Hyperhomocysteinemia accompany with metabolic syndrome increase the risk of left ventricular hypertrophy in rural Chinese

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Research article

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Abstract

Background: To investigate the influence of hyperhomocysteinemia (HHcy) and metabolic syndrome (MetS) on left ventricular hypertrophy (LVH) in residents in rural Northeast China. **Methods:** We performed a cross-sectional baseline data analysis of 6837 subjects (mean age: 54 ± 10 years) recruited from a rural area of China. Anthropometric indicators were measured according to standard methods. MetS was defined by the modified ATP III criteria. HHcy was defined according to the WHO standard: an Hcy level $>15 \mu\text{mol/L}$ representing HHcy. Four groups were defined: non-HHcy & non-MetS, HHcy & non-MetS, MetS & non-HHcy and HHcy & MetS. **Results:** The left ventricular mass index for height^{2.7} (LVMH^{2.7}) in both sexes was significantly higher in the HHcy & MetS group than in the non-HHcy & non-MetS group (females: 51.23 ± 16.34 vs. $40.09 \pm 10.55 \text{ gm-}2.7$, $P < 0.001$; males: $48.67 \pm 12.24 \text{ gm-}2.7$ vs. $42.42 \pm 11.38 \text{ gm-}2.7$, $P < 0.001$). A similar result was observed in those groups when using the left ventricular mass index for body surface area (LVMI) to define LVH (females: $103.58 \pm 31.92 \text{ gm-}2$ vs. $86.63 \pm 20.47 \text{ gm-}2$, $P < 0.001$; males: $106.10 \pm 24.69 \text{ gm-}2$ vs. $98.16 \pm 23.29 \text{ gm-}2$, $P < 0.001$). The results of multiple regression analysis indicated that the HHcy & MetS group had a higher risk of LVH than the other three groups (OR: 1.628 for LVMI, $P < 0.001$, OR: 2.433 for LVMH^{2.7}, $P < 0.001$). Moreover, subjects in the HHcy & non-MetS group [OR (95% CI): 1.297 (1.058, 1.591) for LVMI, $P < 0.05$; OR (95% CI): 1.248 (1.044, 1.492) for LVMH^{2.7}, $P < 0.05$] also had a statistically greater risk of LVH than subjects in the non-HHcy & non-MetS group. The HHcy & non-MetS group was also found to be significantly and independently associated with LVH. **Conclusion:** Hyperhomocysteinemia has an independent effect on LVH. The combined effect of MetS and hyperhomocysteinemia might increase the strength of the abovementioned effects.

Background

Hyperhomocysteinemia has been reported to be relevant in cardiovascular diseases linked to atherosclerosis and has been considered to be an independent marker of many cardiovascular risk factors [1]. Zhao J and colleagues claimed that the combination of hyperhomocysteinemia and hyperuricemia could result in accelerated atherosclerosis [2]. In addition, Zhang Z and colleagues confirmed that the coexistent of hyper-homocysteinemia and elevated blood pressure increased the risk of early atherosclerosis in carotid artery [3]. The possible mechanisms include changing the total antioxidant status and regenerating endothelial cell or decreasing the synthesis of high-density lipoprotein [4].

Left ventricular hypertrophy (LVH) has already been confirmed to be independently correlated with deterioration of health and increasing risk of cardiovascular death. Additionally, LVH statistically elevated the risk of myocardial infarction, dysfunction of heart, stroke and sudden cardiac death [5]. One study claimed that homocysteine levels were explicitly associated with cardiac systolic function in subjects with CAD [6]. Furthermore, Nesrin Sarıman et al. reported that, in all OSAS groups, homocysteine levels were elevated and accompanied by echocardiographic changes such as left ventricular (LV) hypertrophy and cardiac diastolic dysfunction [7]. All of the previous studies aiming to confirm the association between left ventricular hypertrophy and homocysteine were conducted in patients with specific clinical

