



Sex differences in changes in BMI and blood pressure in Chinese school-aged children during the COVID-19 quarantine

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Abstract

There may be sex differences in BMI and blood pressure levels in school-age children, especially in the face of lifestyle changes. This study aimed to explore sex differences in changes in BMI and blood pressure in Chinese school-aged children during the COVID-19 quarantine. The cohort study of 445 school-aged children examined the change of BMI and blood pressure during the five-month quarantine. Multivariable Cox regression models were created to identify potential predictors of overweight, obesity, and elevated blood pressure (EBP). During the COVID-19 quarantine, the proportion of boys with overweight and obesity increased ($P = 0.036$), and the proportion of both boys and girls with Pre-EBP and EBP increased ($P = 0.004$ in boys; $P < 0.001$ in girls). The multivariate Cox regression analysis demonstrated that the setting, eating chili, parents' perception of their child's size and family doting were associated with overweight, obesity, and EBP. The study showed that BMI was more likely to increase in boys, and blood pressure increased in both boys and girls during the COVID-19 quarantine.

Introduction

At the end of 2019, the coronavirus disease 2019 (COVID-19) broke out in Wuhan, Hubei Province, China [1]. To prevent the spread of COVID-19, the Chinese government adopted a strict policy of “stay-at-home” [2]. Schools were closed and the children spent about 5 months studying online. As a result, children's study and life patterns were

disrupted, with possible effects on the children's physiological well-being.

Therefore, to understand this possible impact of the COVID-19 pandemic, body mass index (BMI) and blood pressure data was collected from school-age children. In total, 445 children aged 7–12 from five primary schools were selected to complete a baseline survey by a random sampling method between October and November 2019. Then they were followed up from July to September 2020 after the COVID-19 quarantine ended. In this cohort study, we explored sex differences in changes in BMI and blood pressure in children during the COVID-19 quarantine, and the potential factors for these changes.

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Methods

Study design and population

The cohort was established from October to November 2019. 935 school-age children were selected between 7 and 12 years old by a simple random sampling method from five primary schools. In December 2019, COVID-19 broke out, the schools were closed and children were quarantined at home. It was not until mid-May 2020 that primary and secondary schools reopen in China. We followed up with these students.

But because of the epidemic prevention policy, we could only follow up the students in the hospital, and only 445 students completed the survey from July to September 2020. Other children lost to follow up because parents and guardians did not approve or had no time to participate.

A set of standardized questionnaires for students and parents assessed demographic characteristics, lifestyle, diet, learning and social skills, family situation, and other risk factors. Students filled out questionnaires with the guidance of investigators. Parent questionnaires were filled out by the students' parents or guardians. The anthropometric measurements (weight, height, blood pressure, and pulse) were measured by trained professionals. Written informed consent was obtained from parents or guardians. The study was approved by the Ethics Committee of Henan University.

Measurements

The school-aged children wearing light clothing and no shoes were measured for height and weight using standard methods with a metric scale to the nearest 0.1 cm and 0.1 kg. Blood pressure was measured in triplicate at 30-s intervals by using an electronic sphygmomanometer (Omron HEM-7136) and the mean was used for analysis. BMI was calculated as weight in kilograms divided by the square of height in meters.

Definitions

Pre-EBP (elevated blood pressure) and EBP were defined as SBP (systolic blood pressure) and/or DBP (diastolic blood

pressure) \geq age-, sex-, and height-specific 90th and 95th percentile, according to the blood pressure cutoff for Chinese children at 7–17 years of age [3]. Overweight and obesity were defined using the sex- and age-specific BMI criteria, that is, BMI percentile at least 85th and 95th, respectively [4].

Statistical analysis

The baseline data are summarized as median (interquartile range) for quantitative variables and number (percentage) for categorical variables. Differences between groups were tested by nonparametric Wilcoxon test for quantitative variables and chi-square test for categorical variables. Cox proportional-hazards regression models were created using a forward LR elimination procedure to calculate the hazard ratio (HR) and corresponding 95% confidence interval (CI) for overweight/obesity and Pre-EBP/EBP. The potential risk factors included family setting (Urban = 0, Rural = 1), father's and mother's BMI (Continuous variable), father's and mother's education level (Junior school and below = 0, High school = 1, University undergraduate or junior college = 2, Graduate student and above = 3), the number of cars in the family (No cars = 0, One car = 1, Two cars = 2, More than two cars = 3), frequency of eating chili (0 times/week = 0, 1–3 times/week = 1, ≥ 4 times/week = 2), parents' perception of child's body size (Obese = 0, Overweight = 1, Normal = 2, Thin = 3, Emaciation = 4), whether parents think obesity is associated with chronic diseases (No = 0, Yes = 1, Don't know = 2), family doting (No = 0, Yes = 1) and parents strictness regarding child's

Table 1 Changes in BMI and blood pressure of school-age children during the COVID-19 quarantine ($n = 445$).

