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Research Article

Visceral Adiposity Indicators and Anthropometric Indices as Screening Tools of Metabolic Syndrome among Chinese Patients with adult Growth Hormone Deficiency -

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ABSTRACT

Aim: It is alarming that the prevalence of Metabolic Syndrome (MetS) is on the rise in Adult Growth Hormone Deficiency (AGHD) patients. The prevalence of MetS in AGHD contribute to the increased risk of cardiovascular disease. Chinese Visceral Adipose Index (CVAI) is a new tool of visceral adiposity with verified predictive ability for MetS among Chinese population. However, the predictive ability has not been inquired in patients with AGHD. This study aims to prove that and directly compare the screening ability of CVAI, Visceral Adipose Index (VAI), Lipid Accumulation Product (LAP), Waist-To-Height Ratio (WHtR), Waist-To-Hip Ratio (WHR) and Waist Circumference (WC) to identify MetS among Chinese patients with AGHD.

Materials and methods: The study included 113 AGHD patients and 113 healthy persons matched with age and gender. CVAI, LAP, VAI, WHR, WHtR, HOMA-IR and BMI were calculated. MetS was defined by the Joint Interim Statement criteria. The Receiver Operating Characteristic Curve (ROC) was used to compare the Area under the ROC Curve (AUC) of each index and find out the cut-off points of each index to predict MetS.

Results: Subjects with AGHD presented higher WC, WHR, WHtR, VAI, LAP and CVAI. The prevalence of MetS was 41.3 % in AGHD patients. Compared to AGHD patients without MetS, AGHD patients with MetS showed significantly higher WC, WHR, WHtR, VAI, LAP, CVAI and lower IGF-1.Basedon the CVAI,AGHD patients were divided to 4 quartiles, Age, height, weight, BMI, WC, HC, WHR, FPG, FINS, HOMA-IR, TG, LAP, VAI was increased and HDL-C,IGF-1 was decreased as CVAI increased. Pearson analysis showed CVAI, VAI and LAP were significantly correlated to MetS, independent of age and gender. The ROC Curve Of Visceral Adiposity Indicator (CVAI,LAP,VAI) and anthropometric indicators (WHR,WHtR,WC) for diagnosis of metabolic syndrome, the CVAI had the highest AUC value (AUC = 85.80 for man, AUC = 84.45 for woman) in AGHD patients.

Conclusions: The CVAI were effective, reliable and simple indicators for the screening of MetS among Chinese patients with AGHD. The CVAI was superior to all the other adiposity measures of interest to evaluate MetS in Chinese patients with AGHD.

Keywords: Chinese Visceral Adipose Index; Adult Growth Hormone Deficiency; Metabolic Syndrome; Visceral Adipose Index.

INTRODUCTION

Adult Growth Hormone Deficiency (AGHD) refers to decreased secretion of growth hormones in the adults and characterized by several signs and symptoms such as decreased muscle mass and muscle strength, increased body fat [1], decreased bone mass and density, osteoporosis, bone fracture [2,3], abnormal glucolipid metabolism, increases cardiovascular risk(central obesity, insulin

Resistance, dyslipidemia and chronic low-grade inflammation) [4-6] and lower life quality [7]. Some of them are similar to the metabolic syndrome which is characterized by central obesity, raised blood pressure, dysglycemia, elevated Triglyceride (TG) levels, Low High-Density Lipoprotein Cholesterol (HDL-C) levels and insulin resistance [8]. Metabolic syndrome, a combination of cardiovascular disease and diabetes mellitus risk factor, refer to one of the most challenging public health issues in worldwide [9,10]. In addition, More and more studies demonstrated the prevalence of MetS in AGHD patients is high and increasing, compared with health population [11,12]. The prevalence of MetS in AGHD contribute to the increased risk of celebrovascular disease, diabetes millitus and cardiovascular disease, was found in a study of 2479 hypopituitary patients with adult-onset growth hormone deficiency [12]. Several studies have suggested that AGHD are closely related with visceral adiposity and visceral adiposity is almost well-validated for prediction of MetS [13-15].