diseases. There is a lack of research that estimates the possible link between homocysteine and left ventricular hypertrophy among the general population. It is worthy to estimate this relationship in a general population with various backgrounds in terms of genetic predisposition, food customs, and environments different from those of previous studies. In rural China, the prevalence of MetS is 39.0% [8]. The relationship between MetS and LVH has already been reported [9, 10]. An epidemiological study named PAMELA (Pressioni Arteriose Monitorate E Loro Associazioni) confirmed that elevation of left ventricular mass index and increased rate of LVH is the major characters of MetS associated heart problems. Metabolic syndrome markedly increases the risk of CV and all-cause death (71% and 37%, respectively) [11]. However, whether the coexistence of HHcy and MetS has worse deteriorative effect on cardiac remodeling remains to be confirmed. We conducted research in rural Northeast China which enrolled general population in order to estimate whether HHcy is linked to LVH and whether HHcy combined with the presence of MetS might increase the risk of LVH.

Methods

Study population

In our previous paper, we described the characteristics of the study in detail [8]. From January 2001 to August 2003, we enrolled residents older than 35 years in order to evaluate the prevalence rate, morbidity rate and historical process of CVD in villages of Liaoning Province in the Northeast area of China. The excluded criteria has been mentioned previously [12].

Pregnant subjects and those who had a mental disorder or malignant tumors were excluded in the present research. We asked 14016 eligible residents from different villages who aged more than 35 years to attend our research. Of the 14016 residents, 85.3% responded, agreed to participate and completed the research. This research was proved by the Ethics Committee of the Chinese Medical University (China Shen Yang, AF-SDP-07-1,0-01). We performed the research procedures following the ethically normative criteria. Participants' welfare, medical plans and confidentiality agreements associated to their contact details have been informed ahead of the research starting. Then written consent form was given to the participants. In the present study report, we only used the data from participants who were older than 65 years, so the final sample count was 6837 (3150 men and 3687 women).

Data Collecting and Measurements

Both cardiologist and nurses with skilled training will sit face to face with study subjects during the interview and retrieved data using a standardized questionnaire. An organized training meeting from training center was held to qualified investigators [8, 12]. After the training, trainers will have a test to figure out whether they are qualified as investigators to collect data. More guidance and backed up will be supplied to them during the investigation. The specific aspects acquired in the interview has been mentioned before, like family annual income, food habits, socioeconomic characteristics [8, 12]. The central steering committee and quality control committee are responsible to guide this study. In this research, we evaluated subject's education situation, sleep during and annual family income and the

specific categories have been described. We also estimated subjects’ daily frequency of beans or soy products consumption and tea consumption as previously reported [8]. As for blood pressure (BP) measurement, we used a standard protocol as many guidelines have recommended. Participants should be at rest for at least five minutes and without caffeinated drinks or exercise before BP measurement. Omron Healthcare automatic electronic sphygmomanometers (HEM-907; Omron Healthcare, Kyoto, Japan) were used to measure participants BP. We used the average of three times BP measurements in all the analyses. While measuring height and weight, we asked subjects to wear light clothes and take off shoes. We took down the measurement of height and weight to the accuracy of 0.1cm and 0.1 kg. Subjects’ waist circumference (WC) were also measured with nonelastic tape at the umbilicus (0.1cm). BMI= body weight (kg)/ height (m) ².

Participants were required to fast at least twelve hours and taken fasting blood specimens in the morning. As previous described, we used enzymatic analysis to exam total cholesterol (TC), triglycerides (TGs), fasting blood glucose (FPG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) by an automatic biochemical analyzer and biochemical indicators [8, 9]. Technician calibrated the laboratory equipment before using and the specimen analyses were repeated by using blind specimens.

We took M-mode measurements at end diastole and end systole according to the American Society of Echocardiography (ASE) recommendations [13]. The detail of the procedures has been reported previously [8]. Average five consecutive cardiac cycles were used to calculate the echocardiographic data. A single cardiologist read those images under the circumstance that without knowing the subjects’ clinical characteristics.

