for sedentary behaviors, other factors including diet, sleep, physical activity have been confirmed to be implicated in overweight/obesity. Most studies analyzed the contribution of these factors through multivariate regression mod-

els (McBride, 2018; Roblin, 2007; Sluggett et al., 2019). By contrast, very scare studies observed the long-time tracks of these factors with comparion to the change of overweight/obesity.

China's development was very fast in the past decades, however, there was significant imbalance in different areas, which made a regional gap not only in economy but also in lifestyle choice and the access to health care. The exploration of change in screen time among Chinese children, adolescents and youths should take regional difference into account. This study would examine the changing trend of screen exposure among Chinese young generation from 2004 to 2015 using data of China Health and Nutrition Survey (CHNS). To get clear knowledge on the temporal trend, stratification analyses by age, gender, urban/rural and urbanization index would be emphasized. In addition, we would observe if the prevalence of overweight/obesity has the similar long-term change of screen exposure.

2. Methods

2.1. Study Design

The CHNS is an ongoing longitudinal and family-based survey that has completed eleven waves since 1898. Briefly, the survey initially included eight provinces and a new was added in 1997, making the survey cover nine provinces, including Heilongjiang, Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guizhou and Guangxi (from north to south). A multistage, random cluster sampling strategy was applied to draw sample in each of the provinces. A total of four counties and two cities in each province were randomly selected, and 20 households in each community were randomly selected and all household members were interviewed by trained investigators (Popkin et al., 2010). CHNS is not a strict nationally representative design, but the nine provinces vary widely in terms of geography, economic development, public resources, and health indicators, as well as adopting a rigorous random sampling scheme in each sampled province, so that this survey can be seen to a large extent as representing the general situation in China. The survey instruments were designed by an interdisciplinary group of social and biomedical scientists with extensive experience in survey research related to their respective fields. More detailed information can be obtained at http://www.cpc.unc.edu/projects/china.

The study procedure was approved by the institutional review committees of the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, and the China-Japan Friendship Hospital, Ministry of Health before the recruitment of participants. Each participant signed an informed consent at the enrollment (Popkin et al., 2010).

2.2. Study Participants

The study involved children, adolescents, and youths between the ages of 6 and

24, which was drawn from more than 13,000 records surveyed in 2004, 2006, 2009, 2011 and 2015. After excluding subjects with missing data, mainly age, gender, residential area or screen exposure being unavailable, the final sample in each survey year was 2435 in 2004, 1971 in 2006, 1934 in 2009, 2318 in 2011, and 2461 in 2015, respectively.

2.3. Socio-Demographic Variables

Demographics included participant's age, gender, family location and the level of urbanization. Age was stratified into three groups as 6 - 10 (children), 11 - 18 (adolescents), and 19 - 24 years (youths). The location of the family was divided into urban and rural areas. The level of urbanization was reflected by the urbanization index, which was divided into three categories as low, medium, and high urbanization index area. BMI (body mass index) was calculated through weight (kg) divided by the square of height (m), and BMI z score was used to assess overweight and obesity status. BMI z score was calculated by (individual BMI value-mean BMI value)/BMI standard deviation (SD), based on gender- and age-standard published by WHO (Roblin, 2007). Individual BMI z score ranged between ≥1 and <2 was defined as overweight, and ≥2 was defined as obesity (de Onis et al., 2007). Variables regarding subjects' screen-based behaviors included watching TV, playing video games, surfing on web, chatting online, playing computer games and watching movies.

2.4. Screen Exposure Time

Screen exposure was surveyed through a set of questions on usual time spent on TV watching, video games, Internet surfing, online chatting, computer games, and movie watching. In 2004, only the time regarding TV watching and video game was collected. Since 2006, Internet surfing, online chatting, and computer games were further included in the survey, and since 2009, movie watching was simultaneously added. The sum of time on these items made up the total screen time. The cutoff for excessive screen exposure was defined as more than 2 hrs/day with the reference of screen time recommendation for children and adolescents (American Academy of Pediatrics, 2016). So far the optimal duration of screen time for youths is not yet recommended, and this study adopted 2 hrs/day as the uniform cutting point.

2.5. Statistical Analysis

Statistical descriptions were made utilizing the mean, along with standard deviation, for continuous variables, and percentage for categorical variables. The Kruskal-Wallis one-way analysis of variance and the χ^2 tests were applied to examine group difference in sample characteristics of five surveys.

The overall trend of screen exposure across survey years was examined using the Kruskal-Wallis one-way analysis of variance when screen time was analyzed as continuous variable, or adopting χ^2 tests when screen time was grouped into

categorical variable. Then the screen exposure in each survey was stratified according to age groups, gender, urban/rural area, and urbanization index, and the hierarchical trend across survey years was also checked. Percentile bar graph was depicted to describe the screen exposure constitution across years. The line graph and bar graph were plotted to described the trend of screen time and the comparison by socio-demographic characteristics.

All analyses were performed with the Statistical Package for the Social Sciences (SPSS) (IBM-SPSS Statistics version 23.0, Inc., Chicago, IL). Statistical significance level was set at p value < 0.05 (two sided).