Recently, Chinese developed a clinical index, named Chinese Visceral Adipose Index (CVAI), which comprised age, waist circumference, TG, HDL-C and BMI, which is a reliable and applicable index to evaluate visceral fat dysfunction for Chinese [16]. In addition, CVAI is a powerful marker to predict metabolic syndrome, hypertension and diabetes in adult Chinese [16]. However, few studies have explored the relationship between CVAI and MetS in AGHD patients. Our previous study only present the Visceral Adiposity Index (VAI) and the Lipid Accumulation Product (LAP) are two reliable markers of central lipid accumulation and two simple and economic tools to evaluate MetS in AGHD patients, but our team did not directly compare LAP and VAI in the screening of MetS among Chinese patients with AGHD [17,18].Thus, we conducted this study to investigate the relationship between CVAI and AGHD and whether CVAI was a more reliable and accuracy index compared to other visceral adiposity and anthropometric indicators (VAI,LAP, WHtR, WHR and WC) to evaluate MetS in Chinese AGHD patients.

MATERIALS AND METHODS

The present study was approved by ethics committee of First Affiliated Hospital of Chongqing Medical University. All of the participants provided their written informed consent prior to the start of the study. The study includes 113 patients diagnosed with AGHD at the Department of Endocrinology of First Affiliated Hospital of Chongqing Medical University during February 2009 to March 2017 and 113 apparently healthy persons with similar characteristics (matched with age and gender) at the same hospital. GHD had been defined before start of GH replacement by a GH peak response to Insulin Tolerance Test (ITT) < 5.0 μg/L [19,20]. All patients were evaluated by Insulin Tolerance Test (ITT) with GH peak < 5.0 μg/L. All patients had been receiving adequate, stable, conventional hormone (thyroid hormones, glucocorticoids, oestrogen, and androgen) replacement and target hormone levels but GH were keep within the normal reference range. None of the patients had ever received GH therapy. 113 apparently healthy persons was also evaluated by insulin tolerance test to exclude they are AGHD.

The exclusion criteria: liver and kidney functional disorders, mental disorder, heart diseases, current treatment with antihypertensive, antidiabetic and lipid-regulating drugs, a history of malignant tumor.

Metabolic syndrome were defined according to new Harmonized definition (JIS criteria), using specific WC cut-off points previously developed for the Chinese population. Participants had to meet any three or more of the following 5 factors: i) waist circumference ≥ 85 cm for males and ≥ 80 cm for females ii)antihypertensive treatment

or blood pressure ≥ 130/85 mmHg, iii)antidiabetic treatment or fasting blood glucose ≥ 5.6 mmol/L, iV)triglycerides ≥ 1.7 mmol/L V)HDL cholesterol < 1.03 mmol/L for males and < 1.29 mmol/L for females [21].

All participants completed a questionnaire detailing history of diabetes, hypertensive

Disease, medication use, smoking status, alcohol consumption and regular physical exercise. Anthropometric measurements include weight, Height, waist circumferences, hip circumferences, systolic blood pressure and diastolic blood pressure. Body weight was measured to an accuracy of ± 0.2 kg and height, WC and Hip Circumferences (HC) were measured to minimum recorded unit 0.1 cm. Blood biochemical indexes included Fasting Serum Glucose (FPG), Total Cholesterol (TC), Triglyceride (TG), Low Density Lipoprotein-Cholesterol (LDL-C), High-Density Lipoprotein-Cholesterol (HDL-C); Fasting Insulin (FINS), Growth Hormone(GH), Insulin-Like Growth Factor 1 (IGF-1). All blood samples were obtained after at least 12 h of fasting.

The Homeostasis Model Assessment For Insulin Resistance (HOMA-IR) formula was calculated as Fasting insulin (mIU/L) × Fasting plasma glucose (mmol/L)/22.5.BMI was calculated as weight (kg)/ heigh (m)^2. WHtR was calculated as the waist circumference/ height and WHR was calculated as waist circumference/hip circumference. LAP was estimated as follows: Males: [WC (cm) − 65] ×

triglycerides concentration (mmol/L) Females: [WC		(cm) − 58] × triglyceride concentration		
(mmol/L)[22].CVAI is estimated as follows: Males: CVAI =		− 267.93 +	0.68 * age +	0.03 * BMI
+ 4.00 * WC +	22.00 * Log10TG − 16.32 * HDL-C Females: CVAI =		− 187.32 +	1.71 * age
+ 4.23 * BMI +	1.12 * WC + 39.76 * Log10TG −	11.66 * HDL-C[16]. VAI was calculated as		
follows[23]:Males:VAI = WC⁄[39.68 +(1.88 × BMI)]		×	TG⁄1.03 × 1.31⁄HDL; Females:VAI =	
WC⁄[36.58 +(1.89	× BMI)]× TG⁄0.81 × 1.52⁄HDL.			