Definitions

At present, there is no uniform definition of HHcy. According to the WHO standard, the average level of Hcy for healthy adults is 5– 15 µmol/L, with an Hcy level >15 µmol/L representing HHcy [14]. MetS was diagnosed according to the modified NCEP ATP III criteria. At least 3 or more of the following 5 components were needed to diagnose MetS:

Components	Criteria
Elevated WC	≥ 90 cm (Male); ≥ 80 cm (Female)
Elevated TG	> 150 mg/dL (1.7 mmol/L)
Reduced HDL-C	< 40 mg/dL or 1.04 mmol/L (Male) < 50 mg/dL or 1.29 mmol/L (Female)
Hypertension or elevated BP	≥130/85 mmHg
Diabetes or elevated FPG	≥ 5.6 mmol/L

WC ≥ 88 cm for females and WC ≥ 102 cm for males was defined as abdominal obesity [16].

TC $\geq$ 6.21 mmol/L (240 mg/dL) means high TC while high LDL-C was diagnosed as the concentration of LDL-C $\geq$ 4.16 mmol/L (160 mg/dL). According to the WHO criteria, FPG $\geq$ 7 mmol/L (126 mg/dL) and/or being on treatment for diabetes was diagnosed as diabetes [17].

The LVM was calculated according to the formula of Devereux and Reichek [18]:

$$\text{LVM (g)} = 1.04 \times [(\text{LV end-diastolic dimension (LVEDD)}^* + \text{end-diastolic interventricular septum thickness (IVSd)}^\# + \text{end-diastolic LV posterior wall septum thickness (PWd)}^\$)^3 - (\text{LVEDD})^3] - 13.6$$

* LVEDD is the end-diastolic LV internal diameter; # IVSd is the ventricular septal thickness; \$ PWd is the posterior LV wall thickness

It was indexed by both body surface area (LVMI) and by height raised to a power of 2.7 (LVMH^{2.7}), as suggested by De Simone et al. [18].

We used cutoff point of 51 gm^{-2.7} in either sex to separate normal left ventricular thickness from LVH due to its value was related to prognostics [19]. In line with the ASE recommendations, high LVMI was defined as LVMI larger than 115 g/m² for male patients and larger 95 g/m² for female patients. Participants who were never smoking or drinking defined as never smokers or never drinker and who are smoking presently were defined as current smokers or current drinkers. Physical activity was evaluated using questions that have been described in many previous studies which were similar to those used and validated in the “Seven Countries Study” [20].

Statistical Analysis

Continuous variables which were expressed using standard deviations and averages and categorical variables which were expressed using percentages and numbers were calculated using a nonparametric test, ANOVA, Student’s t-test, or the χ^2 -test, as appropriate, to assess the differences among diverse groups. Multivariate logistic regression analysis was used to estimate the independent elements correlated with cardiac metabolic syndrome. The corresponding 95% confidence intervals (CIs) and odds ratios (ORs) were calculated to infer the possible relationship. Basic multivariate logistic regression models were used to estimate the relationship among different social hierarchies. All statistical analyses were carried out using SPSS version 17.0 software (SPSS Inc., Chicago, IL, US), and P values <0.05 were deemed to be of statistical value.

Results

The average age of the total eligible participants was 54.42 ± 10.73 years. The proportion of male and female was 46.1% and 53.9% separately. Of the 6837 subjects, 696 (10.2%) had diabetes, and 3576 (52.3%) had hypertension. The median homocysteine level was $17.34 \mu\text{mol/L}$ (IQR: 17.05-17.64). The proportion of hyperhomocysteinemia was 41.3% (2821/6837). Among the study subjects 2660 participants (38.9%) had MetS while 1057 (39.7%) had hyperhomocysteinemia (Table 1).

In Table 1, it shown the characteristics of the participants according to the elevated homocysteine level and MetS. The participants in the non-HHcy coexistent with non-MetS subgroups were younger in compared with the other groups. Participants with HHcy alone and with coexistent of HHcy and MetS were more likely to be men than the other group.

