



Dietary and activity habits associated with hypertension in Kunming school-aged children and adolescents: A multilevel analysis of the study of hypertension risks in children and adolescents

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ABSTRACT

Objective: Hypertension has become a public health challenge for Yunnan children and adolescents. The study aims to assess the dietary and activity habits associated with hypertension in Kunming children and adolescents and to develop effective strategies for preventing and controlling, Southwest China.

Methods: Conducted in 2019, the cross-sectional study involved 3,150 students, aged 13.25 ± 2.77 years, multistage, stratified, randomly sampled from Chenggong and Fumin areas, Southwest China.

Results: Among 3,150 participants, 6.19 % never drank milk, 3.46 % never consumed fresh fruit. 2.67 % never consumed fresh vegetables, 2.48 % never ate breakfast and 10.06 % frequently drank sugary beverages (soft drinking). Additionally, 21.56 % engaged in moderate-intensity exercise less than one Day a week, and 31.97 % performed high-intensity exercise less than one Day a week. The intraclass correlation coefficient indicated that 49.40 % of the total variance was attributed to the dietary level and 42.10 % was attributed to the activity level. Eating fresh vegetables and fruit, taking physical education classes they attended per week and the frequency of moderate-intensity and high-intensity exercise per week were independent protective factors for hypertension ($P < 0.01$); drinking sugary beverages (soft drinking) was an independent risk factor against hypertension ($P < 0.05$); breakfast skipping was a possible risk factor for hypertension ($P < 0.15$). No significant associations were found with fried food or sweet food weekly consumption ($P < 0.15$).

Conclusions: The hypertension of children and adolescents cannot be ignored in Kunming, Southwest China. Dietary and activity factors are modifiable. We should make comprehensive child-friendly health education materials as soon as possible.

1. Introduction

A recent study showed that the prevalence of hypertension in school-aged children and adolescents in Kunming had increased in recent years, and children's hypertension was strongly associated with overweight and obesity (Yunjuan et al., 2022). Moreover, the prevalence of

overweight and obesity among school-aged children and adolescents in Yunnan Province had increased (Yunjuan et al., 2022). Hypertension has become a public health challenge for Yunnan children and adolescents.

Hypertension and obesity in children and adolescents not only increase their risk of cardiovascular disease, musculoskeletal disorders, and abnormal neurodevelopment, but also contribute to a dysfunctional

Abbreviations: WHO, World Health Organization; BMI, Body mass index; WGOC, Working Group for Obesity in China; BP, Blood Pressure; HBP, Hypertension; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure.

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immune system in later life (Voraphani et al., 2021; Chen and Wang, 2008; Triosh et al., 2010; Howe et al., 2014). These conditions simultaneously undermine their current overall health (Norris et al., 2021). Moreover, Childhood hypertension has a trajectory effect (Ingelfinger and Clinical, Practice, 2014; Su et al., 2015), often persisting into adulthood. Without proactive measures to control and prevent hypertension and obesity in young populations, this problem will increase the burden of chronic noncommunicable diseases in adults of the future.

According to previous studies, some risk factors for hypertension can be modified, such as body weight, unhealthy food consumption (fast food, alcohol and smoking), and socioeconomic level (Berenson et al., 1998; Pérez-Izquierdo and Aranda-González, 2022; Ewald et al., 2016,16.; Hu et al., 2022). However, expecting children and adolescents to be capable of managing themselves without support will be unsuccessful (Vivian et al., 2019). Few studies have evaluated factors influencing hypertension in Kunming children and adolescents.

Therefore, the aim of this study was to evaluate the dietary and activity habits associated with hypertension in Kunming school-aged children and adolescents and to provide the scientific basis for making effective interventions to prevent and control the development of hypertension in children in Kunming. This study collected cross-sectional data in 2019 for analysis.

2. Materials and methods

2.1. Study design and data source

Data was obtained in 2019 in Kunming, Southwest China. In brief, the participants in this study were multistage, stratified, randomly sampled from two survey areas in Kunming (Chenggong and Fumin), Southwest China.