STATISTICAL ANALYSIS

All acquired data was performed by using SPSS22.0 statistical software. Continuous variables are expressed as mean ± SD and analyzed by independent-samples t-tests in two groups and ANOVA in multiple groups. Skewed variables were presented the median with interquartile range (25–75%) and analyzed by Mann-Whitney U-test in two groups and Kruskal-Wallis test in multiple groups. Categorical variables were presented as frequency and analyzed using the Chi-square test .The Pearson correlation tests was used to correlate the analyzed anthropometric and biochemical parameters with MetS components. The Receiver Operating Characteristic (ROC) curve analysis was performed and The Area Under the Curve (AUC) of the ROC with 95% confidence intervals was calculated. All statistical tests were two-sided, and *p*-values < 0.05were considered statistically significant.

RESULT

Among 113 AGHD group, 46 patients had MetS, 40.71 % of AGHD patients fulfilled the JIS criteria for MetS in this study, which is higher than the controls(15.04%).As shown in table 1, subjects with AGHD presented higher WC, WHR, WHtR, DBP, TG, VAI, LAP and CVAI and lower HDL-C ($P < 0.05$). There were no significant differences in age, alcohol drinker, cigarette smoker, regular physical exercise, height, weight, BMI, SBP, HC, FPG, TC and LDL-C. Compared to AGHD patients without MetS group, AGHD patients with MetS showed significantly higher weight, BMI, WC, HC, WHR, WHtR, SBP, DBP, FBG, PINS, HOMA-IR,TG, VAI, LAP and CVAI, and lower HDL-C and IGF-1 ($p < 0.05$) (Table 2). The clinical characteristics of the subjects were shown in (Table 3), according to the quartiles of CVAI, Age, height, weight, BMI, WC, HC, WHR, FPG, FINS, HOMA-IR, TG, LAP, VAI was increased and HDL-C,IGF-1 was decreased as CVAI increased. A higher proportion of metabolic syndrome (MetS) was found in Chinese AGHD patients with higher CVAI ($P < 0.001$). As shown in table 4, in male AGHD patients, VAI was only correlated with TG and HDL-C and LAP was only correlated with TG ,HDL-C,WC and HOMA-IR but CVAI was significantly correlated with all of MetS components expect blood pressure. In female AGHD patents, VAI was only correlated with

TG, HDL-C, DBP and LAP was only correlated with TG, HDL-C, WC and HOMA-IR but CVAI was significantly correlated with all of MetS components expect DBP. Even after adjusting the age, the association existed. According to the JIS criteria, The ROC curve of

Table 1: Basic characteristics of the study population.

Variables	AGHD group	Control group	P - value
Age(year)	47.11 13.37	45.44 14.01	0.362
Alcohol drinkers n%	31.5%	22.8%	0.246
Cigarette smokers n%	16.3%	8.7%	0.18
Regular physical exercise (n%)	41.3%	50%	0.236
MetS(n%)	40.71%	15.04%	0.000
Height(cm)	162.57 7.83	161.89 9.20	0.555
Weight(kg)	62.60(53.95,71.75)	57.30(52.55,67.60)	0.112
BMI(kg/m^2)	23.59 3.50	22.90 2.89	0.107
WC(cm)	86.32 9.98	79.01 7.95	0.000
HC(cm)	95.81 6.78	94.29 4.94	0.057
WHR	0.90 0.06	0.84 0.06	0.000
WHtR	0.53 0.05	0.49 0.05	0.000
SBP(mmHg)	123.5 17.28	123.7 16.09	0918
DBP(mmHg)	76.69 13.62	74.69 10.21	0.002
FPG(mmol/L)	5.30(4.90,5.90)	5.30(5.00,5.80)	0.563
FINS(Mu/L)	8.00(5.31,10.45)	6.03(3.88,7.84)	0.000
HOMA-IR	2.04(1.21,2.67)	1.41(0.98,1.88)	0.000
TC(mmol/L)	4.94 1.57	4.69 0.92	0.142
TG(mmol/L)	1.73(0.87,2.59)	1.02(0.82,1.61)	0.003
LDL-C(mmol/L)	2.98 1.15	2.83 0.87	0.291
HDL-C(mmol/L)	1.10(0.93,1.71)	1.50(1.22,1.71)	0.000
LAP	34.20(21.19,75.96)	19.24(10.77,33.73)	0.000
VAI	2.31(0.93,4.28)	1.06(0.75,1.79)	0.000
CVAI	77.19 40.97	50.57 35.62	0.000