3. Results

3.1. Participant Characteristics

Table 1 summarized the description of participant characteristics in 2004, 2006, 2009, 2011, and 2015. A total of 2435, 1971, 1934, 2318, and 2461 were respectively involved in the final analyses, and the mean age was 14.50, 14.21, 14.72, 13.99, and 13.71 years in chronological order from 2004 to 2015 survey. There

Table 1. Sample characteristics across years from 2004 to 2015, n (%) unless indicated.

	2004 (n = 2435)	2006 (n = 1971)	2009 (n = 1934)	2011 (n = 2318)	2015 (n = 2461)	Time trend p value
Age, years, mean (SD)	14.50 (5.09)	14.21 (5.32)	14.72 (5.59)	13.99 (5.75)	13.71 (5.65)	<0.001
Age groups						
6 - 10	484 (19.9)	474 (24.0)	423 (21.9)	643 (27.7)	727 (24.7)	<0.001
11 - 18	1269 (52.1)	925 (46.9)	836 (43.2)	1008 (43.5)	1025 (41.6)	
19 - 24	682 (28.0)	572 (29.0)	675 (34.9)	667 (28.8)	709 (28.8)	
Gender						
Boy	1289 (52.9)	1056 (53.6)	1054 (54.5)	1170 (50.5)	1286 (52.3)	0.093
Girl	1146 (47.1)	915 (46.4)	880 (45.5)	1148 (49.5)	1175 (47.7)	
Region						
Urban	749 (30.8)	639 (32.4)	566 (29.3)	899 (38.7)	798 (32.4)	<0.001
Rural	1686 (69.2)	1332 (67.6)	1368 (70.7)	1420 (61.3)	1663 (67.6)	
Urbanization index						
Low; <P25	922 (37.9)	633 (32.1)	464 (24.0)	448 (19.3)	314 (12.8)	<0.001
Medium; P25 - P75	1157 (47.5)	932 (47.3)	1036 (53.6)	1021 (44.0)	1419 (57.7)	
High; ≥P75	356 (14.6)	406 (20.6)	434 (22.4)	849 (36.6)	727 (29.6)	
BMI, kg/m^2, mean (SD)	18.73 (0.07)	18.67 (0.08)	18.85 (0.09)	19.27 (0.10)	19.79 (0.13)	<0.001
Overweight/obesity						
No	1856 (88.6)	1486 (86.6)	1403 (84.2)	1708 (79.3)	1460 (75.6)	<0.001
Yes	239 (11.4)	230 (13.4)	264 (15.8)	446 (20.7)	471 (24.4)	

BMI: body mass index.

wasn't gender difference across the five surveys, however, characteristics in urban versus rural area, urbanization index, and BMI significantly changed. The proportion of those participants who came from urban area waved over surveys years, and was at a top in 2011. The proportion of high urbanization index was in an increased trend in the first four surveys, from 14.6% in 2004 to 36.6% in 2011, however, fell to 29.6% in 2015. The participant BMI significantly increased from 18.83 to 19.79 between 2004 and 2015, and the prevalence of overweight/obesity correspondingly increased from 11.4 to 24.4 (both $p < 0.001$).

3.2. Screen Time among Our Sampled Participants across Years from 2004 to 2015

Table 2 described the time spent on TV watching, video games, Internet surfing, online chatting, computer games, and movie watching for the whole sample across the five survey. Overall, TV watching constituted the largest proportion all throughout the five surveys, though the time on TV relatively kept stable and even in a declining trend since 2009. By contrast, time on Internet surfing and computer games was in a rapid rise until 2011, and time on online chatting kept rising until 2015. As for the total screen time, it started with an apparent up trend from 2004 to 2011, while in 2015, it dropped significantly. Correspondingly, the prevalence of spending more than 2 hrs per day on screen increased from 34.4% in 2004 to 68.1% in 2011, and then fell to 38.2% in 2015. Figure 1 shows the proportion of daily screen exposure constitution across years from 2004 to 2015.

Table 2. Daily screen time among our sampled participants across years from 2004 to 2015.

	2004 (n = 2435)	2006 (n = 1971)	2009 (n = 1934)	2011 (n = 2318)	2015 (n = 2461)	Time trend *p* value
Watching TV						
In continuous (hrs/d)	1.39 (1.12)	1.49 (1.09)	1.49 (1.12)	1.36 (1.04)	0.98 (1.06)	<0.001
In categorical						<0.001
Yes	2206 (93.2)	1810 (94.0)	1747 (94.6)	2105 (92.1)	1669 (85.2)	
No	160 (6.8)	115 (6.0)	99 (5.4)	180 (7.9)	290 (14.8)	
Video games						
In continuous (hrs/d)	0.06 (0.29)	0.07 (0.31)	0.06 (0.27)	0.07 (0.29)	0.09 (0.39)	0.003
In categorical						0.001
Yes	228 (9.7)	174 (9.1)	150 (8.1)	249 (10.9)	230 (11.8)	
No	2131 (90.3)	1747 (90.9)	1696 (91.9)	2035 (89.1)	1727 (88.2)	
Surfing Internet						
In continuous (hrs/d)	-	0.13 (0.44)	0.19 (0.50)	0.27 (0.59)	0.21 (0.57)	<0.001
In categorical						<0.001

