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ORIGINAL PAPER

The relationship between the Chinese visceral adiposity index and the presence of nonalcoholic fatty liver disease in obese children – a pilot study

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ABSTRACT

Introduction: Nonalcoholic fatty liver disease (NAFLD) has become a major contributor to chronic paediatric liver disease. The Chinese visceral adiposity index (CVAI) is an emerging indicator of visceral adiposity. However, there has been no research on the association between CVAI and the presence of NAFLD in obese children. The aim of the study was to investigate the association of CVAI with the occurrence of NAFLD in obese children with body mass index (BMI) > 30 and to compare the diagnostic execution of CVAI with other traditional markers of visceral adiposity.

Material and methods: We enrolled 153 obese children (63 male, 90 female) with an age range of 9–18 years. NAFLD was diagnosed via ultrasonographic evidence of fatty liver.

Results: Visceral adiposity indices were calculated. The complete lipid profile, liver enzyme alanine aminotransferase (ALT), fasting blood glucose (FBG), fasting insulin, HbA_{1c}, and insulin resistance non-NAFLD were calculated using the homeostasis model (HOMA-IR). The obese subjects were divided into 2 groups: the NAFLD group (53 [34.7%] obese children) and the non-NAFLD group (100 obese children). In the NAFLD group, 33 were boys and 20 were girls, with a mean age of 13.0 ±2.99 years. The frequency of metabolic syndrome was 26.71% of participants. CVAI was significantly higher ($p = 0.001$) in obese children with NAFLD. CVAI had a statistically significant positive correlation with HOMA-IR, FBS, fasting insulin, and LDL ($r = 0.227$, $p = 0.005$), ($r = 0.183$, $p = 0.024$), ($r = 0.267$, $p = 0.006$), ($r = 0.224$, $p = 0.006$), respectively, and negatively correlated to HDL ($r = –0.267$, $p = 0.001$).

Conclusions: The results suggest that CVAI was strongly associated with IR. The results of linear multiple regressions to predict NAFLD showed that CVAI, VAI, and visceral fat thickness were the most independent predictors. The receiver operating characteristic curve (ROC) showed that CVAI was the best predictor of NAFLD among obese children.

KEY WORDS:
Chinese visceral adiposity index, childhood obesity, nonalcoholic fatty liver disease.

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) has become a major contributor to chronic paediatric liver disease. Several studies have reported a 26.0–68.7% prevalence of (NAFLD) in obese children [1–5]. Variable methods of NAFLD diagnosis make estimating the true prevalence challenging; for a more accurate diagnosis of NAFLD, a single diagnostic definition is needed [1]. The Expert Committee on NAFLD (ECON) has recommended liver

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ultrasonography for the diagnosis of NAFLD in the paediatric population [6].

Excess central (intra-abdominal) body fat distribution in obesity can lead to insulin resistance and glucose metabolism disorders, dyslipidaemia, or hypertension – all signs of metabolic syndrome (MS) [6, 7]. However, the interactions of metabolic diseases with NAFLD could not be clarified using traditional markers of visceral adiposity. Recently, a novel Chinese visceral adiposity index (CVAI), based on age, body mass index (BMI), waist circumference (WC), high-density lipoprotein (HDL), and triglycerides (TG), was suggested to evaluate visceral adipose distribution and dysfunction. Many authors reported that (CVAI) is a reliable indicator of visceral adiposity [8–11]. However, there has been no research on the association between CVAI and the presence of NAFLD in obese children. This study aimed to assess the association of CVAI with the occurrence of NAFLD in obese children and to compare the diagnostic execution of CVAI with other traditional markers of visceral adiposity. Also, the presence of MS in obese children with NAFLD was evaluated.

MATERIAL AND METHODS

STUDY POPULATION

We implemented a cross-sectional study. The Human Ethics Committee of the National Research Centre approved the study protocol, and written informed consent was obtained from the children's caregivers (Approval No. 14019). We enrolled 153 obese children (63 male, 90 female) attending the Paediatrics Obesity Clinic in Centre of Excellence in the National Research Centre, with an age range of 9 to 18 years. A child was defined as obese if their BMI > 95th percentile for age and gender percentile curves of growth for our population [12].