MetS, metabolic syndrome; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; WHtR waist-to-height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting serum glucose; FINS, fasting serum insulin; HOMA-IR, homeostasis model assessment index for insulin resistance.; TC, total cholesterol; TG, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; LAP, lipid accumulation product; VAI: visceral adiposity index; CVAI, Chinese Visceral adiposity Index.

visceral adiposity and anthropometric indicators for diagnosis of metabolic syndrome, the CVAI had the highest AUC value (AUC = 0.966), followed by LAP(AUC = 0.930),VAI (AUC = 0.879), WHR (AUC = 0.879), WC(AUC = 0.910) and WHtR(AUC = 0.b92) in male AGHD patients(Table 5) (Figure 1) and the CVAI had the highest AUC value (AUC = 0.964), followed by LAP(AUC = 0.934),VAI(AUC = 0.872) ,WHR (AUC = 0.815), WHtR (AUC = 0.812) and WC (AUC = 0.703) in female AGHD patients(Table 5) (Figure 2). No matter in male AGHD patients and female AGHD patients, the CVAI had the highest AUC value. Correspondingly, CVAI also had the highest Youden's index with the optimal cut-off as 82.42 (man) and 85.80 (woman).

DISCUSSION AND CONCLUSIONS

Chinese Visceral Adipose Index (CVAI) is a more reliable and applicable index for prediction of metabolic syndrome in Chinese population, the largest Asian ethnic group [16]. However, few studies have explored the relationship between CVAI and MetS in AGHD patients. In the present study, we found that AGHD group has higher CVAI. Besides, compared with AGHD patients without MetS, AGHD patients with MetS had higher CVAI. Meantime, in AGHD patients, subjects in the fourth quartiles of CVAI had a higher proportion of MetS. What more, we also found that there were significant associations between CVAI and MetS in both male AGHD

Table 2: Basic characteristics of AGHD patients with or without MetS.

Variables	MetS group(n = 46)	no-MetS group(n = 67)	*P*- value
Age(year)	54.07 11.00	42.33 12.79	0.000
Alcohol drinkers n%	48.8%	33.3%	0.125
Cigarette smokers n%	30.2%	16.7%	0.133
Regular physical exercise(n%)	41.8%	41.7%	0.844
MetS(n%)	162.39 8.03	162.69 7.76	0.845
Height(cm)	66.53 13.64		0.003
Weight(kg)	25.02 3.91	22.612.82	0.000
BMI(kg/m^2)	92.42 10.30	82.137.26	0.000
WC(cm)	97.87 7.59	94.395.82	0.007
HC(cm)	0.94 0.005	0.87 0.01	0.000
WHR	48.8%	33.3%	0.000
WHtR	30.2%	16.7%	0.001
SBP(mmHg)	\0.57 0.05	0.50	0.021
DBP(mmHg)	129.74 21.49	119.2512.10	0.001
FPG(mmol/L)	89.00(67.25,98.00)	76.00(70.00,80.00)	0.000
FINS(Mu/L)	5.80(5.00,6.10)	5.20(4.80,9.30)	0.000
HOMA-IR	13.38 8.46	6.63	0.499
TC(mmol/L)	3..42 2.07	1.54	0.000
TG(mmol/L)	5.06 1.81	4.86	0.906
LDL-C	2.35(1.89,3.69)	0.92(0.79,1.47)	0.000
HDL-C(mmol/L)	2.56(2.05,3.59)	2.81(2,3.63)	0.104
GH(nmol/L)	0.27(0.08,1.68)	0.16(0.04,0.59)	0.000
IGF1(nmol/L)	48.15 20.27	96.07	0.000
LAP	76.14(65.68,94.12)	22.3612.00,29.70)	0.000
VAI	4.13(2.81,5.88)	1.01(0.62,2.28)	0.000
CVAI	113.56 25.30	5.22	0.000