	Baseline, n (%)		Follow-up, n (%)			Baseline, n (%)		Follow-up, n (%)		
			Normal BMI	Overweight	Obesity	Normal BP	Pre-EBP	EBP		
All						All				
Normal BMI	153 (34.38)	110 (71.90)	40 (26.14)	3 (1.96)	Normal BP	296 (66.52)	158 (53.38)	53 (17.91)	85 (28.72)	
Overweight	99 (22.25)	12 (12.12)	45 (45.45)	42 (42.42)	Pre-EBP	56 (12.58)	24 (42.86)	12 (21.43)	20 (35.71)	
Obesity	193 (43.37)	2 (1.04)	16 (8.29)	175 (90.67)	EBP	93 (20.90)	24 (25.81)	20 (21.51)	49 (52.69)	
Total	445 (100.00)	124 (27.87)	101 (22.70)	220 (49.44)	Total	445 (100.00)	206 (46.29)	85 (19.10)	154 (34.61)	
Boys					Boys					
Normal BMI	86 (33.08)	56 (65.12)	29 (33.72)	1 (1.16)	Normal BP	166 (63.60)	95 (57.23)	25 (15.07)	46 (27.71)	
Overweight	57 (21.92)	3 (5.26)	24 (42.11)	30 (52.63)	Pre-EBP	37 (14.18)	18 (48.65)	8 (21.62)	11 (29.73)	
Obesity	117 (45.00)	1 (0.85)	8 (6.84)	108 (92.31)	EBP	58 (22.22)	16 (27.59)	13 (22.41)	29 (50.00)	
Total	260 (100.00)	60 (23.08)	61 (23.46)	139 (53.46)	Total	261 (100.00)	129 (49.43)	46 (17.62)	86 (32.95)	
Girls					Girls					
Normal BMI	67 (36.22)	54 (80.60)	11 (16.42)	2 (2.99)	Normal BP	130 (70.65)	63 (48.46)	28 (21.54)	39 (30.00)	
Overweight	42 (22.70)	9 (21.43)	21 (50.00)	12 (28.57)	Pre-EBP	19 (10.33)	6 (31.58)	4 (21.05)	9 (47.37)	
Obesity	76 (41.08)	1 (1.32)	8 (10.53)	67 (88.16)	EBP	35 (19.02)	8 (22.86)	7(20.00)	20 (57.14)	
Total	185 (100.00)	64 (34.59)	40 (21.62)	81 (43.78)	Total	184 (100.00)	77 (41.85)	39 (21.20)	68 (36.96)	

study (Never = 0, Occasionally = 1, Often = 2). $P < 0.05$ was considered statistically significant. Statistical analyses involved use of SPSS 26.0 (IBM, Armonk, NY, USA).

Results

The demographic characteristics of the baseline study population are shown in Supplementary Table 1. The baseline median BMI, SBP, and DBP of the children were 20.9 kg/m², 100.8 mm Hg, and 67.0 mm Hg, respectively. After isolation, the median BMI, SBP, and DBP were 22.4 kg/m², 108.7 mm Hg, and 72.7 mm Hg. BMI and blood pressure increased significantly ($P < 0.001$). The baseline and follow-up data included 445 school-age children whose BMI and blood pressure are shown in Table 1. During the COVID-19 quarantine, 28.1% of children with a normal BMI became overweight or obese, and 42.42% of children with overweight became obese. There was no significant difference in the distribution of normal BMI, overweight, and obesity groups between boys and girls at baseline ($\chi^2 = 0.72$, $P = 0.697$). But during follow-up, the difference in BMI distribution between boys and girls was statistically significant ($\chi^2 = 7.36$, $P = 0.025$). The BMI distribution of boys at follow-up was statistically different from that at baseline ($\chi^2 = 6.66$, $P = 0.036$). However, there was no significant change in the distribution of BMI among the girls at follow-up compared to baseline BMI ($\chi^2 = 0.28$, $P = 0.871$).

Compared to baseline, 46.63% of children with normal blood pressure became Pre-EBP and EBP. Whether at baseline or during follow-up, there was no significant difference in the distribution of normal BP, Pre-EBP, and EBP groups between boys and girls ($\chi^2 = 2.61$, $P = 0.272$ at baseline; $\chi^2 = 2.56$, $P = 0.278$ at follow-up, respectively). However, we found that more children with normal blood pressure became Pre-EBP and EBP. Thus, there was a statistically significant difference between the baseline and follow-up blood pressure in boys ($\chi^2 = 11.06$, $P = 0.004$). The difference was also seen in girls ($\chi^2 = 31.04$, $P < 0.001$).

In addition, the ANCOVA analysis showed that there were no significant sex differences in BMI, SBP, and DBP during follow-up after adjusting baseline age, BMI, SBP, and DBP. These analyses are not shown in the manuscript. Therefore, large sample population is needed to verify.

Due to the requirements of COVID-19 prevention and control measures, some students were not followed up. But there was no statistical difference in the baseline demographic characteristics of the study subjects and the lost follow-up population (Supplementary Table 2).

