

## Original Article

# Nonalcoholic fatty liver disease prevalence in urban school-aged children and adolescents from the Yangtze River delta region: a cross-sectional study

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**Purpose:** To determine the prevalence of nonalcoholic fatty liver disease (NAFLD) and explore the relationship of NAFLD with anthropometric parameters among school children from the Yangtze River delta region. **Methods:** A cross sectional study on childhood NAFLD was conducted using the stratified cluster sampling method in four regions of the Yangtze River delta in September 2009 to October 2011. In all, 7,229 students, aged 7-18 years, from 12 primary, middle and high schools participated in the study. Height, weight, and waist circumference were measured; body mass index (BMI) and waist to height ratio (WHtR) were calculated and liver ultrasonography was performed. **Results:** The overall NAFLD prevalence was 5.0%; 7.5% in boys, 2.5% in girls, 5.6% in subjects with peripheral obesity, 12.9% in those with abdominal obesity and 44.8% in those with mixed obesity. The prevalence was also increased with regional difference. Binary logistic regression analysis showed that WHtR was the major independent risk factor for childhood NAFLD, causing a 14.4-fold increase in NAFLD risk. Receiver operating characteristic curve analysis also showed that WHtR was the best obesity index to evaluate the presence of NAFLD in Chinese schoolchildren with the optimal cutoff of 0.47. **Conclusions:** Mixed obesity had the strongest association with NAFLD. Male gender and regional urbanization also influenced NAFLD prevalence among schoolchildren. WHtR may be an effective indicator to predict NAFLD.

**Key Words:** fatty Liver, children, obesity, prevalence, risk factors

## INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) is the most common liver disease in children in America, Europe, Australia and Asia.<sup>1-5</sup> The affected children are usually asymptomatic or only complain of fatigue so as to be ignored. However the risks of NAFLD may persist into early adulthood, with a varied clinical course that ranged from bland (simple) steatosis to nonalcoholic steatohepatitis (NASH) that may lead to fibrosis and cirrhosis in a short period of time.<sup>6,7</sup> A long-term follow-up study with sixty-six children observed for 20 years showed that NAFLD in children has a continuous deterioration which was associated with a set of outcomes such as diabetes, metabolic syndrome, end-stage liver disease and significantly shorten the survival as compared with the general population.<sup>8</sup> Another prospective study from Valerio Nobili et al reported that a two-year intervention program which consisted of healthy diet and physical exercise could result in a significant decrease in body mass index (BMI), levels of fasting glucose, insulin, lipids, and liver enzymes, thus improving the liver condition in NAFLD pediatric.<sup>9</sup> Consequently, the best man-

agement of NAFLD is screening for high risk children and adolescents with prompt intervention program.

NAFLD was initially thought to be largely restricted to affluent, industrialized, Western countries, and this condition affects 2.6%-9.6% of the general pediatric population in North America and other Western countries.<sup>1-3,5</sup> Recently, China has encountered unprecedented urbanization, which has led to rapid changes in lifestyle and a consequent increase in the prevalence of childhood obesity.<sup>10,11</sup> However, no reliable data exists on the prevalence of NAFLD in Chinese school-aged children from varied economic backgrounds. We therefore sought to obtain data on NAFLD in Chinese children of both genders, dif-

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ferent age groups and economic backgrounds.

Owing to the lack of a reliable, non-invasive screening tool, the standard approach for the diagnosis of NAFLD is a liver biopsy, which is not a viable option in population-based studies. The level of serum alanine aminotransferase is the usual screening tool for NAFLD in many studies, but some biopsy results found that the advanced fibrosis can be seen in children with normal liver enzymes.<sup>6</sup> Magnetic tomography can clearly distinguish fat tissue from other tissues and is useful in adults, but is inappropriate in children because of its cost and longer acquisition time. Computed tomography is also a common technique to evaluate fat accumulation in liver in adults, however its association with radiation exposure restricts its use in children and adolescents.<sup>12</sup> Ultrasonography, which has more than 90% specificity and sensitivity, may be the best technique to screen for childhood NAFLD.<sup>13</sup> This technique can reveal the degree of fatty infiltration of the liver, but may not be reliable in the case of mild disease because it is operator dependent. Hence, if supplemental methods could be utilized to screen populations at high risk for NAFLD, it may improve diagnosis accuracy and increase prevention efficiency. Anthropometric indicators are possibly the most simple, convenient and suitable predictors of early NAFLD in children and adolescents; however, opinions are divided on which anthropometric indices are the optimal indicators of NAFLD.<sup>14,15</sup> Data from large-scale surveys is required to determine the relationship between anthropometric indices and NAFLD.