MetS, metabolic syndrome; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; WHtR waist-to-height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting serum glucose; FINS, fasting serum insulin; HOMA-IR, homeostasis model assessment index for insulin resistance.; TC, total cholesterol; TG, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; GH, growth hormone; IGF-1, insulin-like growth factor 1; LAP, lipid accumulation product; VAI: visceral adiposity index; CVAI, Chinese Visceral adiposity Index.

Table 3: Baseline Characteristics of AGHD patients according to quartiles of CVAI.

Variables		Chinese Visceral Adipose Index		
	Q 1	Q2	Q3	Q4
Age(year)	40.29	40.68	50.57	56.55
Mets(n)	0/28	2/28	19/28	25/29
Alcohol drinkers n%	34.8%	34.8%	34.8%	34.8%
Cigarette smokers n%	26.1%	8.7%	21.7%	56.5%
Regular physical exercise(n%)	30.4%	43.5%	52.2%	39.1%
Height(cm)	159.96	159.39	163.71	167.03
Weight(kg)	54.58	59.02	61.01	75.43
BMI(kg/m^2)	21.29	22.80	23.03	27.11
WC(cm)	78.02	84.57	85.04	97.26
HC(cm)	91.77	94.91	94.39	101.93
WHR	0.85	0.89	0.90	0.95
WHtR	0.49	0.52	0.53	0.58
SBP(mmHg)	118.04	121.21	123.27	131.28
DBP(mmHg)	74.00 (68.50,92.00)	79.50 (72.00,80.00)	80.00 (61.00,87.00)	89.00 (79.50,98.00)
FPG	5.00(4.83,5.30)	5.25 (4.60,5.80)	5.40 (5.00,6.05)	5.90 (5.30,6.08)
FINS(Mu/L)	4.25(2.77,5.91)	7.59 (6.96,9.68)	9.35 (7.39,10.00)	14.72 (10.23,16.50)
HOMA-IR	1.03	1.84	2.22	4.07
TC(mmol/L)	4.87(4.71,6.84)	4.53 (3.68,5.51)	4.46 (3.48,6.03)	4.70 (3.70,4.95)
TG(mmol/L)	0.80(0.49,0.96)	0.96 (0.89,1.75)	2.28 (1.44,3.81)	2.18 (1.91,3.69)
LDL-C	3.00(2.72,4.34)	2.97 (2.18,3.61)	2.50 (1.98,4.45)	2.11 (1.81,3.20)
HDL-C	1.94(1.30,2.20)	1.18 (1.05,1.67)	1.07 (0.09,1.32)	0.88 (0.85,1.08)
GH(nmol/L)	0.12(0.04,0.71)	0.14 (0.03,0.38)	0.40 (0.17,1.58)	0.21 (0.06,1.30)
IGF1(nmol/L)	119.26	92.99	58.62	36.79
LAP	11.93 (9.37,24.09)	23.14 (21.58,33.77)	61.14 (38.38,81.30)	84.00 (72.89,101.47)
VAI	0.55(0.42,1.01)	1.08(0. 94,2.48)	3.34 (2.32,5.70)	4.41(2.54,5.70)
CVAI	26.21 (21.32,34.30)	67.00 (55.17,70.47)	88.49 (83.87,98.74)	125.05 (114.02,135.42)

MetS, metabolic syndrome; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; WHtR waist-to-height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting serum glucose; FINS, fasting serum insulin; HOMA-IR, homeostasis model assessment index for insulin resistance.; TC, total cholesterol; TG, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; GH, growth hormone; IGF-1, insulin-like growth factor 1; LAP, lipid accumulation product; VAI: visceral adiposity index; CVAI, Chinese Visceral adiposity Index.

Table 4: Correlation between components of MetS and visceral adiposity indicators and anthropometric indices.