In hyperhomocysteinemia group, the rate of smoking and drinking habit were relatively higher comparing with the rest groups, whereas the proportion of subjects with higher physical activity decreased in the normal group. Participants who have solely MetS have increased rate of elevated fast glucose levels, diabetes and abdominal obesity than those in the reference group. Coexistent of HHcy and MetS suffered a significantly higher proportion of elevated triglyceride levels, LDL-C and TC and exhibited a higher prevalence of high total cholesterol, high trigly, high LDL-C, low HDL-C and hyperuricemia than those in the reference group.

Fig 1. shows that, in the HHcy alone group and the HHcy and MetS group, the highest prevalence of LVH was in the 55-65 age group in both sexes (30.2% for males; 27.7% for females vs. 35.4% for males; 40.4% for females). For the MetS alone group, the highest prevalence was in the 45-55 age group in males (33.9%) and in the 55-65 age group in females (35.8%). Males with HHcy alone and females with MetS alone had the lowest prevalence in the 35-45 age group (19.4%, 5.9%). Similarly, females with HHcy alone and males with MetS alone had the lowest prevalence in the 45-55 age group (7.8%, 8.6%). In the MetS alone group, both males and females had the lowest rate in the >65 age group (10.2%, 14.7%).

The prevalence of LVH in the total subgroups exhibited in Figure 2. The highest proportion of LVH in males (19.1% for LVMI; 31.6% for LVMH^{2.7}) and females (37.3% for LVMI; 40.6% for LVMH^{2.7}) was existed in different subgroups with coexistent of HHcy and MetS, showing a descending trend in females by the subgroup with MetS alone (23.5% for LVMI; 34.0% for LVMH^{2.7}) and the subgroup with HHcy alone (17.5% for LVMI; 21.5% for LVMH^{2.7}). In male, the rate of LVH increased in the HHcy alone group (14.8%) in comparing with the MetS alone group (13.9%) according to the LVMI definition, and using the LVMH^{2.7} criteria, there were opposite results (21.0% vs. 30.7%).

The cardiac indexes of the study participants subdivided with the presence or absence of HHcy or MetS are shown in Table 2. The data show that the highest values of all cardiac indexes were found in the group with both HHcy and MetS (all $P < 0.001$). Except for the end-diastolic LV internal dimension and LV mass indexed for BSA, all mean values gradually increased according to the following sequence: the HHcy alone group, the MetS alone group and the HHcy and MetS group.

Table 3 shows the effect of coexistence of HHcy and MetS on LVH with the crude and adjusted ORs and 95% CIs. The risk of LVH increased in the group with HHcy (OR: 1.175, 95% CI: 1.002-1.377) and with MetS (OR: 1.615, 95% CI: 1.393-1.873) and showed highest risk in the coexistent of HHcy and MetS (OR: 1.628, 95% CI: 1.364-1.944) after adjusting for all confounders. Similar associations were observed when using LVMH^{2.7} to diagnose LVH. The risk of the presence of LVH was significantly augmented in the group with HHcy (OR: 1.248, 95% CI: 1.044-1.492) and MetS (OR: 2.567, 95% CI: 2.174-3.032) and in the group with coexistent of HHcy and MetS (OR: 2.433, 95% CI: 2.019-2.932) compared with the reference group. The interaction of HHcy and MetS had the greatest risk effect on LVH according to the different diagnostic criteria.

Discussion

The current study reconfirmed that MetS alone increased the risk of LVH in rural Northeast China. Similarly, we demonstrated that HHcy alone was associated with a higher risk of LVH than the other groups. We observed the greatest interaction effect of the HHcy and MetS group on LVH compared with the non-HHcy & non-MetS group and the HHcy or MetS alone group. Therefore, the results from the present study support the hypothesis that HHcy may enhance the risk of developing LVH among MetS residents.