Continued

Yes	-	296 (15.4)	467 (25.3)	771 (33.8)	512 (26.1)	
No	-	1622 (84.6)	1377 (74.7)	1511 (66.2)	1447 (73.9)	
Joining chat rooms						
In continuous (hrs/d)	-	0.15 (0.52)	0.22 (0.57)	0.25 (0.58)	0.29 (0.73)	<0.001
In categorical						<0.001
Yes	-	297 (15.5)	479 (26.0)	701 (30.7)	593 (30.3)	
No	-	1621 (84.5)	1365 (74.0)	1581 (69.3)	1361 (69.7)	
Computer games						
In continuous (hrs/d)	-	0.18 (0.61)	0.25 (0.65)	0.30 (0.67)	0.30 (0.73)	<0.001
In categorical						<0.001
Yes	-	327 (17.0)	485 (26.3)	779 (34.1)	648 (33.1)	
No	-	1591 (83.0)	1359 (73.7)	1504 (65.9)	1310 (66.9)	
Watching movies						
In continuous (hrs/d)	-	-	0.18 (0.57)	0.21 (0.58)	0.20 (0.60)	<0.001
In categorical						0.018
Yes	-	-	313 (17.0)	459 (20.1)	393 (20.1)	
No	-	-	1532 (83.0)	1826 (79.9)	1565 (79.9)	
Total						
In continuous (hrs/d)	1.45 (1.18)	1.99 (1.78)	2.35 (2.07)	2.47 (2.07)	1.95 (2.40)	<0.001
In categorical						<0.001
≤2 hrs/d	1840 (77.3)	1224 (64.2)	1051 (55.8)	1215 (53.8)	1551 (66.1)	
>2 hrs/d	539 (22.7)	683 (35.8)	831 (44.2)	1045 (46.2)	797 (33.9)	

BMI: body mass index.

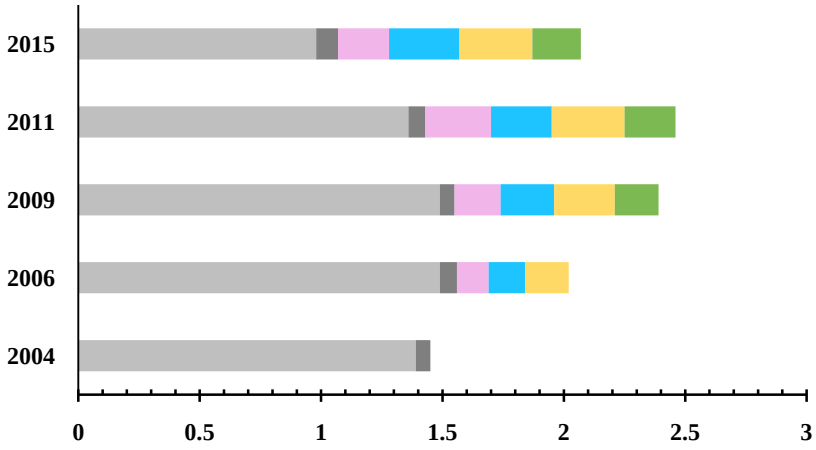


Figure 1. The proportion of daily screen exposure (hrs/day) constitution across years from 2004 to 2015. Light gray: TV watching; Black gray: video games; Pink: Internet surfing; Blue: online chatting; Yellow: computer games; Green: movie watching.

Table 3 and Table 4 analyzed gender- and age-specific daily screen time after stratification by urban versus rural area or urbanization index, respectively.

Table 3. Gender- and age-specific daily screen time among our sampled participants stratified by urban vs. rural area across years from 2004 to 2015.