	TG	HDL-C	FPG	HOMA-IR	SBP	DBP	WC
Man CVAI	0.449**	-0.554**	0.360**	0.638**	0.252	0.174	0.830**
CVAI(age adjusted)	0.438**	-0.640**	0.361**	0.614**	0.110	0.027	0.823**
VAI	0.985**	-0.551**	0.113	0.174	0.237	0.146	0.042
VAI(age adjusted)	0.985**	-0.570**	0.118	0.160	0.257	0.244	0.025
LAP	0.947**	-0.589**	0.002	0.426**	0.006	0.118	0.404**
LAP(age adjusted)	0.950**	-0.637**	0.010	0.398**	0.114	0.057	0.376**
Woman CVAI	0.559**	-0.482**	0.410*	0.697**	0.339**	0.097	0.626**
CVAI(age adjusted)	0.463**	-0.580**	0.309*	0.658**	0.331**	0.016	0.784**
VAI	0.863**	-0.667**	0.245	0.299	0.178	0.325*	0.005
VAI(age adjusted)	0.866**	-0.671**	0.202	0.252	0.234	0.361**	0.010
LAP	0.866**	-0.591**	0.306	0.442**	0.101	0.179	0.395**
LAP(age adjusted)	0.848**	-0.610**	0.233	0.370**	0.025	0.239	0.409**

Table 5: ROC curves of CVAI,LAP,VAI,WHtR, WHR and WC to diagnose metabolic syndrome in AGHD.

Variables	cut-off	Area	P-value
Man CVAI	85.80	0.952	0.000
VAI	2.97	0.895	0.000
LAP	57.82	0.927	0.000
WHR	0.94	0.856	0.000
WHtR	0.52	0.845	0.000
WC	91.50	0.854	0.000
Woman CVAI	84.45	0.964	0.000
VAI	1.95	0.872	0.000
LAP	39.23	0.934	0.000
WHR	0.88	0.815	0.000
WHtR	0.49	0.812	0.000
WC	82.50	0.703	0.010

patients and in female AGHD patients. Even after adjusting the age, the association existed. The areas under the ROC curve of CVAI was 0.952 for man and 0.964 for woman. Taken together, it has indicate that CVAI is closely associated with MetS and had the discriminatory power for MetS among Chinese patients with adult growth hormone deficiency.

According to JIS criteria, we found that 40.71% of AGHD patients had MetS, which was in agreement with previous study. It is well known that visceral obesity is the core of the other 4 components of MetS and plays a key role in MetS. Our team previous studies presented the Visceral Adiposity Indicator (VAI and LAP) appeared to better tool to evaluate MetS in AGHD patients, compared to BMI, WC, WHR and WHtR, but our team did not directly compare LAP and VAI [17,18].To the best of our knowledge, this is the first study to directly compare visceral adiposity indicators (LAP,VAI,CVAI) for prediction of MetS among Chinese patients with AGHD.

In comparison with visceral adiposity (LAP, VAI, CVAI), WC, WHR and WHtR has poor diagnostic performance to predict MetS in both male AGHD patients and in female AGHD patients, as shown in figure 1 and figure 2. Although WC, WHR and WHtR is closely correlated with central obesity and included in the MetS diagnosis criteria [24], WC,WHR and WHtR has limitations in distinguishing between visceral adipose tissue and subcutaneous adipose tissue [25]. Enormous researches showed that visceral adipose tissue rather than subcutaneous adipose tissue plays a key role in MetS [14,15]. Besides, the diagnostic performance of WHtR for central obesity is diminished in tall and short individuals [26].