The prevalence of HHcy in the present study was 41.3% in the general population (59.3% for males and 25.9% for women). These data were significantly higher than the overall pooled prevalence in China (27.5%) [21]. Although studies have claimed that the prevalence of HHcy is higher in northern areas (34.4%), the results from our study still showed an even higher rate. In addition, the prevalence was higher than many other places in the world, such as Brazil [22], Lebanon [23], Korea [24] and West Africa [25]. One of the major possible reasons for the high prevalence of HHcy might be the different dietary habits in rural Northeast China. In rural Northeast China, especially during the winter season, the major vegetable intake is pickled cabbage, which is easy to store and does not easily deteriorate [8]. Since the pickling method would easily destroy the folate and vitamin B12 in vegetables, it ultimately results in HHcy. Another reason that could possibly explain this might be the relatively higher prevalence of alcohol consumption in the HHcy group than in the other groups. As shown in Table 1, residents with hyperhomocysteinemia with and without metabolic syndrome had a higher prevalence of alcohol consumption than residents without hyperhomocysteinemia. Choi SH and colleagues reported that hyperhomocysteinemia is related to heavy alcohol consumption and low serum levels of folate and vitamin B12 in patients who have had a stroke [26]. Similarly, Coppola M confirmed that plasma homocysteine concentration is associated with craving hazardous and harmful patterns of alcohol consumption [27]. Previously, there are studies estimate the relationship between homocysteine and LVH. Kharlamova UV and colleagues claimed that a positive relationship was found between the concentrations of homocysteine and LV mass (LVM), suggesting that homocysteine has an unfavorable effect on LV structure and function [30]. Peer M and colleagues also determined that homocysteine as well as CRP was significantly positively associated with LVM and LVMI in females [29]. Many of the

previous studies confirmed the possible relationship between homocysteine and LVH. However, all of those previous studies enrolled subjects with programmed hemodialysis or with hypertension, and the coexistence of other conditions or diseases may change the effect of homocysteine on LVH. In the Framingham Heart Study, data from women participants who did not have heart failure or a previous myocardial infarction had homocysteine levels that were directly related to left ventricular mass and wall thickness [30]. In our present study, we also found that HHcy alone could increase the risk of LVH in general rural Northeast Chinese residents, which coincides with many other previous studies. The possible reasons for the hyperhomocysteinemia-induced cardiac hypertrophy might be the increase in oxidative stress and density of mast cells caused by hyperhomocysteinemia in the heart [31] or the activation of protein kinase C [32] and alteration of collagen metabolism [33]. As far as we know, there are limited researches aiming to establish the possible effect of coexistence of HHcy and MetS on LVH using different sonographic clinical indicators. Studies have aimed to estimate the relationship between HHcy, MetS and LVH separately [34, 35]. To the best of our knowledge, our present study is the first to evaluate the combined effect of HHcy and MetS on LVH. The results showed that both HHcy alone and MetS alone increase the risk of LVH in the general population from rural Northeast China. Furthermore, the combination of HHcy and MetS had the greatest risk on LVH.

There are some limitations of our investigation. First, there is no causal relationship from the present study can be infer due to the innate drawbacks of cross-sectional studies. Second, we did not evaluate whether the participants had ever taken folic acid fortification treatment. Third, selection bias may exist because there were some participants excluded due to the lack of laboratory assessments and ultrasonic data.

Conclusion

The results of this community-based population study demonstrate that HHcy has either an independent or a combined effect with MetS on the presence of LVH.

Abbreviations

WC: Waist circumference; BMI: Body mass index; EDTA: ethylenediaminetetraacetic acid; FPG: Fasting plasma glucose; TC: total cholesterol; LDL: low-density lipoprotein cholesterol; HDL: high-density lipoprotein cholesterol; TG: triglycerides;

Declarations

Acknowledgements

None

Authors' Contributions

SSY contributed to the data collection, analysis and interpretation. YTC and HMY contributed to data collection. XFG and LQZ contributed to data analysis. YXS contributed to the study conceptions and design. All authors read and approved the final version of the manuscript.