Following up with children with normal baseline BMI and blood pressure, the multivariate Cox regression analysis demonstrated that three factors were associated with the risk of overweight and obesity in school-age children (Table 2),

Table 2 Univariate and multivariate Cox proportional-hazards regression analysis of risk of incident overweight/obesity and Pre-EBP/EBP.

	Overweight/obesity			Pre-EBP/EBP				
	Crude HR (95%CI)	P^a	Adjusted HR (95%CI)	P	Crude HR (95%CI)	P^a	Adjusted HR (95%CI) ^a	P
Baseline BMI	—	—	—	—	1.28 (0.90–1.80)	0.169	—	—
Setting	0.11 (0.05–0.22)	<0.001	0.13 (0.06–0.28)	<0.001	0.26 (0.18–0.39)	<0.001	0.25 (0.16–0.38)	<0.001
Father's BMI	1.11 (1.02–1.20)	0.014	—	—	1.01 (0.96–1.06)	0.665	—	—
Mother's BMI	1.00 (0.90–1.11)	0.991	—	—	0.98 (0.93–1.04)	0.502	—	—
Father's education level	1.07 (0.70–1.65)	0.747	—	—	1.23 (1.00–1.53)	0.056	—	—
Mother's education level	1.27 (0.85–1.90)	0.247	—	—	1.09 (0.87–1.36)	0.449	—	—
The number of cars in the family	0.72 (0.42–1.24)	0.239	—	—	0.76 (0.56–1.01)	0.061	—	—
Frequency of eating chili	2.26 (1.57–3.23)	<0.001	1.66 (1.13–2.43)	0.009	1.21 (0.98–1.50)	0.074	—	—
Parents' perception of child's body size	0.61 (0.38–0.99)	0.044	0.56 (0.38–0.81)	0.002	1.02 (0.82–1.25)	0.892	—	—
Whether parents think obesity is associated with chronic diseases	1.07 (0.94–1.22)	0.289	—	—	1.07 (0.99–1.15)	0.074	—	—
Family doting	0.74 (0.39–1.38)	0.343	—	—	0.66 (0.47–0.94)	0.022	0.62 (0.43–0.88)	0.008
Parents strictness regarding child's study	0.66 (0.45–0.98)	0.039	—	—	1.02 (0.81–1.28)	0.883	—	—

^aThe variables with $P < 0.05$ in univariate Cox regression analysis entered the multivariate Cox regression analysis.

including setting ($HR < 1$), frequency of eating chili ($HR > 1$) and parents' perception of their child's size ($HR < 1$). Moreover, setting ($HR < 1$) and family doting ($HR < 1$) were associated with risk of elevated blood pressure.

Discussion

The COVID-19 pandemic has already led to poverty, food insecurity, and poor health outcomes [5]. Measures being taken to control the spread of COVID-19 are causing what has been dubbed a "secondary pandemic" of child neglect and abuse [6]. Our study showed that BMI was more likely to increase in boys, but blood pressure increased in both boys and girls during the school closure. These changes were related to where the children lived, their eating habits, and parents' concern for their children.

Some studies suggest that lifestyle changes during the COVID-19 quarantine including decreased sports activities, increased sleep time, and increased screen time are associated with obesity [7, 8]. Our studies have shown a sex difference in BMI and blood pressure changes in school-age children, which may reflect sex differences in body composition and growth patterns from the neonatal period through adulthood. There are also sex differences in energy requirements, interaction with the home environment and food consumption, and overall levels of physical activity [9].

We found that the risk of obesity and elevated blood pressure was reduced in children who lived in rural areas and had high levels of parental concern during follow-up. The prevalence of overweight, obesity, and elevated blood pressure in urban children was higher than in their rural peers in China [10, 11]. Parents' ability to classify accurately their child's weight status is regarded as important [12]. Increased parental concern has been associated with many positive dietary changes in families, because parents may be more able to take effective measures to help their children regain a healthy weight. Chili peppers can promote fat metabolism, energy expenditure, and thermogenesis, so chili consumption was inversely associated with the incidence of overweight and obesity in adults [13, 14], but chili consumption was a risk factor for overweight and obesity in children in our study. Therefore, a larger sample size is needed to confirm the association between eating chilies and overweight and obesity in school-age children. In addition, we found an interesting finding that children's blood pressure increased independently of BMI. This may be due to environmental factors affecting blood pressure during isolation. For example, excessive screen time is associated with poor sleep and risk factors for cardiovascular diseases such as high blood pressure [15].

This cohort study has several limitations. With a small sample size, the effect of the COVID-19 pandemic on BMI and blood pressure may be underestimated and limit the assessment of risk factors for obesity and elevated blood pressure. In addition, there is a population lost to follow-up in this study. However, since the baseline demographic characteristics of the study subjects and the lost follow-up population were not statistically different, lost to follow-up may not lead to bias.

The COVID-19 pandemic will continue to undermine global health and economic indicators. The health of children is particularly important during the COVID-19 pandemic. The personal, family, and physical environment, the social environment and policies, including improvements in the family dietary environment, parental rearing patterns and coping with environmental stress, can reduce overweight, obesity, and elevated blood pressure in children.

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Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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