The purpose of this study was to (a) investigate the epidemiological characteristics of NAFLD among schoolchildren in rapidly urbanized areas of China and (b) determine which anthropometric parameters is the strongest risk for NAFLD.

## SUBJECTS AND METHODS

### Study design and subjects

Before starting the investigation, we forecast the prevalence of childhood NAFLD was around 2%-14% according to some previous studies in Asia and assumed the incidence of fatty liver was 8%. A sample size of 6000 could produce a two-sided 95% confidence interval with a width equal to 1.4%.<sup>14,16-18</sup> In order to ensure the adequate sample in this multi-regional study, the sample size was increased to at least 7000.

Subjects were selected using a multi-stage, cluster, random sampling of 7 to 18 year olds in urban areas of the Yangtze River Delta, according to gross domestic product and population demographics. Shanghai (tier 1 city, both the city center and suburbs were included) subjects were placed at the top level, followed by Jiaying City and Zhejiang Province at the middle level and Huai'an City and Jiangsu Province at the bottom level (in the tier 2 and 3 cities, only the city center was included). Public elementary, middle and high schools that were randomly selected from the surveyed cities and each had over 300 pupils. If the chosen subjects were unavailable at some point, they were not replaced but merely excluded. The process of sample selection is described as follows (see Figure 1).

Students were excluded from the study if they did not

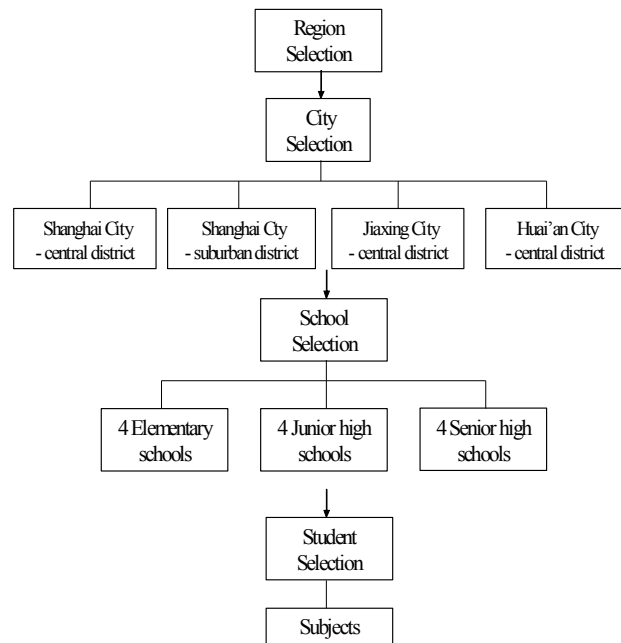


Figure 1. The process of sample selection

fill within the required age range, had not resided within the chosen location for a minimum of 3 years or were known to have a history of liver disease (including viral hepatitis, genetic autoimmune disease, congenital, metabolic liver disease or drug-induced liver damage).

The ethics committee of Shanghai Jiao Tong University, School of Medicine, Renji Hospital approved this research study. The study was conducted from September 2009 through October 2011. A notification explaining the purpose and procedure of this study was given to all the students and their parents. The parents were required to sign informed consent forms and complete a questionnaire including basic information (class, student number, date of birth, genders, medical history, etc). All data were rechecked by class teacher or health staff of the schools. Examinations were held in September or October of each year, in classrooms or school health offices in the afternoon under controlled conditions, including light (proper brightness for ultrasound scan) and temperature (25-26°C).