Exclusion criteria: medical conditions associated with obesity such as cardiac, hepatic, or renal diseases, hypothyroidism, and Cushing syndrome or Turner syndrome, as well as obesity with mental retardation, such as Prader-Willi, Laurence-Moon-Biedl, and Cohen syndrome. Cases with acute infection or history of alcohol intake were excluded.

CLINICAL EXAMINATION

The following were performed on the studied groups: 1) full history taking through clinical examination, with emphasis on any complications or medication; 2) blood pressure was measured according to American Heart Association guidelines – 3 times for patients after a 5-min rest in a sitting position with the use of a manual mercury sphygmomanometer (ALPK2, Japan). The mean value of the second and third measurement was calculated. Systolic blood pressure (SBP) was defined as the onset of the Korotkoff sound (K1), and diastolic blood pressure (DBP) was defined as the fifth Korotkoff sound (K5); and 3) anthropometric indices: body weight measured to the nearest 0.1 kg with a balance scale and height measured to the nearest 0.1 cm. Body mass index was calculated as weight divided by height squared (kg/m^2). Waist circumference (WC) was measured at the level midway between the lowest rib margin and the iliac crest. Hip circumference (HIP C) was measured at the widest level over the greater trochanters in a standing position by the same examiner; then the waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) were calculated.

ABDOMINAL ULTRASONOGRAPHY

NAFLD was diagnosed via ultrasonographic evidence of fatty liver in obese children. We measured the maximum pre-peritoneal visceral fat thickness (VFT) and the minimum subcutaneous fat thickness (SFT) by ultrasonography. The visceral fat thickness (VFT) was measured using a 3.5–5 MHz convex-array probe. VFT is the distance between the internal surface of the abdominal surface of abdominal muscle and the anterior wall of the aorta 1 cm above the umbilicus. The thickness of subcutaneous fat was measured by placement of a 3.75-MHz probe perpendicular to the skin on the epigastrium. Longitudinal scans are obtained along the middle line (*linea alba*). The thickness of the subcutaneous fat is defined as the distance between the anterior surface of the *linea alba* and the fat-skin barrier [5]. Various (0–3) grades of steatosis have been proposed based on analysis of the intensity of the echogenicity [13]. The ultrasound apparatus model is SA–R3 (No S06YM3 HDC00012F) SAMSUNG MEDISON Company – South Korea.

LABORATORY MEASUREMENTS

Ten millimetres of venous blood were withdrawn under complete aseptic precautions from fasting subjects (12–14 hours). Samples were labelled and left to clot at room temperature for 15 min then centrifuged, and then sera were collected and aliquoted for evaluation of the following parameters: 1) complete lipid profile (serum triglycerides, HDL, LDL cholesterol, and liver enzyme [alanine aminotransferase – ALT]) using colorimetric methods on an Olympus AU 400 supplied by Olympus Life and Material Science (Europe GmbH, Wendenstraße, Hamburg, Germany); 2) fasting blood glucose using a Hitachi 912 chemistry analyser (Roche Diagnostics GmbH, D-68298 Mannheim, Germany) by colorimetric techniques; 3) insulin levels estimated by enzyme immunoassay (ELISA); 4) glycosylated Hb (HbA_{1c}) measured using ion exchange HPLC (high-performance liquid chromatography) kit supplied by Crystal Chem, USA.

CALCULATION

Insulin resistance was calculated by the homeostasis model (HOMA-IR) using the following formula.

HOMA-IR = fasting insulin (mU/l) × fasting glucose (mmol/l)/22.5 CVAI and VAI were calculated as follows [8]:

Males: CVAI = −267.93 + 0.68 × age (y) + 0.03 × BMI (kg/m^2) + 4.00 × WC (cm) + 22.00 × Log10 TG (mmol/l) −16.32 × HDL-C (mmol/l)

Females: CVAI = −187.32 + 1.71 × age (y) + 4.23 × BMI (kg/m^2) + 1.12 × WC (cm) + 39.76 × Log10TG (mmol/l) − 11.66 × HDL-C (mmol/l)