	2004	2006	2009	2011	2015	Time trend *p* value
Urban-boys (n = 1805)						
6 - 10 yrs						
In continuous (hrs/d)	1.48 (0.99)	1.51 (1.26)	1.69 (1.03)	1.72 (1.12)	1.63 (1.33)	0.696
>2 hrs/d (n, %)	10 (20.4)	12 (21.8)	24 (38.1)	31 (32.6)	28 (27.5)	0.171
11 - 18 yrs						
In continuous (hrs/d)	1.32 (1.16)	1.94 (1.96)	2.01 (1.99)	2.14 (1.76)	2.09 (2.53)	<0.001
>2 hrs/d (n, %)	41 (21.1)	47 (32.9)	47 (42.0)	75 (39.9)	60 (35.3)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.95 (1.50)	4.18 (3.28)	4.53 (3.05)	5.13 (3.06)	3.26 (3.63)	<0.001
>2 hrs/d (n, %)	47 (37.3)	81 (69.2)	88 (79.3)	108 (79.3)	50 (53.8)	<0.001
Urban-girls (n = 1845)						
6 - 10 yrs						
In continuous (hrs/d)	1.35 (1.09)	1.34 (1.00)	1.73 (1.13)	1.61 (1.07)	1.63 (1.48)	0.215
>2 hrs/d (n, %)	17 (23.3)	11 (17.7)	18 (36.7)	31 (26.5)	34 (30.1)	0.189
11 - 18 yrs						
In continuous (hrs/d)	1.11 (0.92)	1.37 (1.17)	2.05 (1.89)	1.96 (1.67)	1.55 (1.64)	<0.001
>2 hrs/d (n, %)	21 (12.1)	32 (23.7)	38 (33.0)	76 (37.8)	52 (31.5)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.67 (1.31)	2.99 (2.21)	3.37 (2.23)	3.91 (2.39)	3.00 (2.94)	<0.001
>2 hrs/d (n, %)	30 (25.2)	58 (61.1)	63 (64.9)	110 (75.3)	64 (53.3)	<0.001
Rural-boys (n = 4050)						
6 - 10 yrs						
In continuous (hrs/d)	1.43 (0.96)	1.72 (0.91)	1.83 (1.32)	1.81 (1.15)	1.73 (1.39)	0.006
>2 hrs/d (n, %)	45 (22.4)	71 (34.8)	56 (32.7)	71 (31.0)	83 (31.7)	0.072
11 - 18 yrs						
In continuous (hrs/d)	1.39 (1.19)	1.82 (1.60)	1.91 (1.55)	2.07 (1.82)	1.67 (2.15)	<0.001
>2 hrs/d (n, %)	106 (22.3)	109 (33.2)	126 (36.4)	131 (41.5)	103 (28.5)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.78 (1.37)	2.71 (1.96)	3.43 (2.75)	3.87 (2.56)	2.53 (3.46)	<0.001
>2 hrs/d (n, %)	70 (31.7)	90 (51.4)	136 (61.3)	134 (72.0)	93 (39.2)	<0.001
Rural-girls (n = 3419)						
6 - 10 yrs (n)						
In continuous (hrs/d)	1.33 (0.91)	1.65 (1.09)	1.79 (1.04)	1.77 (1.07)	1.70 (1.33)	0.002
>2 hrs/d (n, %)	29 (18.4)	47 (32.0)	51 (38.1)	63 (34.2)	74 (33.6)	0.002
11 - 18 yrs						
In continuous (hrs/d)	1.21 (1.02)	1.39 (1.00)	1.47 (1.17)	1.66 (1.23)	1.35 (1.57)	<0.001
>2 hrs/d (n, %)	58 (14.5)	64 (22.3)	70 (28.7)	87 (30.9)	73 (25.4)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.89 (1.31)	2.05 (1.52)	2.82 (2.14)	3.31 (1.99)	2.43 (3.48)	<0.001
>2 hrs/d (n, %)	65 (34.4)	61 (38,4)	114 (52.4)	128 (68.1)	83 (38.2)	<0.001

Table 4. Gender- and age-specific daily screen time among our sampled participants stratified by urbanization index across years from 2004 to 2015.

	2004	2006	2009	2011	2015	Time trend *p* value
Low Urbanization -boys (n = 1805)						
6 - 10 yrs						
In continuous (hrs/d)	1.50 (0.96)	1.87 (0.90)	1.94 (0.98)	1.82 (1.06)	1.77 (1.48)	0.041
>2 hrs/d, n (%)	25 (22.3)	46 (40.4)	23 (41.1)	26 (32.1)	21 (35.0)	0.036
11 - 18 yrs						
In continuous (hrs/d)	1.35 (1.73)	1.73 (1.41)	2.20 (1.54)	2.10 (2.26)	1.37 (2.41)	<0.001
>2 hrs/d (n, %)	47 (18.4)	52 (32.7)	57 (47.9)	33 (36.3)	15 (24.2)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.87 (1.39)	2.47 (1.54)	2.86 (2.14)	3.23 (2.34)	2.84 (3.49)	<0.001
>2 hrs/d (n, %)	42 (34.4)	36 (49.3)	36 (55.4)	31 (59.6)	14 (35.9)	0.005
Low Urbanization - girls (n = 1845)						
6 - 10 yrs						
In continuous (hrs/d)	1.30 (0.94)	1.70 (1.03)	1.79 (0.96)	1.83 (0.98)	1.51 (1.15)	0.061
>2 hrs/d (n, %)	16 (17.8)	25 (34.2)	15 (36.6)	26 (35.6)	14 (30.4)	0.077
11 - 18 yrs						
In continuous (hrs/d)	1.21 (1.08)	1.48 (0.98)	1.56 (1.29)	1.39 (0.86)	1.11 (1.26)	0.021
>2 hrs/d (n, %)	32 (15.2)	32 (25.0)	30 (34.9)	16 (20.3)	13 (22.8)	0.005
19 - 24 yrs						
In continuous (hrs/d)	1.75 (1.37)	2.23 (1.43)	2.77 (2.18)	2.60 (1.66)	1.91 (2.30)	0.001
>2 hrs/d (n, %)	31 (30.4)	28 (41.2)	45 (54.2)	35 (56.5)	11 (33.3)	0.002
Medium Urbanization-boys (n = 4050)						
6 - 10 yrs (n)						
In continuous (hrs/d)	1.41 (1.02)	1.57 (1.08)	1.83 (1.45)	1.84 (1.20)	1.73 (1.37)	0.035
>2 hrs/d (n, %)	27 (23.9)	32 (28.3)	40 (31.5)	52 (34.4)	65 (31.6)	0.426
11 - 18 yrs						
In continuous (hrs/d)	1.45 (1.23)	1.93 (1.81)	1.92 (1.79)	2.13 (1.68)	1.90 (2.34)	<0.001
>2 hrs/d (n, %)	79 (26.2)	66 (32.5)	86 (37.1)	94 (43.5)	100 (32.1)	0.001
19 - 24 yrs						
In continuous (hrs/d)	1.87 (1.43)	3.23 (2.50)	3.56 (2.78)	4.28 (2.79)	2.54 (3.35)	<0.001
>2 hrs/d (n, %)	60 (33.5)	84 (60.4)	122 (65.2)	115 (75.7)	82 (41.6)	0.190
Medium Urbanization - girls (n = 3419)						
6 - 10 yrs (n)						
In continuous (hrs/d)	1.37 (0.93)	1.54 (1.11)	1.82 (1.10)	1.78 (1.13)	1.81 (1.43)	0.012
>2 hrs/d (n, %)	22 (21.2)	27 (25.5)	41 (38.3)	40 (33.1)	67 (38.7)	0.010
11 - 18 yrs						