### Anthropometric measurements

Weight was measured using a TBF-410 Body Fat Analyzer (Japan Tanita Corp.) with the subjects stripped down to their underwear and barefeet. Measurements were taken in kilograms and were accurate to 0.1 kg. Height measurements were taken using equipment (SZG-180) from the Jiangsu Zilang Company and according to the provisions of the Chinese Students' Physical Fitness and Health Research Guidelines, 2000. Subjects were barefoot for the height measurements. Height was recorded in centimeters and was accurate to 0.5 cm. Waist circumference (WC) was measured over the bare belly midway between the iliac crest and the lowermost margins of the ribs at the end of a normal expiration with the subjects in a standing position and was taken once with a flexible plastic measuring tape and approximated to the nearest 0.1 cm. Body mass index (BMI; weight in kilograms/[height in meters]<sup>2</sup>) and the waist-to-height ratio (WHtR;

WC/Height) were calculated.

### Ultrasonographic assessments

Liver ultrasonography was performed on site by a full-time ultrasound technician of the Shanghai Jiao Tong University, School of Medicine, Renji Hospital, and the results were also assessed on site. Madison SA-600P ultrasound (South Korea) with C3-7ED probes were used for ultrasonography. Ultrasonographic diagnoses were made as per the Fatty Liver and Alcoholic Liver Disease Study Group of the Chinese Liver Disease Association guidelines for the diagnosis and treatment of NAFLD, 2006.<sup>15</sup>

### Definitions and standards

Using the sex- and age-specific BMI cutoffs reported by the Group of China Obesity Task Force 2004 and the sex- and age-specific WC cutoffs reported by Guan-Sheng et al, we classified obesity into the following four types.<sup>11,17,19</sup> Peripheral obesity was defined as BMI  $\geq 95^{\text{th}}$  percentile and WC  $< 90^{\text{th}}$  percentile (normal) for the subject's age and gender. Abdominal obesity was defined as a WC  $\geq 90^{\text{th}}$  percentile and BMI  $< 95^{\text{th}}$  percentile (normal) for the subject's age and gender. Mixed obesity was defined as a BMI  $\geq 95^{\text{th}}$  percentile and WC  $\geq 90^{\text{th}}$  percentile for the subject's age and gender. Non-obesity was defined as normal BMI ( $< 95^{\text{th}}$  percentile) and WC ( $< 90^{\text{th}}$  percentile) for the subject's age and gender.

NAFLD was diagnosed when at least two of the following five abnormal ultrasonographic findings were present.<sup>20,21</sup> (a) diffusely increased echogenicity ("bright") of the liver compared with the kidney, (b) unclear display of intra-hepatic lacuna structure, (c) slight-to-moderate hepatomegaly, (d) intrahepatic vessels undetectable, but with normal distribution of blood flow and (e) deep attenuation of the ultrasound signal, with the right hepatic lobe and diaphragm not seen. Mild NAFLD was diagnosed if point (a) plus any one of points (b) through (d) were present. Moderate NAFLD was diagnosed if point (a) plus any two of points (b) through (d) were present. Severe NAFLD was diagnosed if points (a) and (e) plus any two of points (b) through (d) were present.

### Quality control

On-site monitoring: Samples were obtained in strict accordance with the principle of random sampling to ensure that more than 95% of the survey was completed. All staff responsible for specific measurements had undergone

common standardized training and were employees of the Nutrition Department of Shanghai Jiao Tong University, School of Medicine, Renji Hospital. All instruments were calibrated to zero before the examination.

Ultrasonography: To reduce ultrasound-monitoring differences, all ultrasonographic tests were conducted by the same technician using the same equipment at the same time of the day during the testing period.

Database: The staff of the Clinical Nutrition Department of the Shanghai Jiao Tong University, School of Medicine, Renji Hospital entered all data in Excel sheets in a double-blind manner.

### Statistical analysis

Data were analyzed using SPSS 13.0 (SPSS, Inc.). Continuous variables were expressed as the mean (SD), and discrete variables were expressed as numbers and proportions. Simple totals and percentages were calculated. To compare means and proportions and to calculate associations among variables, the chi-square test (or Fisher's exact test where appropriate) was used. Binary logistic analysis was used to determine the risk of NAFLD. Receiver operating characteristic (ROC) curve analysis was used to compare the different obesity indices to evaluate the presence of NAFLD in schoolchildren. Statistical significance was defined as  $p < 0.05$ .