Males: VAI = WC (cm)/[39.68 + 1.88 × BMI (kg/m^2)] × TG (mmol/l)/1.03 × 1.31/HDL-C (mmol/l)

Females: VAI = WC (cm)/[36.58 + 1.89 × BMI (kg/m^2)] × TG (mmol/l)/0.81 × 1.52/HDL-C (mmol/l)

The obese subjects were divided into 2 groups: the first group included patients with NAFLD. Fatty liver was diagnosed if liver echogenicity exceeded that of the renal cortex and spleen and there was attenuation of the ultrasound wave, loss of definition of the diaphragm, and poor delineation of the intrahepatic architecture [13]. The second group included patients without NAFLD.

MS was defined based on the IDF definition of MS for children aged 10 years or older, which includes BMI > 90th percentile for age and sex and the presence of 2 or more of the following findings: (1) triglycerides > 150 mg/dl; (2) HDL-cholesterol < 40 mg/dl; (3) systolic blood pressure > 130 mm Hg, diastolic > 85 mm Hg; and (4) fasting plasma glucose > 100 mg/dl or known type 2 diabetes.

STATISTICAL ANALYSIS

Data were analysed using SPSS, version 17.0 (SPSS Inc., Chicago, IL, USA). All variables were tested for normality. Normally distributed variables are presented as mean ± standard deviation (SD), and non-normally distributed variables are presented as median and interquartile range. Student's *t*-test was used to compare 2 groups with normalization whereas the Wilcoxon rank sum test was used to compare 2 groups with skewed distribution. Pearson's and Spearman's correlation tests (r = correlation coefficient) were used for correlation of normal and nonparametric variables, respectively. Multiple linear regression analysis was used to evaluate the independent predictor of NAFLD in these subjects. Receiver operating characteristic (ROC) curve analysis was used to determine the predictive value of CVAI, BMI, and WC for incident NAFLD. A p-value less than 0.05 was regarded as statistically significant. The cut-off point, sensitivity, and specificity were obtained for CVAI.

RESULTS

The mean age of all participants (153) was 12.5 ±2.96 years in our study. There were 53 (34.7%) obese subjects who had ultrasonographic evidence of fatty liver (NAFLD group), while another 100 (65.3%) obese subjects were without fatty liver (non-NAFLD group). In the NAFLD group 33 were boys and 20 were girls, with a mean age of 13.0 ±2.99 years. Thirty boys and 70 girls did not have NAFLD, and their mean age was 11.99 ±3.42 years, showing that NAFLD individuals were older than non-NAFLD obese children, with a non-significant difference ($p > 0.05$). There were statistically more males than females in the NAFLD group, with a p-value of 0.002.

In our NAFLD group, a total of 41 out of 53 (77.4%) subjects fulfilled the definition of metabolic syndrome based on the paediatric MS definition of the IDF consensus; 25 were boys and 16 were girls, with a p-value of 0.008. The frequency of MS was 26.8% of participants.

Table 1 shows the characteristics of CVAI values in the study participants according to the presence of NAFLD. The NAFLD group was associated with elevated values of CVAI. Figure 1 shows the CVAI distribution in obese children with and without NAFLD.

SBP and DBP had significantly higher estimates in obese NAFLD patients than in obese subjects without NAFLD (p-value of 0.001).

TABLE 1. Chinese visceral adiposity index (CVAI) values in obese children with and without nonalcoholic fatty liver disease

Factor		CVAI in the obese with NAFLD	CVAI in the obese without NAFLD
n		53	100
Mean ±SD		136.30 ±31.00	64.2 ±27.94
Minimum		97.95	12.34
Maximum		219.18	129.44
Percentiles	25	113.7550	39.6575
	50	125.6000	61.7900
	75	158.3700	87.4800