Firstly, Kunming, the vibrant provincial capital of Yunnan Province in Southwest China, is a dynamic urban center encompassing seven cities and seven counties, One representative urban and rural region were selected randomly- Chenggong and Fumin. Because two survey areas were randomly chosen. Chenggong is situated in southeastern Kunming, the administrative, economy, and culture center of the Kunming government, and it has a large population. Fumin is a county in north-western Kunming and represents a rural area with a poor economy and culture. The comparison between these 2 diverse regions within Kunming can provide insightful perspectives on various aspects such as economic disparities, culture differences, educational dynamics, geography location, and more. This can help for a nuanced understanding of the city's diverse socio-economic landscape.

Secondly, survey schools in each survey prefecture were randomly selected from an educational committee list (including the junior schools and the senior schools). We randomly selected 8 schools in urban areas, and 5 schools in rural areas.

Next, two or three survey classes (depending on their size) were randomly selected from each grade level in the survey schools.

Finally, the participants who had heart, liver, or kidney disease were excluded. All other participants aged 9–18 years were cluster sampled from the survey classes. All participants and/or their parents/guardians provided written informed consent.

Therefore, the samples are representative and the results are extrapolation.

2.2. Measurements

All participants enrolled in the study made a questionnaire, which was designed by the research group and used in all the study surveys to measure the participants' dietary habits, activity habits and family socioeconomic level et al. The questionnaire mainly collected information about the participants' demographic features, parents' basic information, family income, dietary habits, and activity habits et al.

In addition, all participants enrolled in the study made a physical

examination to collect anthropometric data (weight, height and blood pressure). Body mass index (BMI) was calculated as weight in kilograms divide by height in meters squared. Blood Pressure (BP) was measured according to the recommendation of the National High Blood Pressure Education Program (NHBPEP) Working Group in Children and Adolescents (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children Adolescents, 2004; National Student Physique and Health Research Group, 2014).

2.3. Definitions

This study used Chinese age-specific and height-specific BP references to classify the physical status of the children (Flynn et al., 2017; Lurbe et al., 2016; Ji, 2010; Working Group for Obesity in China (WGOC), 2004; Yunjuan et al., 2015; Ingelfinger, 2014; Dong et al., 2017).

Malnutrition encompasses a range of conditions including emaciation, overweight, and obesity. A deficiency in essential nutrients can severely impair the development and function of the heart and vascular system, thereby increasing the risk of cardiovascular diseases. According to the reference of World Health Organization standards, emaciation is defined as $BMI < (\text{means}-2SD)$ (Ji, 2010). For both boys and girls aged 7–17 years, overweight is defined as $BMI \geq 85\text{th}$ percentile but $< 95\text{th}$ percentile, stratified by gender and age, whereas obesity is defined as $BMI \geq 95\text{th}$ percentile. For individuals aged 18 years, the BMI cut-offs for overweight and obesity in boys and girls are set at 24.0 kg/m^2 and 28.0 kg/m^2 , respectively (Working Group for Obesity in China (WGOC), 2004).

2.4. Statistical analysis

All data were analyzed using IBM SPSS 26.0 software. The prevalence and distribution of the different characteristics studied in the sample were calculated. Chi-square analyses were performed to evaluate differences in the distribution and the epidemic situation of hypertension in different categorical variables. Then, chi-square analyses were used to identify the significantly different indicators for use as logistic analysis factors. The factors associated with hypertension were analyzed using both univariate and multivariate unconditional logistic regression models.

To investigate the associations between the characteristics of dietary habits, activity habits, individual characteristics and hypertension, multilevel logistic regression models with mixed effects were constructed in sequential stages, considering the dietary and activity factors as second and third levels. The multivariate analysis was adjusted for age and sex. The level of statistical significance was defined as $P < 0.05$.

Aiming for a better interpretation of this variance on a logarithmic scale, this study used the standardized regression coefficients method to define the intraclass correlation coefficient. The intraclass correlation coefficient assumed an individual-level variation equal to $\pi/\sqrt{3}$ (Larsen and Merlo, 2005) and provided the variation percentage assigned to the individual, dietary and activity habits level.