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Availability of data and materials

Enquiries regarding the availability of primary data should be directed to the principal investigator Professor Yingxian Sun (sunyingxian12@aliyun.com).

Ethic approval and consent to participate

The study was approved by the Ethics Committee of China Medical University (Shenyang, China AF-SDP-07-1, 0-01). All procedures were performed in accordance with ethical standards. Written consent was obtained from all participants after they had been informed of the objectives, benefits, medical items and confidentiality agreement regarding their personal information.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Demographic and clinical data of the study population subdivided according to the presence or the absence of Metabolic syndrome and Hyperhomocysteinemia in rural Northeast China.

Variables	MetS (-)			MetS (+)	
	Overall (n=6837)	(n=4177)		(n=2660)	
		HHcy (-)	HHcy (+)	HHcy (-)	HHcy (+)
		(n=2413)	(n=1764)	(n=1603)	(n=1057)
Age, years	54.42±10.73	51.25±9.84	56.53±11.69	54.37±9.70	58.22±10.40*
Homocysteine (μmol/L)	17.34±12.37	11.35±2.39	25.63±15.11	11.34±2.25	26.32±16.01*
Gender, male (%)	3150(46.1)	902(37.4)	1266(71.8)	381(23.8)	601(56.9) *
Diabetes (%)	696(10.2)	82(3.4)	51(2.9)	350(21.8)	213(20.2) *
Hypertension (%)	3576(52.3)	841(34.9)	834(47.3)	1095(68.3)	806(76.3)*
High TC (%)	874(12.8)	232(9.6)	160(9.1)	273(17.0)	209(19.8)*
High TG (%)	1204(17.6)	105(4.4)	85(4.8)	577(36.0)	437(41.3)*
High LDL-C (%)	390(5.7)	93(3.9)	70(4.0)	118(7.4)	109(10.3) *
Low HDL-C (%)	791(11.6)	84(3.5)	96(5.4)	318(19.8)	293(27.7) *
Hyperuricemia (%)	772(11.3)	116(4.8)	190(10.8)	197(12.3)	269(25.4) *
Abdominal obesity (%)	1212(17.7)	194(8.0)	88(5.0)	638(39.8)	292(27.6) *
Body mass index(kg/m ²)	24.79±3.79	23.51±3.44	23.48±3.30	26.85±3.50	26.78±3.48*
Waist circumference(cm)	83.52±9.85	79.03±8.52	80.27±8.43	89.14±8.33	90.70±8.64*
Fast glucose (mmol/L)	5.87±1.73	5.44±1.17	5.42±0.86	6.59±2.35	6.48±2.16*
Total cholesterol (mmol/L)	5.08±1.03	4.93±0.95	4.95±0.95	5.29±1.14	5.31±1.07*
Triglycerides (mmol/L)	1.65±1.61	1.14±1.02	1.17±0.74	2.39±2.20	2.50±1.90*
HDL cholesterol (mmol/L)	1.44±0.41	1.56±0.38	1.55±0.45	1.26±0.29	1.24±0.34*
LDL cholesterol (mmol/L)	2.83±0.78	2.71±0.71	2.77±0.73	2.96±0.83	3.01±0.84*
Serum creatinine (mmol/L)	70.07±21.65	65.80±11.81	74.84±31.29	66.34±15.17	77.51±23.96*
Systolic blood pressure (mmHg)	142.91±24.58	133.8±22.22	141.31±24.30	149.56±22.47	155.88±24.72*
Diastolic blood pressure (mmHg)	81.73±11.88	77.86±10.63	80.67±11.75	84.86±11.07	87.59±12.41*
Current smoker	2547(37.3)	782(32.4)	922(52.3)	401(25.0)	442(41.8)*
Current drinker	1534(22.4)	506(21.0)	575(32.6)	198(12.4)	255(24.1)*
Exercised status (%)					<0.001
Low	1628(23.8)	455(18.9)	419(23.8)	426(26.6)	328(31.0)
Moderate	4772(69.8)	1819(75.4)	1250(70.9)	1043(65.1)	660(62.4)
High	437(6.4)	139(5.8)	95(5.4)	134(8.4)	69(6.5)
Educational status					<0.001
Primary school or below	3383(49.5)	1065(44.1)	885(50.2)	843(52.6)	590(55.8)
Middle school	2844(41.6)	1140(47.2)	730(41.4)	606(37.8)	368(34.8)
High school or above	610(8.9)	208(8.6)	149(8.4)	154(9.6)	99(9.4)