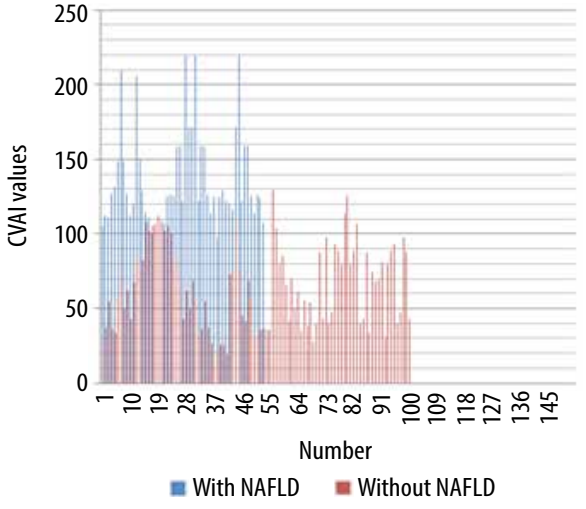

FIGURE 1. The Chinese visceral adiposity index (CVAI) distribution in obese children with and without nonalcoholic fatty liver disease (NAFLD)

TABLE 2. Comparison of body composition between groups

Variable	Without NAFLD ($n = 100$)	With NAFLD ($n = 53$)	Sig. (2-tailed)
Age (years)	11.99 ±3.42	13.06 ±2.99	0.059
BM I [kg/m^2]	30.96 ±3.97	38.82 ±6.32	0.0001
WC [cm]	91.67 ±8.64	105.89 ±7.93	0.0001
WHtR	49.00 ±0.13	0.63 ±0.14	0.0001
WHR	0.69 ±0.13	0.80 ±0.10	0.0001
SFT [cm]	2.00 ±0.66	2.55 ±0.76	0.0001
VFT [cm]	4.42 ±1.36	5.60 ±1.35	0.0001
Liver span [cm]	13.78 ±2.00	15.65 ±1.28	0.0001
VAI	1.58 ±1.02	3.02 ±1.49	0.0001
SBP [mm Hg]	104.45 ±10.12	114.25 ±11.20	0.001
DBP [mm Hg]	66.75 ±8.48	76.70 ±9.20	0.001

BMI – body mass index, WC – waist circumference, WHtR – waist-to-height ratio, WHR – waist-to-hip ratio, SFT – subcutaneous fat thickness, VFT – visceral fat thickness, VAI – visceral adiposity index, SBP – systolic blood pressure, DBP – diastolic blood pressure

TABLE 3. Comparison of biochemical characteristics between groups

Variable	Without NAFLD ($n = 100$)	With NAFLD ($n = 53$)	Sig. (2-tailed)
HOMA-IR	3.12 ±1.98	3.74 ±2.11	0.076
FBG [mg/dl]	78.16 ±11.67	82.09 ±12.93	0.059
Cholesterol [mg/dl]	164.30 ±37.22	168.62 ±32.33	0.477
Triglycerides [mg/dl]	102.87 ±31.36	103.66 ±43.25	0.842
HDL [mg/dl]	48.51 ±19.33	43.33 ±14.26	0.089
LDL [mg/dl]	97.03 ±36.39	104.81 ±31.15	0.190
ALT [U/l]	17.28 ±4.27	24.21 ±3.36	0.001
HbA_{1c} (%)	5.55 ±0.73	5.60 ±0.78	0.697
Fasting insulin [mU/l]	16.41 ±8.46	19.47 ±9.44	0.044

FBG – fasting blood glucose, HDL – high-density lipoprotein, LDL – low-density lipoprotein, ALT – alanine aminotransferase, HbA_{1c} – glycosylated haemoglobin

TABLE 4. Distribution of the Chinese visceral adiposity index (CVAI), nonalcoholic fatty liver disease (NAFLD), and metabolic syndrome (MS) in different quartiles

Quartile according to CVAI ranges	Q1 $N = 67$	Q2 $N = 42$	Q3 $N = 27$	Q$ $N = 17$	TOTAL Obese = 153 100%
CVAI range	>113	113–125	125–158	158–219	
NAFLD	3 5.7%	9 16 0.90%	24 45.40%	17 32.0%	53 100%
MS	3 7.3 %	5 12.1%	18 43.9 %	15 36.7 %	4I 100%

Table 2 shows the comparison of clinical body composition between groups; the mean BMI of the NAFLD group was 38.8 ±6.3 kg/m^2 and the mean BMI for the non-NAFLD group was 30.96 ±3.97 kg/m^2. Furthermore, WC was 105.89 ±7.92 cm for the NAFLD group while the obese without NAFLD group had a mean WC of 91.67 ±7.92 cm. The mean difference was significant between the 2 groups, with a *p*-value of 0.0001. Regarding the other body composition indices, the NAFLD group had significantly higher mean levels of WC/Ht, WC/Hip, SFT, VFT, and liver span, with a *p*-value of 0.0001. We found statistically significant higher mean levels of CVAI and VAI in the NAFLD group.