3. Results

3.1. Demographic characteristics of participants

Participants were collected from primary, middle and high schools in Kunming, China. A total of 3,150 students were enrolled in 2019. There were 1,515 boys and 1,635 girls included in total ($\chi^2 = 4.60, P > 0.05$). 84.98 % was Han minority ($\chi^2 = 1.55, P > 0.05$). There were 1,835 urban and 1,315 rural students ($\chi^2 = 3.79, P > 0.05$). The average age was 13.25 ± 2.77 years old. There was a significant difference in the distribution of number by age group in 2019 ($\chi^2 = 31.52, P < 0.01$).

3.2. Hypertension epidemiology

The prevalence of hypertension in all participants was 7.43 % (234/3150) (95 %CI: 6.51 %–8.34 %) among school-aged (age 9 to 18) children and adolescents in Kunming.

The prevalence of hypertension was 5.41 % in boys and 9.30 % in girls (Fig. 1). Girls had a 1.72 times higher rate of hypertension than boys (Table 1). The prevalence of hypertension was 7.45 % at 9 to 12-year-old, 8.76 % at 13 to 15-year-old and 5.75 % at 16 to 18-year-old ($\chi^2 = 5.91$, $P < 0.05$). As Table 1 shows, 13 to 15-year-old adolescents had a 1.52 times higher rate of hypertension than 16 to 18-year-old children ($OR=1.19$, $P < 0.05$).

The prevalence of hypertension was 8.07 % in urban areas and 6.54 % in rural areas. There was no significant difference in areas ($\chi^2 = 2.59$, $P > 0.05$) (Fig. 1). And the prevalence of hypertension was 7.02 % in the Han minority and 9.73 % in the ethnic minorities. The prevalence of hypertension in minorities was higher than that of Han ($\chi^2 = 4.27$, $P < 0.05$).

The prevalence of hypertension among malnourished children (9.87 %) was higher than that of normal children (6.20 %) ($\chi^2 = 13.70$, $P < 0.01$). As Table 1 shows, malnourished children and adolescents had a 1.59 times higher risk prevalence of hypertension than normal BMI children ($OR=1.66$, $P < 0.01$).

3.3. Hypertension and dietary habits

In the analysis of hypertension-associated factors, the study showed that eating fried food, regularly consuming sweet food and drinking milk were not included in the multilevel logistic regression models. They may be not independent influencing factors ($P > 0.20$).

As Table 1 and Table 2 showed, drinking sugary beverages (soft drinking), eating fresh vegetables, eating fresh fruit, and eating breakfast were independent risk factors for hypertension. In this study, it was confirmed that breakfast skipping was associated with a higher prevalence of hypertension ($P < 0.01$). Children and adolescents who ate fresh fruit and vegetables every day had the lowest hypertension prevalence ($P < 0.05$).

However, in this study, 6.19 % never drank milk, 3.46 % never ate fresh fruit, 2.67 % never ate vegetables, 2.48 % never ate breakfast and 10.06 % often drank sugary beverages (soft drinking).

The intraclass correlation coefficient indicated that approximately 49.40 % of the total variance was attributed to the diet. As Fig. 2 shows, stratified by BMI nutritional status, eating fresh vegetables more than 5 days a week (in normal students: $OR = 0.27$, 95 %CI 0.12–0.61; in malnutrition students: $OR = 0.33$, 95 %CI 0.14–0.81), and eating fresh fruit every day (in normal students: $OR = 0.27$, 95 %CI 0.12–0.61; in

malnutrition students: $OR = 0.33$, 95 %CI 0.14–0.81) had a significant protective effect on preventing and controlling hypertension in school-aged children and adolescents. Drinking sugary beverages (soft drinking) everyday (in normal students: $OR = 1.90$, 95 %CI 0.83–4.34; in malnutrition students: $OR = 1.96$, 95 %CI 0.70–5.47), and breakfast skipping often (in normal students: $OR = 1.88$, 95 %CI 0.65–5.41; in malnutrition students: $OR = 1.32$, 95 %CI 0.45–3.87) were independent risk factors for children's hypertension.