Continued

In continuous (hrs/d)	1.25 (0.97)	1.37 (1.08)	1.62 (1.32)	1.84 (1.47)	1.51 (1.74)	<0.001
>2 hrs/d (n, %)	41 (14.6)	43 (20.9)	51 (27.7)	75 (36.8)	75 (28.2)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.91 (1.31)	2.22 (1.81)	2.93 (2.14)	3.48 (2.25)	2.32 (3.27)	<0.001
>2 hrs/d (n, %)	53 (32.5)	58 (43.6)	92 (53.5)	102 (68.9)	76 (38.6)	<0.001
High Urbanization-boys (n = 4050)						
6 - 10 yrs						
In continuous (hrs/d)	1.35 (0.68)	1.38 (0.94)	1.56 (0.91)	1.66 (1.13)	1.61 (1.31)	0.620
>2 hrs/d (n, %)	3 (12.0)	5 (15.6)	17 (33.3)	24 (26.1)	25 (25.5)	0.220
11 - 18 yrs						
In continuous (hrs/d)	1.20 (1.05)	1.90 (1.93)	1.67 (1.49)	2.07 (1.67)	1.80 (2.12)	0.001
>2 hrs/d (n, %)	21 (18.6)	38 (34.9)	30 (28.0)	79 (40.1)	48 (30.4)	0.002
19 - 24 yrs						
In continuous (hrs/d)	1.66 (1.47)	4.17 (3.43)	5.10 (3.25)	5.07 (2.94)	3.12 (3.86)	<0.001
>2 hrs/d (n, %)	15 (32.6)	51 (63.7)	66 (81.5)	96 (87.3)	47 (50.0)	<0.001
High Urbanization-girls (n = 3419)						
6 - 10 yrs						
In continuous (hrs/d)	1.34 (1.17)	1.33 (1.01)	1.63 (1.08)	1.54 (1.05)	1.53 (1.38)	0.746
>2 hrs/d (n, %)	8 (21.6)	6 (20.0)	13 (37.1)	28 (26.2)	26 (23.0)	0.452
11 - 18 yrs						
In continuous (hrs/d)	0.89 (0.79)	1.30 (1.09)	1.82 (1.86)	1.89 (1.56)	1.38 (1.41)	<0.001
>2 hrs/d (n, %)	6 (7.3)	21 (23.9)	27 (30.3)	72 (36.0)	37 (28.7)	<0.001
19 - 24 yrs						
In continuous (hrs/d)	1.57 (1.20)	3.10 (2.31)	3.49 (2.28)	4.17 (2.17)	3.44 (3.50)	<0.001
>2 hrs/d (n, %)	11 (25.6)	33 (62.3)	40 (66.7)	101 (81.5)	60 (56.1)	<0.001

Generally, daily screen time tended to be longer, alongside with a higher prevalence of excessive screen exposure, in participants with age of 19 - 24 years, being males, living in urban or higher urbanization index area. In accordance with the overall trend observed in Table 2, the same patterns were also observed in most cases, especially in rural areas after taking stratification analyses by age, gender, urban/rural area, and urbanization index. Figure 2 shows the trend of total daily screen time with age and survey years, stratified by gender and urban/rural area.

We also compared screen exposure between participants with and without overweight/obesity, indicating that those participants under overweight/obesity spent longer time on screen, which kept valid during the stratified analyses by survey years, age group, gender, urban/rural area and urbanization index level (as shown in Figure 3). In addition, we found that the prevalence of overweight or obesity kept in growing all through 2004 to 2015, without a sign of slowdown

(as shown in Table 5). Therefore, both screen exposure and the prevalence of overweight/obesity were in the growing tendency before 2011, however, they diverged in 2015.