Table 3 shows the comparison of biochemical characteristics between groups. The mean level of fasting plasma glucose, low-density lipoprotein (LDL), cholesterol, HOMA-IR, and HbA_{1c} were non-significantly higher in the NAFLD group. Also, the NAFLD group had a non-significant lower mean of HDL. The mean fasting insulin level was significantly higher in the NAFLD group than in the obese without NAFLD group, with a *P*-value of 0.044. Our results regarding ALT showed a significantly higher level in the NAFLD group ($p = 0.001$). ALT levels in boys ≥ 26 IU/l and in girls ≥ 22 IU/l were used as the upper limit of normal. There were 16 females of NAFLD cases with Alt levels > 22 IU/l and 30 boys with levels ≥ 26 IU/l.

Participants were stratified by CVAI quartiles. Table 4 shows the distribution of CVAI, NAFLD, and MS in different quartiles. Overall, participants in the third and fourth CVAI quartile groups comprised a higher percentage of NAFLD and MS patients.

In the NAFLD group, interestingly, we observed a positive correlation between CVAI, VAI, VFT, WC, BMI, WHtR, and WHR, which was statistically significant ($r = 0.422$, 0.356, 0.832, 0.788, 0.590, 0.455, respectively). CVAI had a statistically significant positive correlation with HOMA-IR, FBS, F insulin, and LDLP ($r = 0.227$, 0.183, 0.224, 0.224, respectively) and negatively correlated with HDL ($r = -0.267$). Details are included in Table 5.

Results of linear multiple regressions to predict NAFLD showed that CVAI, VAI, and VFT were the most independent predictors ($p < 0.000$, 0.002, 0.041, respectively). Details are included in Table 6.

The predictive power of CAVI for NAFLD in obese children was analysed by receiver operating characteristic curve (ROC), as shown in Table 7. A comparison of (ROC) analysis of BMI, CVAI, WC, WHtR, WHR, and VFT for predicting NAFLD in obese children is shown in Figure 2. The area under the curve of CVAI was found as 0.942 ($p = 0.000$) while that of BMI was 0.861 ($p = 0.000$), WC was 0.877 ($p = 0.000$), WHtR was 0.783 ($p = 0.000$), WHtR was 0.722 ($p = 0.000$), and VFT was 0.747 ($p = 0.000$).

TABLE 5. Correlations between the Chinese visceral adiposity index, obesity indexes, anthropometric parameters, and biochemical parameters in obese children with nonalcoholic fatty liver disease

CVAI			VAI	VFT	WC	BMI	WHtR	WHR
	Correlation coefficient		0.422(**)	0.356(**)	0.832(**)	0.788(**)	0.590(**)	0.455(**)
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
		HOMA-IR	FBG	Cholesterol	HDL	F Insulin	TG	LDL
	Correlation coefficient	0.227(**)	0.183(*)	0.150	–0.267(**)	0.224(**)	0.015	0.224(**)
	Sig. (2-tailed)	0.005	0.024	0.065	0.001	0.006	0.855	0.006

**Significant $p < 0.05$. **Highly significant $p < 0.01$.*
BMI – body mass index, WHtR – waist-to-height ratio, WHR – waist-to-hip ratio, WC – waist circumference, TG – triglycerides, VFT – visceral fat thickness, FBG – fasting blood glucose

TABLE 6. Results of multiple linear regression to predict nonalcoholic fatty liver disease in obese children

Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.
		B	Std. Error	Beta	B	Std. error
1	(Constant)	–0.550	0.149		–3.688	0.000
	CVAI	0.007	0.001	0.641	9.639	0.000
	VAI	0.065	0.021	0.188	3.122	0.002
	VFT	0.040	0.019	0.121	2.065	0.041
	Fasting Insulin	0.004	0.005	0.077	0.835	0.405
	HDL	0.000	0.001	0.014	0.246	0.806
	LDL	0.000	0.001	–0.024	–0.423	0.673
	HOMA-IR	–0.028	0.023	–0.116	–1.218	0.225

[a]Predictors: (Constant), HDL – high-density lipoprotein, VFT – visceral fat thickness, LDL – low-density lipoprotein, VAI – visceral adiposity index, CVAI – Chinese visceral adiposity index, HOMA-IR – fasting insulin
[b]Dependent variable: EQGENICITY

TABLE 7. Area under the curve of body mass index, Chinese visceral adiposity index, visceral adiposity index, waist circumference, waist-to-height ratio, waist-to-hip ratio, visceral fat thickness

Test result variable(s)	Area	Std. error	Asymptotic sig.	Asymptotic 95% CI	
				Lower bound	Upper bound
BMI	0.863	0.030	0.000	0.805	0.922
CVAI	0.976	0.010	0.000	0.956	0.996
VAI	0.781	0.042	0.000	0.699	0.863
WC	0.884	0.026	0.000	0.834	0.934
WHtR	0.784	0.036	0.000	0.713	0.855
WHR	0.728	0.040	0.000	0.649	0.807
VFT	0.748	0.041	0.000	0.668	0.828

BMI – body mass index, CVAI – Chinese visceral adiposity index, VAI – visceral adiposity index, WC – waist circumference, WHtR – waist-to-height ratio, WHR – waist-to-hip ratio, VFT – visceral fat thickness. Cut-off: 112 of CVAI. Sensitivity: 87%; Specificity: 93%

Indicating that the predictability of CVAI was superior to VFT, VAI, WHR, and WHtR. The cut-off value of CVAI for incident NAFLD was 112 (sensitivity = 0.871, specificity = 0.931).

DISCUSSION

Obesity is a major threat to global health. It is usually accompanied by many metabolic abnormalities, including dyslipidaemia, impaired blood glucose level, elevated blood pressure, and inflammation. However, some obese individuals are known as metabolically healthy obese (MHO), and they do not have these metabolic abnormalities [14]. From our study, there were 53 (34.7%) obese subjects who had ultrasonographic evidence of fatty liver (NAFLD group). The prevalence of NAFLD in studies based on child obesity ranged 27.8–41.2% [15]. In our NAFLD group, a total of 41 out of 53 (77.4%) subjects fulfilled the definition of MS. Mohamed *et al.* reported that up to 62% of obese children and adolescents in the NAFLD group had metabolic syndrome [16]. We evaluated gender differences in children with and without NAFLD. Our

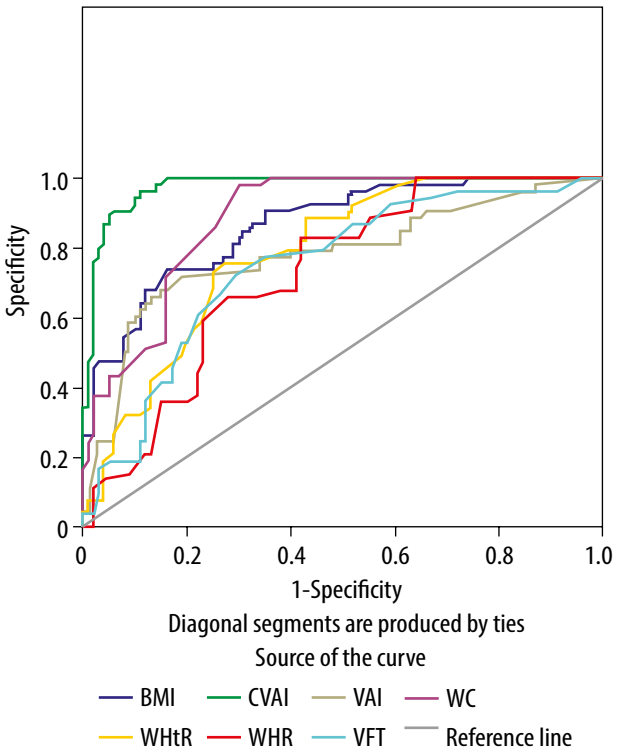

FIGURE 2. Comparison of receiver-operating characteristics analysis of body mass index (BMI), Chinese visceral adiposity index (CVAI), visceral adiposity index (VAI), waist circumference (WC), waist-to-height ratio (WHtR), waist-to-hip ratio (WHR), and visceral fat thickness (VFT), for the prediction of nonalcoholic fatty liver disease in obese children