3.4. Hypertension and activity habits

As Table 1 and Table 2 show, the number of physical education lessons attended ≤ 3 classes per week was an independent protective factor against hypertension in the multilevel logistic regression models ($P < 0.01$). Moreover, the frequency of moderate-intensity exercise and high-intensity exercise per week was also protective factors for children's hypertension. Our analysis confirmed that exercising more than 5 Days a week resulted in the lowest hypertension prevalence ($P < 0.01$).

In this study, 21.56 % of children and adolescents performed moderate-intensity exercise less than one Day a week, and 31.97 % of children and adolescents performed high-intensity exercise less than 1 Day a week.

The intraclass correlation coefficient indicated that approximately 42.10 % of the total variance was attributed to the activity level. As Fig. 3 shows, stratified by BMI nutritional status, performing moderate-intensity exercise for more than 5 Days per week (in normal students: $OR=0.23$, 95 %CI 0.12–0.45; in malnutrition students: $OR=0.01$, 95 %CI 0.00–0.04) and performing high-intensity exercise for more than 5 Days per week (in normal students: $OR=0.30$, 95 %CI 0.17–0.51; in malnutrition students: $OR = 0.06$, 95 %CI 0.02–0.17) had a significant protective effect on preventing and controlling hypertension in school-aged children and adolescents.

4. Discussion

In 2019, the prevalence of hypertension among children and adolescents aged 9–18 years was 7.43 % in Kunming, China. This rate is relatively lower than the prevalence observed in Yunnan (13.82 % to 13.48 %) during the same period (Yang et al., 2021). The previous studies have confirmed the prevalence in Kunming has been steadily rising (2017:6.83 %; 2018: 7.26 %) (Yang et al., 2022). Hypertension in children and adolescents is a silent health problem. It is easy to ignore by their parents, schools, and even society (Hansen et al., 2007). This neglect can increase the risk of these individuals developing arterial hypertension in adulthood (Azegami et al., 2021; Urbina et al., 2019). Therefore, addressing the public health problem of hypertension among children and adolescents in Kunming is imperative. We should implement some effective interventions targeting modifiable factors to prevent and control hypertension in this vulnerable population.

This study confirmed that a robust association between dietary habits/activity habits, and hypertension levels. The intraclass correlation coefficient indicated that approximately 49.40 % of the total variance in hypertension levels was attributed to the diet, while 42.10 % was linked to the activity levels. Daily consumption of fresh fruits and vegetables, participation in three physical education classes per week, and engaging in both moderate-intensity exercise and high-intensity exercise multiple times per week were independent protective factors against hypertension ($P < 0.05$). So balanced amount exercise is crucial for maintaining healthy blood pressure levels. Breakfast skipping and drinking sugary beverages (soft drinking) were risk factors for hypertension.

This study indicated that consuming fresh vegetables ($OR = 0.26$, 95 %CI 0.13–0.53) and fruits ($OR = 0.50$, 95 %CI 0.23–1.09) daily were the protective factors of preventing hypertension, likely due to the high dietary fiber content. Vegetables and fruits are rich in fiber, fruit acid (Krupp et al., 2015), potassium, phytochemicals and antioxidants (John

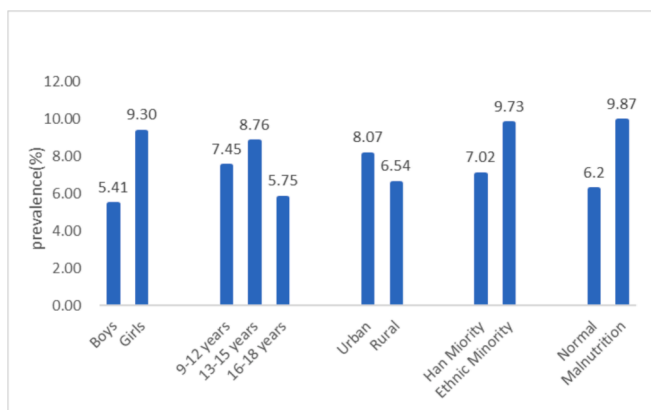


Fig. 1. The Prevalence of Hypertension for School-aged Children and Adolescents in Different Socio-demographic Characteristics in Kunming, Southwest China, 2019.