### RESULTS

The parents of 7505 schoolchildren (age: 7-18 years) provided informed consent for enrollment in the study. Of these, 71 children did not undergo ultrasonography, 66 had incomplete information on age, height, weight, and WC, 116 were over the age limit, 9 had a history of liver disease or drug use and 14 were absent. Of the remaining 7229 subjects, 3689 (51.0%) were boys and 3540 (49.0%) were girls; their average age was 12.3 (3.4) years with no significant gender-related difference. Furthermore, 1554 children were from urban Shanghai (Region 4, tier 1 city), 2865 were from suburban Shanghai (Region 3, Tier 1 city), 1485 were from urban Jiaying (Region 2, medium-sized city) and 1325 were from urban Huai'an (Region 1, small-sized city). The anthropometric data are shown in Table 1.

We presumed that none of the participants habitually consumed alcohol. NAFLD was diagnosed in 362 children, yielding an overall NAFLD prevalence of 5.0%. Of these 362 children, 247 (68.2%) had mild fatty changes, 98 (27.1%) had moderate changes and 17 (4.7%) had

**Table 1.** Characteristics of 7229 schoolchildren from the Yangtze River delta region categorized by region

	Total n=7229	Region 1 n=1325	Region 2 n=1485	Region 3 n=2865	Region 4 n=1554	F/ $\chi^2$ *
Age (years)	12.3 (3.4)	12.0 (3.5)	13.3 (3.5)	12.0 (3.0)	12.1 (3.7)	56.8
Height (cm)	152 (16.6)	151 (16.9)	155 (15.4)	151 (16.0)	151 (18.2)	19.2
Weight (kg)	45.2 (15.7)	45.5 (15.9)	46.7 (15.4)	43.9 (14.5)	46.2 (17.9)	13.2
WC (cm)	64.9 (10.0)	65.0 (10.1)	63.6 (9.1)	64.5 (9.7)	67.5 (11.0)	29.6
BMI (kg/m <sup>2</sup> )	19.5 (3.9)	20.1 (4.3)	19.1 (3.7)	19.4 (3.8)	19.6 (3.9)	104
WHR	0.43 (0.05)	0.43 (0.06)	0.41 (0.05)	0.43 (0.05)	0.45 (0.06)	19.8
NAFLD (%)	362 (5)	37 (2.8)	58 (3.9)	136 (4.7)	131 (8.4)	56.1

\*Data are expressed as mean (SD) or numbers. \*Significant region-related differences,  $p < 0.01$

severe changes. NAFLD prevalence in schoolchildren significantly differed between the four cities. Region 4 (urban Shanghai) had the highest prevalence (8.4%), while Region 1 (urban Huai'an) had the lowest prevalence (2.8%) (see Table 1).

NAFLD prevalence showed a male preponderance (7.5% in boys vs 2.5% in girls,  $\chi^2=94.83$ ,  $p<0.01$ ), and age-specific differences of NAFLD prevalence were significant among boys ( $\chi^2=43.37$ ,  $p<0.01$ ). The prevalence peaked at 13.0% at 10 years of age among boys, but this phenomenon was not observed among the girls ( $\chi^2=11.75$ ,  $p=0.36$ ; Table 2). The NAFLD prevalence in subjects with peripheral, abdominal and mixed obesity was 5.6%, 12.5% and 44.8%, respectively. Approximately 90% of the subjects had neither obese nor NAFLD. Over one-third of the obese children had different degrees of hepatic steatosis. NAFLD prevalence was highest (44.5%) in the mixed obesity group ( $p<0.01$ ). Obesity may be a major risk factor for NAFLD in children and adolescents, and obese individuals, especially those with mixed-obesity, are more likely to develop NAFLD. (see Table 3).

As the prevalence of NAFLD significantly differed with gender, age and obesity status, we used ultrasonographic findings of fatty liver as the dependent variable (NAFLD was scored as 0 or 1), while BMI, WC, WHtR, gender (scored as male=1, female=2), age were used as independent variables in a binary logistic regression anal-

ysis. The results showed that WHtR (OR: 14.40, 95%CI: 10.33-20.08), BMI (OR: 1.23, 95% CI: 1.18-1.28) and male gender (OR: 0.59, 95% CI: 0.43-0.80) were risk factors for NAFLD in children and adolescents, and the OR indicated that WHtR was the strongest multivariable predictor (Table 4).

