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Clustering of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity and hypertension in Mongolian people, China

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Summary
Background and objectives: There is little knowledge on whether clustering of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity increases risk of hypertension in Mongolian people of rural and animal husbandry area.
Methods: A cross sectional study was performed in a Mongolian population. Demographic data, lifestyle factors, family history of hypertension, blood pressure measurements, physical examination were obtained and blood glucose and lipids were examined in 2532 individuals.
Results: Hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity were all independently associated with hypertension (*all* $P < 0.01$), and clustering of these risk factors correlated with risk of hypertension in Mongolian people. Age and gender-adjusted OR of hypertension for clustering of two, three and four or more factors were 1.878(1.262, 2.795), 3.735(2.529, 5.516) and 4.361(2.886, 6.589), respectively.
Conclusions: Hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity were independent risk factors of hypertension. Risk of hypertension in Mongolian people increased with the number of up to five risk factors in clusters. It is imperative that risk factors be controlled at the same time for the primary prevention and early treatment of hypertension.

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Introduction

Hypertension is not only a common cardiovascular disease but also a major risk factor contributing to other cardiovascular diseases. It is generally considered that hypertension is caused by both genetic and environmental factors [1]. The latter mainly refer to lifestyles including alcohol drinking, smoking, unbalanced diet and high salt consumption. Hypertension often develops under combined actions of these risk factors associated with abnormal metabolism including obesity [2,3], high blood glucose [4,5] and dyslipidaemia [6]. Some studies [7—9] have shown a clustering of risk factors with hypertension, the risk of hypertension increasing with the number of risk factors. There are marked ethnic and geographical differences in blood pressure (BP) levels and the prevalence of hypertension as well as risk factors in Asia [10,11]. Findings in our previous studies [12,13] suggested that the prevalence of hypertension and some risk factors, such as, hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity were increased with hypertension, an important public health problem in the Mongolian countryside population of Inner Mongolia, China. The main economic activities of this mainly rural population include agriculture and animal husbandry. Their lifestyle and work activity are different from those of urban living people and of the Han people in other rural areas. However, there is little knowledge on whether clustering of cardiovascular risk factors increases the risk of hypertension in Mongolian people in Inner Mongolia. The purpose of the present study was to examine the relationship between clustering of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity and hypertension in the Mongolian population, and to provide evidence for development of a strategy to prevent and control hypertension.

Materials and methods

Study subjects

A cross sectional survey was conducted in 2002 and 2003, in two townships including 32 villages in Kezuohou Banner (county) and Naiman Banner in Inner Mongolia, China. The two adjacent townships are 100 km from Tongliao city, a prefecture-level city in the east of Inner Mongolia, China. Most of the residents living in the area of the study are Mongolian having lived there for a long time from generation to generation. They have been maintaining traditional ethnic Mongolian customs. Their economics depends on agriculture and grazing. Most are engaged in moderate or heavy physical labor, and their diets are high in fat and salt. There was a total of 3475 Mongolian people aged 20 or more in the 32 villages. Among them, 2589 people signed an informed consent form and were investigated while the rest did not sign an informed consent form and were not investigated because they were either out of the area of study or they refused to respond at the time of investigation.

Data collection and examination

Data on demographic characteristics, lifestyle risk factors, family history of hypertension and history of treatment of hypertension were obtained using a questionnaire administered by trained staff. A cigarette smoker was defined as having smoked at least 1 cigarette per day for 1 year or more. The amount and type of alcohol consumed during the past few years was documented with drinking alcohol defined as consuming at least 50 g of alcohol per day for one year or more.

Three BP measurements were obtained by four trained doctors with the study participants sitting, using a standard mercury sphygmomanometer according to a standard protocol, after the subjects had been resting for 30 min. The first and fifth Korotkoff sounds were recorded as systolic blood pressure (SBP) and diastolic blood pressure (DBP), respectively. The mean of 3 BP measurements was used in the analysis. Hypertension was defined as SBP $\geqslant$ 140 mmHg and/or DBP $\geqslant$ 90 mmHg and/or use of antihypertensive medications in the past 2 weeks.