Table 1
Univariate analysis with logistic regression in hypertension of Kunming school-aged children and adolescents, Southwest China, 2019.

	Variables	N	Hypertension	%	Odds ratio	95 %CI	P value
Individual characteristics	Sex**						
	Boys	1515	82	5.41	1		
	Girls	1635	152	9.30	1.791	1.356–2.366	0.000
	Age (years)*						
	9–12	1328	99	7.45	1		
	13–15	1005	88	8.76	1.191	0.883–1.608	0.252
	16–18	817	47	5.75	0.758	0.529–1.085	0.130
	Area**						
	Urban	1835	148	8.07	1		
	Rural	1315	86	6.54	0.798	0.605–1.051	0.107
	Minority*						
	Han minority	2677	188	7.02	1		
Ethnic minority	473	46	9.73	1.426	1.017–2.001	0.039	
BMI**							
Normal	2096	130	6.20	1			
Malnutrition	1054	104	9.87	1.656	1.265–2.167	0.000	
Dietary habits characteristics	Drinking sugary drinks or not*						
	No	425	17	4.00	1		
	occasion	2408	193	8.01	2.091	1.260–3.472	0.004
	Often	317	24	7.57	1.966	1.037–3.725	0.038
	Eating sweet food (cakes, ice-cream, chocolate et al.) or not						
	No	268	20	7.46	1		
	occasion	2344	173	7.38	0.988	0.611–1.599	0.961
	Often	538	41	7.62	1.023	0.587–1.783	0.936
	Eating fried food or not						
	No	357	20	5.60	1		
	occasion	2414	180	7.46	1.358	0.843–2.185	0.208
	Often	379	34	8.97	1.661	0.937–2.943	0.082
	Eating fresh fruit or not**						
	No	109	11	10.09	1		
	occasion	2239	186	8.31	0.807	0.425–1.532	0.512
	Often	802	37	4.61	0.431	0.231–0.872	0.019
	Eating vegetables or not**						
	No	84	15	17.86	1		
	occasion	1385	118	8.52	0.428	0.238–0.772	0.005
	Often	1681	101	6.01	0.294	0.162–0.532	0.000
Eating breakfast or not*							
Everyday	2021	129	6.38	1			
occasion	1051	97	9.23	1.491	1.133–1.963	0.004	
No	78	8	10.26	1.676	0.789–3.559	0.179	
Drinking milk or not*							
No	195	23	11.79	1			
occasion	2095	158	7.54	0.610	0.383–0.971	0.000	
Often	860	53	6.16	0.491	0.293–0.823	0.000	
Activity habits characteristics	Number of Physical education lessons in a week**						
	≥4 classes	343	38	11.08	1		
	0–3 classes	2807	196	6.98	0.603	0.417–0.870	0.007
	The frequency of moderate-intensity exercise per week**						
	≤1 day	679	99	14.58	1		
	2–4 days	1024	119	11.62	0.770	0.579–1.026	0.074
	≥5 days	1447	16	11.06	0.066	0.038–0.112	0.000
	The frequency of high-intensity exercise per week**						
	≤1 day	1007	139	13.80	1		
	2–4 days	1299	73	5.62	0.372	0.276–0.500	0.000
≥5 days	844	22	2.61	0.167	0.106–0.265	0.000	

Note: P value come from univariate unconditional logistic regression models; *P < 0.05; **P < 0.01.

et al., 2002), etc. Previous study has reported that an increase of one vegetable (200 g) could decrease systolic blood pressure by approximately 0.14 mmHg (Yang et al., 2018). These nutrients are believed to be beneficial for maintaining a healthy blood pressure profile (Riccardi et al., 2022).