As determined by areas under receiver operating characteristic curve (AUC), the sensitivity and specificity associated with the prediction of NAFLD from WHtR were 85.2 and 92.5%, respectively, at a cutoff of 0.47 (ROC-AUC=0.95, 95% CI: 0.94-0.96). WC were 86.2 and 87.4%, respectively, at a cutoff of 80<sup>th</sup> percentile for age (ROC-AUC=0.94, 95% CI: 0.92-0.95) and BMI were 86.2 and 87.6%, respectively, at a cutoff of 80<sup>th</sup> percentile for age (ROC-AUC=0.93, 95% CI: 0.91-0.94).

## DISCUSSION

With the recent economic growth in China, rapid urbanization has occurred in the last decade. The resulting changes in lifestyle and diet have caused an increase in childhood obesity. The Yangtze River delta, a rapidly industrialized area, is the largest urban agglomeration in China. This region includes three littoral provinces (Shanghai, Zhejiang, and Jiangsu) with a local population of approximately 400 million; the development and economy of this region is important in China and even in the Asia-Pacific region.<sup>22</sup> However, to our knowledge, few

**Table 2.** Prevalence of NAFLD in 7229 schoolchildren from the Yangtze River delta region according to age and gender.

Age (years)	NAFLD in all subjects		NAFLD in boys		NAFLD in girls		$\chi^2$ *	$p$ *
	N	NAFLD (%)	N	NAFLD (%)	N	NAFLD (%)		
7	21/928	2.3	16/482	3.3	5/446	1.1	5.06	0.02
8	22/467	4.7	14/229	6.1	8/238	3.4	1.97	0.16
9	30/524	5.7	22/257	8.6	8/267	3.0	7.51	0.01
10	36/429	8.4	31/239	13.0	5/190	2.6	14.7	0.01
11	26/357	7.3	24/210	11.4	2/147	1.4	13.0	0.01
12	43/657	6.5	34/340	10.0	9/317	2.8	13.5	0.01
13	50/994	4.8	36/513	7.0	14/531	2.6	12.3	0.01
14	40/913	4.4	35/473	7.4	5/440	1.1	19.3	0.01
15	16/421	3.8	8/212	3.8	8/209	3.8	0.01	1.00
16	19/392	4.8	12/183	6.6	7/209	3.3	2.20	0.14
17	40/632	6.3	30/288	10.4	10/344	2.9	14.9	0.01
18	19/465	4.1	13/263	4.9	6/202	3.0	1.13	0.29
Total	362/7229	5.0	275/3689	7.5	87/3540	2.5	94.8	0.01
$\chi^2$ **	39.2		43.4		11.8			
$p$ **	0.01		0.01		0.36			

†Data are expressed as numbers or parentheses.

\*Gender-related differences. \*\*Age-related differences

**Table 3.** Association between weight status and NAFLD among 7229 schoolchildren from the Yangtze River delta region

Hepatic steatosis	Peripheral obesity	Abdominal obesity	Mixed obesity	No obesity
	BMI $\geq 95^{\text{th}}$ and WC $< 90^{\text{th}}$ (n=36)	BMI $< 95^{\text{th}}$ and WC $\geq 90^{\text{th}}$ (n=527)	BMI $\geq 95^{\text{th}}$ and WC $\geq 90^{\text{th}}$ (n=533)	BMI $< 95^{\text{th}}$ and WC $< 90^{\text{th}}$ (n=6133)
Absent	34 (94.4)	459 (87.1)	294 (55.2)	6080 (99.1)
NAFLD	2 (5.6)	68 (12.9)	239 (44.8)	53 (0.9)
Mild	2 (5.6)	48 (9.1)	152 (28.5)	45 (0.7)
Moderate	0 (0)	18 (3.4)	72 (13.5)	8 (0.1)
Severe	0 (0)	2 (0.4)	15 (2.8)	0 (0)

†Data are expressed as n (%).