Abbreviations: , TC total cholesterol; TG triglyceride; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MetS, metabolic syndrome.* P<0.001;# P<0.05

Table 2. Cardiac parameters of the study population subdivided according to the presence or the absence of Metabolic syndrome and Hyperhomocysteinemia;

	MetS (-)		MetS (+)	
	HHcy (-)	HHcy (+)	HHcy (-)	HHcy (+)
End-diastolic LV internal dimension(mm)	4.61±0.41	4.74±0.43	4.72±0.42	4.85±0.44*
End-diastolic posterior wall thickness(mm)	0.83±0.08	0.86±0.11	0.88±0.12	0.90±0.11*
End-diastolic interventricular septum(mm)	0.85±0.11	0.89±0.15	0.90±0.12	0.94±0.14*
LV mass(g)	144.60±38.59	162.44±47.21	165.74±47.11	181.69±50.27*
LV mass indexed for BSA(gm ⁻²)	90.93±22.27	99.19±26.93	98.77±26.92	105.01±28.06*
LV mass indexed for height ^{2.7} (gm ^{-2.7})	40.96±10.93	43.78±13.10	47.96±13.94	49.77±14.21*

Abbreviations: LV, left ventricular; MetS, metabolic syndrome.

Table 3. Association between the presence or the absence of Metabolic syndrome and Hyperhomocysteinemia and LVH.

LVMI	Unadjusted		Model 1		Model 2		Model 3	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Non-MetS & normal Hcy	ref		ref		ref		ref	
HHcy & Non-MetS	1.208*	1.049-1.391	1.201#	1.025-1.407	1.201#	1.025-1.407	1.175#	1.002-1.377
Normal Hcy & MetS	2.300*	2.006-2.638	1.820*	1.575-2.103	1.817*	1.572-2.100	1.615*	1.393-1.873
MetS & HHcy	2.284*	1.957-2.666	1.929*	1.627-2.286	1.921*	1.620-2.278	1.628*	1.364-1.944
LVMH ^{2.7}	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Non-MetS & normal Hcy	ref		ref		ref			
HHcy & Non-MetS	1.760*	1.494-2.074	1.291#	1.082-1.541	1.291#	1.081-1.541	1.248#	1.044-1.492
Normal Hcy & MetS	3.261*	2.787-3.815	2.974*	2.528-3.499	2.951*	2.508-3.473	2.567*	2.174-3.032
MetS & HHcy	4.143*	3.492-4.915	3.013*	2.519-3.603	2.960*	1.084-3.542	2.433*	2.019-2.932

Model1 adjusted for gender, age, current smoking, current drinking, activity, education

Model2 adjusted for gender, age, current smoking, current drinking, activity, education, high LDL-C.

Model3 adjusted for gender, age, current smoking, current drinking, activity, education, high LDL-C, hyperuricemia and medication treatment of hypertension or dyslipidemia.

* means $P < 0.001$, # means $P < 0.05$

Abbreviations: LVH, left ventricular hypertrophy; MetS, metabolic syndrome.

Figures

Figure 1

The prevalence of different subgroups of HHcy and MetS according to gender and age groups.

Figure 2

The prevalence of LVH in different gender and different subgroups with or without HHcy or MetS according to different diagnostic criteria.