Additionally, this study found that drinking sugary beverages (soft drinking), even occasionally (OR = 1.91, 95 %CI 1.12–3.27), would increase the risk factor of hypertension (P < 0.05). This association is likely due to the high sugar intake. Previous studies have confirmed sugar-sweetened beverages was associated with higher blood pressure (Habib et al., 2014; Bamini et al., 2012; Baldo, 2010).

Meanwhile, this study also found that breakfast skipping was a

possible risk factor for hypertension (P < 0.10). Previous studies has underscored the importance of considering the daily habit of eating breakfast separately (Aparicio-Cercós et al., 2020). Skipping breakfast is associated with a higher body fat percentage (Gilardini et al., 2015). While, a regular daily breakfast-eating habit is related to lower body fat and reduced cardiovascular risk profiles (Hallström et al., 2013; Gibney et al., 2018; Wennberg et al., 2015).

As we all know, physical activities are benefit for our health. A previous study highlighted that inactivity (OR = 1.204) was a potential risk factor for hypertension in primary and secondary school students in Yunnan, China (Jinping et al., 2019). This study corroborated those findings. When stratified by BMI nutritional status, the prevalence of

Table 2
Association between individual, dietary and activity habits characteristics and hypertension in Kunming school-aged children and adolescents, Southwest China, 2019.

Variables	Model 1		Model 2		Model 3		Model 4			
	Odds ratio	95 %CI	Odds ratio	95 %CI	Odds ratio	95 %CI	Odds ratio	95 %CI		
Individual characteristics	Area									
	Urban	Ref.						Ref.		
	Rural	0.584***	0.412–0.827					0.577***	0.399–0.835	
	BMI									
	Normal	Ref.						Ref.		
	Malnutrition	1.697***	1.294–2.227					1.517***	1.129–2.038	
Ethnics	Han									
	Han	Ref.						Ref.		
	Minority	2.159***	1.407–3.313					1.858***	1.173–2.944	
Dietary habits characteristics	Eating fresh fruits or not									
	No occasion			Ref.				Ref.		
	Often			0.889	0.448–1.765			0.911	0.444–1.867	
	Eating vegetables or not									
	No occasion			Ref.				Ref.		
	Often			0.403***	0.216–0.753			0.353***	0.176–0.710	
	Eating breakfast or not									
	Everyday			Ref.				Ref.		
	Occasion			1.352**	1.019–1.793			1.341*	0.985–1.824	
	No			1.574	0.719–3.446			2.080*	0.887–4.879	
	Drinking sugary drinks or not									
	No occasion			Ref.				Ref.		
	Often			1.927**	1.150–3.229			1.914**	1.120–3.272	
	Drinking milk or not									
	No occasion			Ref.				Ref.		
	Often			0.640***	0.398–1.028			0.528***	0.312–0.893	
	Activity habits characteristics	The frequency of moderate-intensity exercise per week								
		≤1 day					Ref.		Ref.	
2–4 days						1.714***	1.171–2.509	1.967***	1.326–2.919	
≥5 days						0.106***	0.061–0.183	0.109***	0.062–0.189	
The frequency of high-intensity exercise per week										
≤1 day						Ref.		Ref.		
2–4 days						0.254***	0.172–0.377	0.233***	0.155–0.349	
≥5 days						0.236*	0.147–0.379	0.230***	0.142–0.373	
Physical education lessons per week										
≥4 classes						Ref.		Ref.		
≤3 classes						0.573***	0.380–0.864	0.576***	0.378–0.878	

Ref., reference category.

Model 1, individual variables; Model 2, dietary variables; Model 3, activity variables; Model 4, individual variables, dietary variables and activity variables. All models were adjusted for age and gender.