**Table 4.** Results of multivariate logistic regression analysis

	$\beta$	SE	Wald	Exp (B)*	95% CI	
					Upper	Lower
WHtR	2.67	0.17	247.4	14.4	10.3	20.1
BMI	0.21	0.02	88.9	1.23	1.18	1.25
Gender	-0.54	0.16	11.3	0.59	0.43	0.80

\*Data are expressed as numbers or parentheses. †Significant region-related differences,  $p < 0.01$

WHtR: waist to height ratio; BMI: body mass index; WC: waist circumference; NAFLD: nonalcoholic fatty liver disease

population-based epidemiological studies on NAFLD in children from this region have been conducted. This is the largest population-based study that surveyed NAFLD prevalence and assessed the significance of anthropometric parameters as indicators of NAFLD in Chinese schoolchildren, so far. NAFLD prevalence in the study subjects was 5.0%, 7.5% in boys and 2.5% in girls. These findings were very similar to those studies conducted in Japan and Korea (4.4%-5.2%).<sup>14,18,23</sup> The prevalence in urban Shanghai (8.4%) was similar to that found in white US teenagers in a 1999-2004 survey.<sup>24</sup> Thus, the prevalence of childhood NAFLD in eastern China was similar to that in some developed countries and was more common in Chinese ethnicity.<sup>25</sup> Importantly, NAFLD prevalence differed among the four regions with different levels of urbanization. This finding shows that NAFLD may be associated with local economy and social practices. A growing body of evidence has indicated that unhealthy diet (refined sugars, high consumption of saturated fats), inadequate physical activity (sedentary lifestyle, less sleep) and even environmental exposure (smoking, air pollution) could influence the development of NAFLD in the early years of life.<sup>26</sup> Socioeconomic status plays a vital role in behavior transition in China, and less healthy lifestyles have become prevalent among children over time.<sup>27,28</sup> We speculated that in the last 10 years, rapid urbanization, lifestyle changes and atmospheric particulate pollution in China have affected the health of children and adolescents; however, no studies had examined the relationship of health with lifestyle, behavior and economic status in Chinese children and adolescents. Most studies have reported that NAFLD is more common among boys than girls.<sup>2-5,14,23,29</sup> A US study reported that among patients aged 6-25 years, hospitalization rates for NAFLD were higher among females than males.<sup>30,31</sup> In our study, a distinct male preponderance was observed in NAFLD prevalence. However, this phenomenon could not be explored further because biochemical tests and liver biopsy were not performed in this study. Other studies have suggested that sex and growth hormones play a role in the predisposition to and/or development of fatty liver disease.<sup>2,4,32</sup> In our study, the minimum age of NAFLD onset was 7 years. Boys, but not girls, showed age-specific differences in prevalence. A plot of the age-specific prevalence in boys resembled a parabola, with a peak during adolescence (10-12 years). These results may indicate that testosterone is a risk factor for NAFLD, while estrogen is protective against liver steatosis.<sup>7,29,33</sup> However, additional evidence from further studies is required to explore the role of hormones in childhood NAFLD. Although the available data indicated that most cases of childhood NAFLD manifested during puberty,

we also observed a subgroup of children who exhibited fatty liver disease at a very young age. NAFLD has been detected in children as young as 2 years.<sup>34</sup> In a study that ultrasonographically diagnosed fatty liver disease in 3- to 11-month-old non-obese infants, the prevalence of fatty liver disease was 2.2%-5%.<sup>35</sup> Therefore, it is difficult to determine if early-onset NAFLD is the same as adult-onset NAFLD and has the same risk factors. We propose that children who exhibit NAFLD should undergo further examination to exclude other factors that could have led to the abnormal ultrasonography results.

Pooled data from studies conducted in medical centers and specialist outpatient departments show that NAFLD prevalence among obese children is 20%-77%.<sup>30,36</sup> In our study, NAFLD prevalence was higher in obese subjects than non-obese subjects, and nearly half of the subjects with mixed-obesity had NAFLD. Thus, obesity, especially mixed-obesity, is an important risk factor for NAFLD. The mechanism that links increased body weight and fatty liver is undoubtedly complex.