Visceral Adiposity Index (VAI), that Comprises Anthropometric Parameters (BMI and WC) and metabolic parameters (TG and HDL-C), and the Lipid Accumulation Product (LAP), that comprises WC and TG, are two reliable markers of central lipid accumulation [22,23]. Further, A previous study showed that LAP and VAI were two powerful markers to predict risk of MetS, type 2 diabetes, cardiovascular diseases and insulin resistance [17,18,22,23]. However, in the present study, we found that LAP is superior to VAI to predict MetS in AGHD patients, which is similar to previous study. In low income rural adults of Xinjiang, the AUC of LAP for the screening of MetS was more than that of LAP in both men and women [27]. In women with polycystic ovary syndrome, compared with VAI, the LAP showed the better discriminatory power for MetS [28]. However, LAP and VAI have poor diagnostic performance to predict MetS in Chinese AGHD patients compared with CVAI.AS shown in table 4, compared with the other indices, the CVAI had the highest AUC value(AUC=85.80 for man, AUC= 84.45 for woman) in AGHD patients. Hence, CVAI has best screening ability to discriminate Chinese AGHD patients with and without MetS. It may be due to the fact that the remarkable differences in adipose tissue distribution existed among various ethnicity. Asians seems to be more prone to have visceral adipose accumulation compared with western population [29]. The CVAI was established in Chinese population, but the VAI was established in Caucasian populations and the LAP was derived from studies of white, non-Hispanic blacks and Mexican Americans [16,22,23]. In addition to this, these differences could also be attributed to different lifestyle, dietary habits and genetic factors. CVAI, an index based on age, BMI, WC, TG and HDL-C,VAI, an index based on BMI, WC, TG and HDL-C, and LAP, an index based on WC and TG are used as indicators of visceral adiposity, While CVAI is the only index which took age into account. A study in Gujarati Asian Indians also suggested that The optimal cut-offs for VAI and LAP for young and old population are (75.42,87.4) and (35.88,34.7) respectively [30]. Hence, Age is also an important cardiovascular risk factors and could influence cut off values of metabolic risk markers.

The first limitation of the current study is that the study population

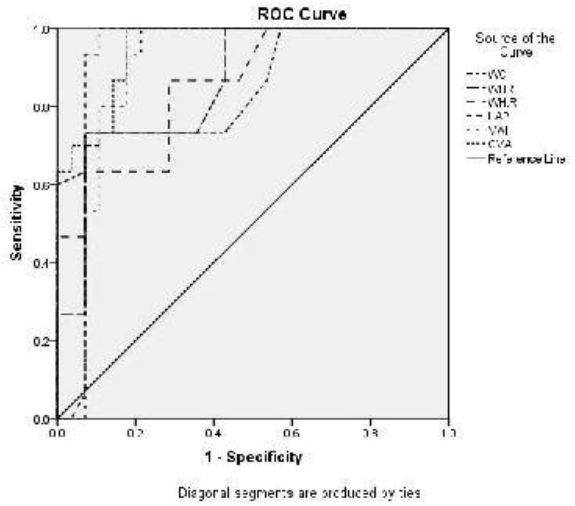

Figure 1: ROC curves analyses of CVAI, LAP, VAI, WHR, WHtR and WC for the screening of MetS in male AGHD patients.

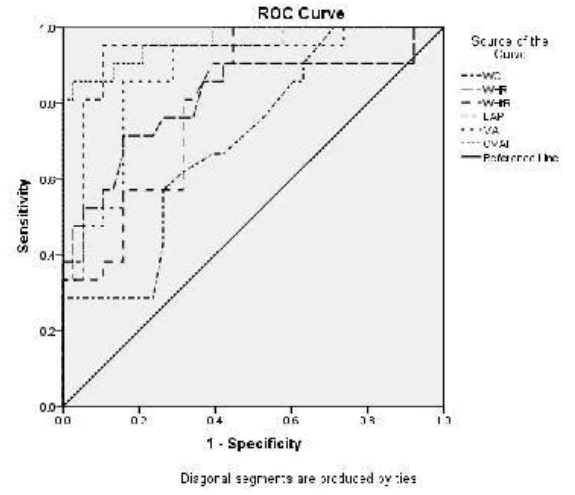

Figure 2: ROC curves analyses of CVAI, LAP, VAI, WHR, WHtR and WC for the screening of MetS in female AGHD patients.

was relatively small. Further research should be undertaken in larger sample sizes. Second, although we take into account the effects of GH on metabolic parameters, but we did not evaluate the effect of the rhGH replacement therapy in AGHD patients. Further research should take the effects of rhGH into consideration. Third, we only study Chinese population, the largest Asian ethnic group, thus, further research should be undertaken in other ethnic groups.

In conclusion, The LAP,VAI and CVAI were effective, reliable and simple indicators for the screening of MetS among Chinese AGHD patients, but the CVAI was superior to all the other adiposity measures of interest to evaluate MetS in Chinese patients with AGHD , with the optimal cut-offs of 85.80 in men and 84.45 in women.

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