P value come from multivariate unconditional logistic regression models; *P < 0.15; *P < 0.05; ***P < 0.01.

hypertension among the school-aged malnutrition children who engaged in moderate-intensity exercise for more than five days in a week was 0.23 times lower than those who did not (OR = 0.01, 95 %CI 0.00–0.04). Similarly, children who performed high-intensity exercise more than 5 days a week had a prevalence 0.06 times lower than those who did not (OR = 0.06, 95 %CI 0.02–0.17). Therefore, regular exercise may be particularly protective against hypertension in children and adolescents, especially those suffering from malnutrition children. And taking physical education lessons also play an important role in preventing hypertension of children.

However, previous study has indicated that daily milk consumption was good for health (Choi et al., 2022). This may be due to milk’s high animal protein and calcium content. Increasing protein intake may promote cardiovascular health and prevent the progression of hypertension. The calcium in dairy products may help lower cholesterol by

inhibiting the intestinal absorption of saturated fatty acids and increasing the fecal excretion of bile acids (Dauchet et al., 2006). This study has not confirmed these findings, suggesting the need for further research.

According to this study, 6.19 % of children and adolescents never drank milk, 3.46 % never ate fresh fruit, 2.67 % never ate vegetables, 2.48 % never ate breakfast and 10.06 % often drank sugary beverages (soft drinking). Additionally, 21.56 % of children and adolescents performed moderate-intensity exercise less than one day a week, and 31.97 % of children and adolescents performed high-intensity exercise less than one day a week. These results suggest that a significant portion of school-aged children and adolescents exhibit unhealthy dietary behaviors and activity habits, which are modifiable risk factors. If we develop comprehensive child-friendly educational electronic animations and pamphlets for children (Yang et al., 2022), this might change these

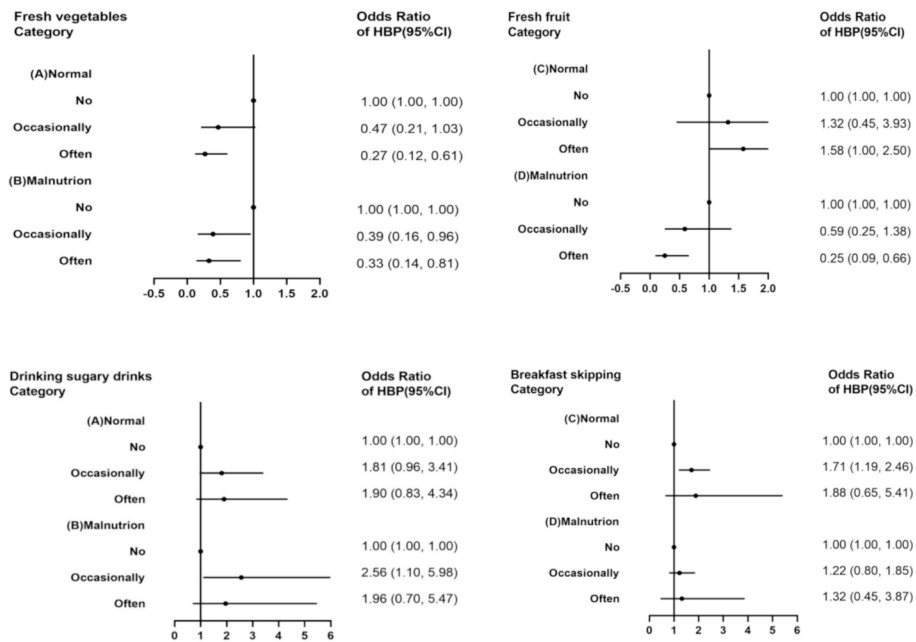


Fig. 2. Association between dietary habits and the risk of hypertension by BMI (normal and malnutrition) of Kunming school-aged children and adolescents, Southwest China, 2019. Values are adjusted for age and sex.