data showed that NAFLD is more frequent in males, with a *p*-value of 0.002. The gender differences can be due to body fat distribution, sex hormone metabolism, or lifestyle [17]. Many studies have reported a higher prevalence of NAFLD in males in obese paediatric subjects, with a 2 : 1 ratio [17–20]. Villanueva-Ortega *et al.* showed that NAFLD should be intentionally screened in obese children, particularly in boys [17].

Ultrasound and liver function tests should be part of the initial evaluation for early identification of NAFLD in obese children. Regarding ALT, there was a significantly higher level in obese children with NAFLD. There were 16 female NAFLD cases with AlT levels > 22 IU/l and 30 boys with levels ≥ 26 IU/l. NAFLD starts as simple steatosis progressing through non-alcoholic steatohepatitis (NASH) and fibrosis to cirrhosis, ending in liver failure. Various studies found that NAFLD could occur in individuals with normal ALT values [21–23].

Overall, participants in the third and fourth CVAI quartile groups had a higher percentage of NAFLD and MS patients. Participants in the highest CVAI quartiles had an elevated risk of developing NAFLD and MS than those in the lower quartiles. Early estimation of CVAI could help in the diagnosis and management of NAFLD and may be beneficial in reducing risk of complications and limiting the healthcare burden.

In this cross-sectional study of obese children, CVAI was significantly higher in obese children with NAFLD. In addition, we demonstrated that CVAI was positively correlated with VFT measured by ultrasonography. Thus, CVAI has the potential to be a novel marker to assess visceral adipose deposition [8, 9], and it might be used to estimate the risk of metabolic disturbances associated with VFT accumulation.

Moreover, CVAI had a statistically significant positive correlation with HOMA-IR, FBS, fasting insulin, and LDL and negatively correlated with HDL, suggesting that CVAI was strongly associated with IR, and this would aggravate the progression of NAFLD. Similar results were reported by Xia *et al.* [8, 9]. It could be useful in the assessment of increased VFT accumulation associated with disturbances in glucose and lipid metabolism.

Results of linear multiple regression to predict NAFLD showed that CVAI, VAI, and VFT were the most independent predictors. Moreover, CVAI was superior to VFT, VAI, WHR, and WHtR in predicting NAFLD among obese children. Our results pointed to the use of CVAI as a simple, reliable, and convenient index for identifying NAFLD in obese children. It is a simple marker of adipose tissue dysfunction before it develops into an overt MS and/or a cardiovascular complication. Also, CAVI is more sensitive in predicting NAFLD than VAI because it includes age in the equation. Age is a principal factor in evaluating body composition.

Our study is the first to analyse the association of CVAI with the presence of NAFLD in obese children. However, the study has some limitations. First, we used abdominal ultrasonography to diagnose NAFLD instead of liver biopsy (gold test) to determine NAFLD. Compared with liver biopsy, it is less sensitive (but less invasive), especially when the hepatic fat deposition is < 30% [25]. We used it due to the inherent risks related to the procedure of liver biopsy and ethical issues. Second, the study was limited by its cross-sectional design, which could not identify a causal relationship between CVAI and the occurrence of NAFLD in obese children. Therefore, there is a need to increase the sample size and conduct a prospective study to explore the predictive power of CVAI for the presence of NAFLD in obese children.

CONCLUSIONS

Increased CVAI values were independently associated with the presence of NAFLD in obese children. CVAI has the potential to be a novel simple reliable index for diagnosing NAFLD in obese children.

DISCLOSURE

The authors declare no conflict of interest.

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