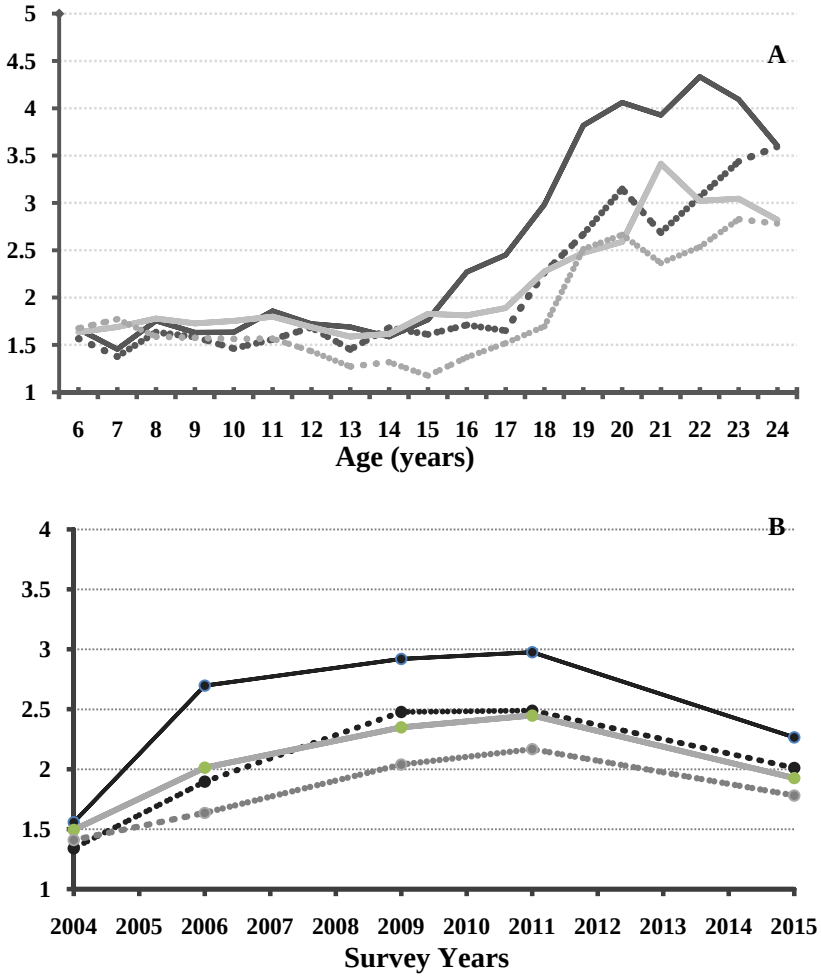
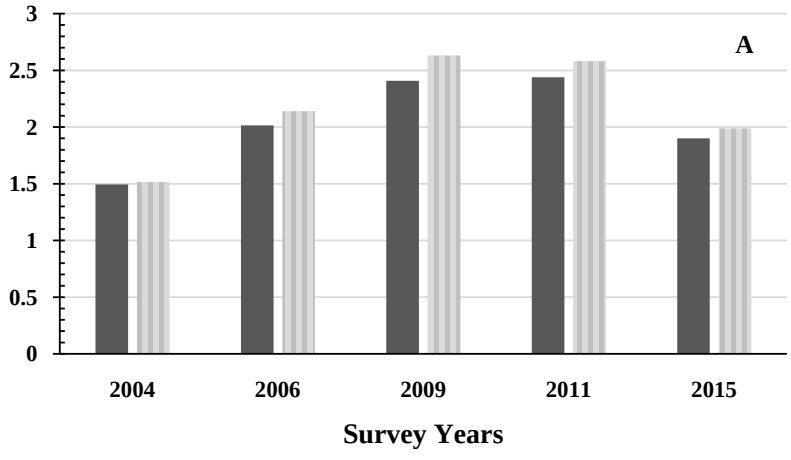


Figure 2. The trend of total daily screen time (hrs/day) with age (A) and survey years (B); Black solid line: urban males; Black dotted line: urban females; Gray solid line: rural males; Gray dotted line: urban females.



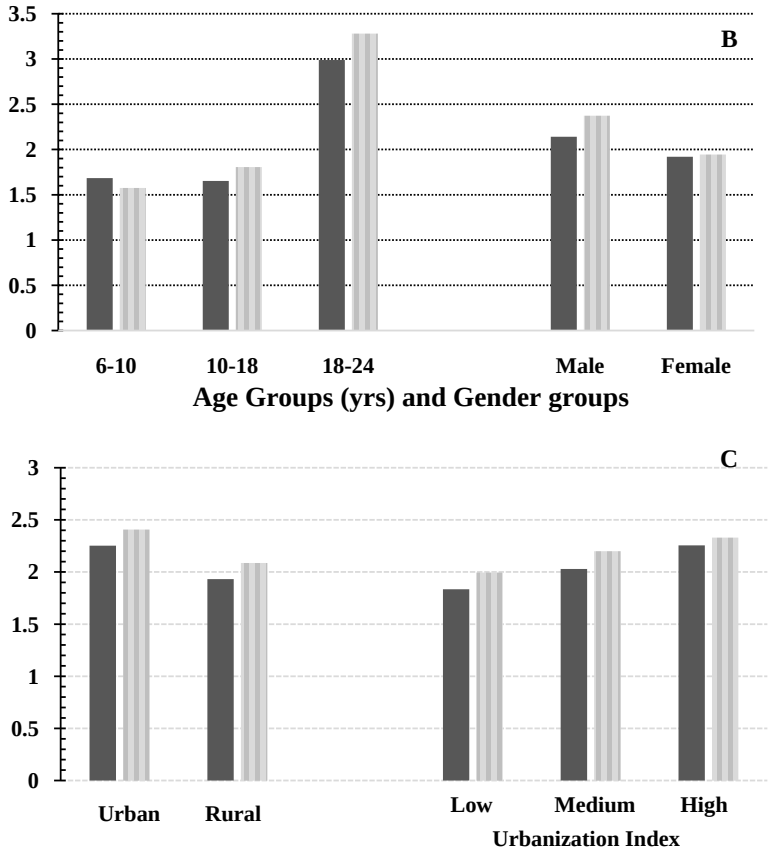


Figure 3. The comparison of total screen time (hrs/day) according to survey years (A), age groups and gender (B), and urban/rural area and urbanization index level (C); stratified by BMI groups; Dark gray: subjects without overweight/obesity; Light gray: subjects with overweight/obesity.