Body weight and height were measured by trained staff with subjects wearing light clothing and without shoes. The body mass index (BMI) was calculated as weight in kilograms divided by squared height in meters. The waist circumference was measured 1 cm above the umbilicus. Overweight was defined as BMI $\geqslant$ 25 kg/m^2 and central obesity was defined as WC $\geqslant$ 85 cm for males and $\geqslant$80 cm for females [14,15].

Antecubital fasting blood samples were collected from all subjects in the morning after at least 8 h of fasting. Serum was subsequently isolated from whole blood, and all serum samples were frozen at -80°. Fasting blood glucose (FBG) was examined using a glucose meter (Roche, Basel, Switzerland) in the field. Hyperglycemia was defined as FBG $\geqslant$ 6.1 mmol/L. Total cholesterol (TC), triglycerides (TG), high density lipoprotein—cholesterol (HDL—C), and low density lipoprotein (LDL—C) level were analyzed enzymatically on a

Beckman Synchrony CX5 Delta Clinical System (Beckman Coulter, Inc., Fullerton, CA, USA) using commercial reagents. Hyperlipidemia was defined as TC $\geqslant$ 5.72 mmol/L and/or TG $\geqslant$ 1.69 mmol/L and/or HDL $\leqslant$ 0.90 mmol/L or LDL-C $\geqslant$ 3.64 mmol/L.

Statistical analysis

Prevalence of hypertension, hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity were calculated among different age groups by gender. Associations between hypertension and hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity were analyzed by using logistic regression. All subjects were grouped by the number of risk factors, and the prevalence of hypertension by gender and age groups was calculated and compared among different numbers of risk factors using a χ^2 test. Associations between hypertension and the number of risk factors were analyzed using logistic regression. The odds ratio (OR) and 95% confidence intervals (95% CI) were calculated. Statistical analysis was conducted with SAS statistical software (version 9.1).

Results

Among 2589 study subjects, 2532 people with 1035 males and 1497 females were included in this analysis. The remainder, i.e. 57 people were excluded from the present analysis because of a lack of various bio-marker tests. There were 942 people with hypertension, a prevalence of 37.2% (45.5% in males and 31.5% in females), ($P < 0.01$). The demographic characteristics, family history of hypertension and lifestyle risk factors for subjects are presented in Table 1. There were statistical differences for these factors between normotensive and hypertensive participants.

The prevalence of hypertension, hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity by gender and age are presented in Table 2. The prevalence of hypertension, hyperlipidemia, alcohol drinking, overweight and central obesity showed an increase with age in both genders (*all* $P < 0.05$). The prevalence of hyperglycemia increased with age in females ($P < 0.01$), but not in males. The prevalence of hypertension increased with the number of risk factors in various age groups in both genders (all *P* values for trends <0.01), (Table 3).

The age and gender-adjusted ORs (95% CIs) and multivariate adjusted ORs (95% CIs) of hypertension for hyperlipidemia, hyperglycemia, and alcohol drinking, overweight and central obesity are presented in Table 4. There were still significant positive associations between these risk factors and hypertension after multivariate adjustment (all $P < 0.01$).

ORs (95% CIs) of hypertension associated with various clusters of factors are presented in Table 5. Any combination of two or more risk factors showed a greater odds ratio for hypertension than did any single risk factor. Furthermore, the prevalence of hypertension increased with the number of clustered risk factors (all *P values* for trends <0.01).

Discussion

The Framingham study found that about 80% of hypertensives had other risk factors of cardiovascular disease, the most common being hyperlipidemia [16]. Thomas et al.'s study showed that more than 50% of hypertensive patients aged less than 55 years suffered from hyperlipidemia in France [17] and O'Meara's study in America demonstrated a prevalence of 79% and 65% of hyperlipidemia among hypertensive males and females, respectively [18]. In addition to hyperlipidemia, heavy alcohol drinking [19], overweight or obesity [20—23] and hyperglycemia [24] were also independent factors associated with hypertension. Our findings were consistent with those study findings.