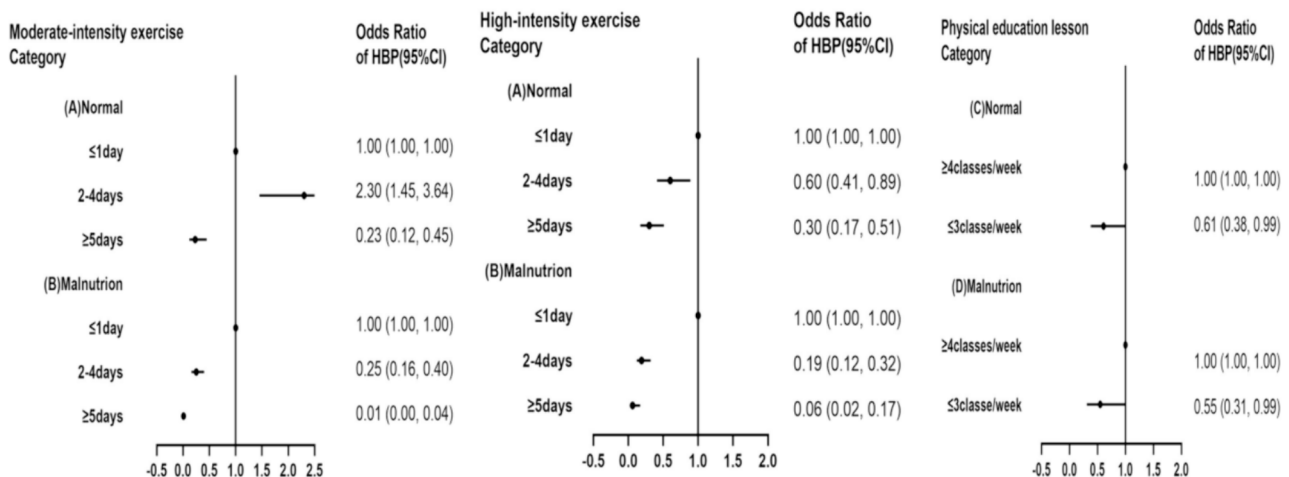


Fig. 3. Association between activity habits and the risk of hypertension by BMI (normal and malnutrition) of Kunming school-aged children and adolescents, Southwest China, 2019. Values are adjusted for age and sex.

behaviors. These interventions could not only improve the dietary and activity behavior habits of children and adolescents but also influence their parents, and other family members, ultimately reducing their risk of developing hypertension in adulthood.

This study has a few limitations. Firstly, this study was a cross-sectional study, it was inability to establish causality. Secondly, because the dietary and activity habits were self-reported, which may introduce bias due to the sensitivity and subjectivity of self-assessment. Thirdly, this study results may underestimate the prevalence of hypertension. Because the hypertension was defined as SBP and/or DBP at least 95th percentile based on age-, sex-, and height- percentiles.

5. Conclusion

In conclusion, the study found that a strong association between dietary habits/activity habits and hypertension levels. Dietary factors accounted for 49.40 % of the total hypertension variance, while activity

habits accounted for 42.10 %. Specifically, drinking sugary beverages (soft drinking) increased the risk of hypertension, whereas consuming fresh vegetables and fruit every day and engaging in physical exercise more than five days per week were beneficial for reducing the risk of developing hypertension in children and adolescents. This study also indicated some school-aged children and adolescents had unhealthy dietary and activity lifestyles. It was bad for preventing children’s hypertension. Therefore, it is essential to develop comprehensive, child-friendly health education materials to improve the healthy growth and prevent hypertension in children and adolescents as soon as possible.

Author contributions

All authors were involved in the drafting of this manuscript and have read and approved the content. L.M. and Y.J.Y. conceived the study and its design, wrote the manuscript. H.H.S. coordinated survey fields. Y.K.C. analyzed data. T.N.L. drew pictures. All authors have read and agreed

to the published version of the manuscript.

Ethics approval

The survey was approved by the Medical Research Ethics Committee of Yunnan Preventive Institute. And all participants' parents gave the written informed consent for their children's participation in this survey.

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CRedit authorship contribution statement

Yunjuan Yang: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis. **Honghai Su:** Investigation. **Yukun Chen:** Formal analysis, Data curation. **Tunan Li:** Visualization, Formal analysis. **Le Ma:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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