Another primary objective of our study was to identify any studies which suggest mechanisms that might explain correlates of obesity with NAFLD. BMI, WC and WHtR are recommended as screening tools to identify obesity and body fat distribution, and are strongly related with many chronic conditions in children, such as hypertension, hyperinsulinemia, dyslipidemia and elevated alanine aminotransferase.<sup>15,25,37</sup> While studies involving obese subjects have confirmed that visceral fat is a determinant factor for NAFLD, the relationship between anthropometric data and fatty liver remains controversial.<sup>13,36,38</sup> Moreover, studies of these associations in the general population are more representative than studies in obese subjects. Our study was a large-scale, population-based survey of schoolchildren, and binary multivariate logistic regression analysis showed that high WHtR was a major, independent risk factor for NAFLD in Chinese children. WHtR may be a more reliable indicator of visceral fat than WC in children. This result is in accordance with another study conducted in China among 12- to 24-year-old students, which reported that WHtR was strongly correlated with metabolic syndrome and elevated serum alanine aminotransferase.<sup>15</sup> BMI was consistently correlated with NAFLD in children. Further, WC was found to be a simple and effective parameter for evaluating liver fat accumulation, especially in children aged 7-10 years.<sup>14,16,36</sup> In our sample of children, we have further been able to show that among these obesity indices, the WHtR cutoff of 0.47 could be a constant and simple prediction of NAFLD. Until now, national Chinese data on WHtR has not been established. Therefore, we recommend that BMI, WC and WHtR be used in conjunction to screen for childhood

NAFLD and that more epidemiological studies should be conducted.

### Limitations

A major limitation of our study was that we did not assess breast development in girls and genital development in boys according to the Tanner criteria. This may cause bias when assessing pubertal status and NAFLD. In addition, the personal history of liver diseases of all the participants was obtained from questionnaire completed by the parents, which may not have been reliable. Furthermore, data were not obtained from all the classes of the selected schools; some of the graduating classes refused to participate in the survey because of examinations or out-of-school internships. Therefore, the sample size was relatively small in some age groups, and this may have limited the reliability of our results to some degree.

### Implications and contribution

This is the largest scale cross-sectional study in the world at present that attempted to survey the prevalence of NAFLD by ultrasound in Chinese schoolchildren. The prevalence of NAFLD was 5.0%, with a prevalence of 7.5% in boys and 2.5% in girls. We also propose that WHtR may be an effective indicator of NAFLD with the optimal cutoff of 0.47 in the general population.

### Conclusion

This population-based survey used ultrasonographic examinations and anthropometric parameters to assess NAFLD in children. Our data represent the NAFLD status in schoolchildren from the Yangtze River delta region in eastern China. The overall NAFLD prevalence was 5.0%, 7.5% in boys and 2.5% in girls. The high prevalence and the early onset of NAFLD indicated that the prevalence of fatty liver disease is gradually increasing in Chinese children, even in young children. WHtR is the most sensitive obesity index for NAFLD at an optimal cutoff of 0.47. Our future studies will focus on biochemical investigations in obese outpatients and continue screening for childhood NAFLD in well-designed, prospective, epidemiological studies.

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### AUTHOR DISCLOSURES

The authors have no conflicts of interest to declare in this study.

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## Original Article

# Nonalcoholic fatty liver disease prevalence in urban school-aged children and adolescents from the Yangtze River delta region: a cross-sectional study

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## 中国长三角地区在校学生儿童非酒精性脂肪性肝病流行病学调查

**目的：**调查中国长三角地区在校学生儿童非酒精性脂肪肝发生率及其与体格指标之间的关系。**方法：**2009年9月至2011年10月，长三角地区分层抽取4个城市，12所中小学，7229名7-18岁在校学生纳入本次调查。所有研究对象均测量身高、体重、腰围、计算腰围身高比和体重指数，并进行肝脏超声检查。**结果：**调查显示该地区在校学生儿童非酒精性脂肪肝总发生率为5%，其中男生7.5%，女生2.5%。非酒精性脂肪肝在外周型肥胖，腹型肥胖及混合型肥胖人群中的发生率分别为5.6%，12.9%，44.8%。4个城市在校学生儿童非酒精性脂肪肝发生率也有不同。二元logistic回归分析显示腰围身高比是儿童非酒精性脂肪肝的主要危险因素，每升高0.1，患病风险增加14.4倍。ROC分析显示，腰围身高比同样是该病的最佳预测体格指标，适宜切点值在0.47。**结论：**混合型肥胖与儿童非酒精性脂肪肝密切相关。男性，地区等因素同样影响该病在儿童青少年群体中的发生。腰围身高比可作为该病发生的有效预测指标。

**关键词：**脂肪肝、儿童、肥胖、患病率、危险因素