Table 5. The prevalence of overweight/obesity among our sampled participants stratified by age, gender, region, or urbanization index across years from 2004 to 2015.

	2004	2006	2009	2011	2015	Time trend (*p*)
BMI						
Age group						
6 - 10 yrs	16.09 (2.52)	16.03 (2.85)	15.98 (2.94)	16.79 (3.96)	16.83 (3.64)	<0.001
11 - 18 yrs	18.61 (2.79)	18.45 (2.87)	18.48 (3.22)	19.14 (3.67)	19.62 (4.94)	<0.001
19 - 24 yrs	20.99 (2.63)	21.22 (2.96)	21.15 (3.25)	21.99 (4.60)	23.18 (6.08)	<0.001
Gender						
Male	18.87 (3.22)	18.92 (3.64)	18.94 (3.91)	19.49 (4.46)	20.22 (5.71)	<0.001
Female	18.56 (3.09)	18.38 (3.21)	18.74 (3.50)	19.04 (4.43)	19.33 (5.28)	<0.001
Region						
Urban	19.22 (3.29)	19.34 (3.53)	19.29 (3.90)	19.65 (4.24)	19.98 (5.01)	0.005
Rural	18.49 (3.09)	18.35 (3.37)	18.67 (3.64)	19.03 (4.55)	19.71 (5.74)	<0.001
Urbanization Index						

Continued

Low; <P25	18.29 (3.14)	18.21 (3.35)	18.26 (3.59)	18.22 (3.88)	18.87 (4.97)	0.133
Medium; P25 - P75	18.89 (3.14)	18.63 (3.50)	18.89 (3.67)	19.26 (4.42)	19.93 (5.86)	<0.001
High; ≥P75	19.24 (3.20)	19.38 (3.38)	19.35 (3.91)	19.80 (4.65)	19.98 (5.00)	0.036
Overweight/obesity						
Age group						
6 - 10 yrs	82 (19.2%)	68 (16.6%)	68 (18.2%)	141 (23.2%)	148 (25.5%)	0.003
11 - 18 yrs	94 (8.5%)	80 (9.9%)	94 (12.8%)	170 (17.9%)	170 (21.2%)	<0.001
19 - 24 yrs	63 (11.3%)	82 (16.6%)	102 (18.2%)	135 (22.6%)	153 (27.9%)	<0.001
Gender						
Male	139 (12.5%)	149 (16.3%)	164 (18.1%)	268 (24.8%)	289 (28.8%)	<0.001
Female	100 (10.2%)	81 (10.2%)	100 (13.1%)	178 (16.6%)	182 (19.6%)	<0.001
Region						
Urban	94 (14.2%)	88 (15.9%)	88 (18.4%)	187 (22.6%)	157 (26.6%)	<0.001
Rural	145 (10.1%)	142 (12.3%)	176 (14.8%)	259 (19.5%)	314 (23.4%)	<0.001
Urbanization Index						
Low; <P25	63 (8.3%)	53 (10%)	49 (12.3%)	67 (16.4%)	46 (17.0%)	<0.001
Medium; P25 - P75	124 (12.3%)	112 (13.9%)	148 (16.5%)	194 (20.8%)	282 (24.9%)	<0.001
High; ≥P75	52 (15.7%)	65 (17.2%)	67 (17.9%)	185 (22.8%)	143 (27.1%)	<0.001

4. Discussion

Based on five national cross-sectional surveys of CHNS, this study characterized the secular trend of screen time among Chinese young generation aged 6 - 24 years over the period of 2004 to 2015. Daily screen time, along with the prevalence of excessive screen exposure, started with an up trend from 2004, reached the peak in 2011, and then dropped significantly in 2015. The stratification analyses by age, gender, urban/rural area, and urbanization index to most extend copied the same trajectory, especially in urban area. During the same period, the prevalence of overweight/obesity kept increasing, without showing a reverse trend or sign of slowdown. Our findings, for the first time, revealed that the rising trend of young generation's screen use showed a turning in recent years. Moreover, we are also the first to reveal that overweight/obesity was still in growing instead of having the similar reverse trajectory synchronously.

As far as we know, one earlier study focused on the secular trend of screen exposure among Chinese children aged 6 - 18 years, displaying a continuous ascending tendency through the period of 1997 to 2006 (Cui et al., 2011). Two recent studies respectively analyzed the prevalence of screen viewing more than 2 hours per day among Chinese children and adolescents aged 7 - 19 years in 2016 and 2017 based on an ongoing nationwide study, and the finding demonstrated that the prevalence in 2017 (34.6%) was lower than that of 2016 (36.8%) (Cai et al., 2017; Zhu et al., 2019). Taken these findings as well as the present study to-

gether, it became much clear that, of late years, there has been a pullback in screen-based behaviors after a long-term increase. About 10 years earlier than Chinese children, a decreasing trend in overall screen time has been observed in their peers in the US (Iannotti & Wang, 2013). A national survey examined the secular trend of screen exposure among US young people ages 11 to 16 through the quadrennial surveys from 2001 to 2010, and the results started with and kept a decreasing trend throughout the surveys (Iannotti & Wang, 2013), by contrast, researches prior to this mainly got an ascending curve (Adams, 2006; Grunbaum et al., 2002; Grunbaum et al., 2004). It should be the effort in public health promotion was bearing fruits. However, we noticed that the decrease in TV watching explained the majority of the declining trend, other screen exposure, especially online chatting and video/computer games, was still increasing, and as high as one third of the young people continued to spent more than 2 hours per day on screen; indicating there's still considerable work ahead to keep the positive change.

Gender, age, and socioeconomic status exerted a significant influence on an individual's lifestyle choice. This study found that participant with ages 19 - 24 years, being males, living in urban or higher urbanization index area tended to have higher level of screen exposure, though the overall secular trends were generally the same for different gender, age, and residential area over the period being studied. So far the optimal duration of screen time for youths is not yet recommended, while for children and adolescents, the recommendation was not more than 2 hours per day (American Academy of Pediatrics, 2016). This study found that, compared to children, adolescents were more likely to meet screen time guideline, which was also reported in previous studies in China (Cai et al., 2017; Cui et al., 2011; Zhu et al., 2019). By contrast, data from the western countries, such as US, Brazil, Norway, and Israel, indicated screen time increased with age (Adams, 2006; Dalene et al., 2018; Kelishadi et al., 2017; Iannotti & Wang, 2013; Schaan et al., 2019). Back on China's intrinsic sociocultural value, Chinese children burden themselves with a tremendous academic pressure, and they spend more and more time on their studies as the grades increase from primary schools to high schools. In addition, it is a common practice for Chinese adolescents in high schools to board schools, especially in rural areas, which may restrict the access to screen facilities. In accordance to majority of studies, we also found that males have more screen exposure at all age (Adams, 2006; Cai et al., 2017; Cui et al., 2011; de Onis et al., 2007; Grunbaum et al., 2002; Grunbaumet al., 2004; Iannotti & Wang, 2013; Zhu et al., 2019). The mechanism for explaining this gender-specific impact remains unclear, biological factors (such as sex hormone) may be partly responsible for this gender difference in the behavior preference (Corre et al., 2016; Mitsui et al., 2019). Our study also explored the geographical and economic differences by taking into account urban/rural area and urbanization index level. In accordance with our hypothesis, the distinguishing impact mainly lied in urban vs rural area, but rather than different urbanization index level. We observed that, although young people in urban

than rural area generally spent more on screen in all surveys, the gap was shrinking with time going on. In the recent decades, China has achieved great progress in economy, screen-based device has been widely available. We speculate that lifestyle choice and health awareness may become more prominent in determining the usage of media devices.

There is an increasing prevalence of overweight/obesity among Chinese young people over the recent decades, which has been a public health challenge (Song et al., 2015; Zhang et al., 2018; Zong et al., 2017). It has been well recognized that excessive screen use contributes to the rising trend of overweight/obesity (Cai et al., 2017; Carson et al., 2016; Tremblay et al., 2011; Tremblay et al., 2014; Wu et al., 2016; Zhu et al., 2019). With greater awareness and understanding of the importance of physical activity in health, increasing attention has been focused on the intervention strategy to control screen-base sedentary behaviors. This study is the first to report that the rising trend of Chinese young generation's screen use showed an encouraging change in recent years. However, overweight/obesity was still in growing during the same period. Usually, there need time to let modified behaviors ferment to achieve health benefits, which has been confirmed by previous behavioral intervention studies (Rigby et al., 2020). In addition, except for screen-based sedentary behaviors, other factors, such as diet, sleep, physical activity, exert considerable impact on energy metabolism in human body (Asghari et al., 2017; Finck Barboza et al., 2013; Meurling et al., 2019; Zhu et al., 2019), however, this study didn't take these factors into account simultaneously.

The present study has several strengths. First, we used data covering eleven years from 2004 to 2015, which is the longest time span to date to observe the trends of screen exposure in Chinese young generation. Secondly, a standardized survey programme and rigorous random sampling scheme were consistently performed in all sampled province throughout every survey, which promised the CHNS data some nationally representative to a large extent. Third, short survey interval made it possible to identify screen exposure's change in early time. However, several limitations should be noted. The primary one is that there is the possibility that data collection on screen exposures lagged behind screen technology's development and application. Secondly, bias in screen time is inevitable since it was self-reported, however, collecting data through self-reported question is the only option feasible in large epidemiological study. Finally but most importantly, only one descend was followed in the secular trend, its sustainability needs further demonstration by future studies.

5. Conclusion

This study explored screen use trajectory in Chinese young generation over the duration from 2004 to 2015, and the results demonstrated that the rising trend in daily screen reached the peak in 2011, and then followed by a drop in 2015. The stratification analyses by age, gender, residential area to most extend copied the same trajectory, especially in participants living in urban area. During the

same period, the prevalence of overweight/obesity kept increasing, without showing the similar reverse synchronously, indicating other factors, such as diet, sleep, and physical activity, could be playing a stronger role in children's weight gain. Maintaining a focus on screen-based sedentary behaviors, especially its updated change and the possible health effect should be of significance for the modification of health promotion strategy.

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Authors' Contributions

ZW, YD and QL were involved with study design and data recruitment. ZW and YD drafted the manuscript. ZW performed the statistical analysis. QL helped to review the manuscript. All authors read and approved the final version of the manuscript, and agreed with the order of presentation of the authors.

Conflicts of Interest

The authors declare that they have no competing interests.

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