Table 1 Demographic characteristics, family history of hypertension and lifestyle risk factors of 2532 Mongolian participants.

	N	Age[#] (Years) $\bar{x} \pm$ SD	Sex[#] Male:female	Family history of hypertension[#] *n* (%)	Smoking[#] *n* (%)	Drinking[#] *n* (%)
Normotensive	1590	43.2 ± 11.5	564:1026	97(6.1)	669(42.1)	425(26.7)
Hypertensive	942	52.0 ± 12.1	471:471	233(24.7)	454(48.2)	416(44.2)
Total	2532	46.5 ± 12.4	1035:1497	330(13.0)	1123(44.4)	841(33.2)

[#] Comparison between hypertensive and normotensive: $P < 0.01$.

Table 2 Number and percent with hypertension, hyperglycemia, hyperlipidemia, alcohol consumption, overweight and central obesity by gender and age groups among 2532 Mongolian participants.

	Male					Female				
	20–29 yrs	30–44 yrs	45–59 yrs	60+ yrs	Total	20–29 yrs	30–44 yrs	45–59 yrs	60+ yrs	Total
n	49	420	381	185	1035	91	650	562	194	1497
Hypertension	6(12.2)	146(34.8)	192(50.4)	127(68.6)	471(45.5)	7(7.7)	120(18.5)	228(40.6)	116(59.8)	471(31.5)
Hyperglycemia	4(8.2)	33(7.9)	50(13.1)	27(14.6)	114(11.0)	8(8.8)	47(7.2)	71(12.6)	34(17.5)	160(10.7)
Hyperlipidemia	20(40.8)	168(40.0)	161(42.3)	54(29.2)	403(38.9)	26(28.6)	186(28.6)	195(34.7)	66(34.0)	473(31.6)
Alcohol Drinking	19(38.8)	256(61.0)	272(71.4)	122(65.9)	669(64.6)	1(1.1)	33(5.1)	100(17.8)	38(19.6)	172(11.5)
BMI $\geqslant$ 25	5(10.2)	80(19.0)	59(15.5)	15(8.1)	159(15.4)	14(15.4)	148(22.8)	158(28.1)	34(17.5)	354(23.6)
Central obesity	9(18.4)	118(28.1)	144(37.9)	59(31.9)	330(31.9)	17(18.7)	263(40.5)	322(57.3)	113(58.2)	715(47.8)

Table 3 Number and percent with hypertension by age, sex and number of risk factors in clusters in 2532 Mongolian participants.

Number of factors	Male					Female				
	20–29 yrs	30–44 yrs	45–59 yrs	60+ yrs	Total	20–29 yrs	30–44 yrs	45–59 yrs	60+ yrs	Total
0	2(12.5)	12(15.6)	11(26.2)	16(64.0)	41(25.6)	1(2.2)	31(11.8)	45(32.4)	18(50.0)	95(19.6)
1	1(5.6)	43(27.2)	47(33.1)	48(60.8)	139(35.0)	1(3.3)	26(14.2)	49(31.2)	47(59.5)	123(27.4)
2	0(0.0)	47(47.0)	52(55.9)	41(77.4)	140(54.9)	2(2.2)	34(25.6)	60(43.2)	25(62.5)	121(37.7)
3	1(33.3)	26(54.2)	48(77.4)	15(75.0)	90(67.7)	3(50.0)	22(39.3)	60(59.4)	22(71.0)	107(55.2)
4 and more	2(66.7)	18(48.6)	34(81.0)	7(87.5)	61(67.8)	0(-)	7(46.7)	14(53.8)	4(50.0)	25(51.0)

In recent years, some studies [7—9] focusing on the number of risk factors and hypertension, have shown that the risk of hypertension increases with the number of risk factors. In a cross sectional study of 820 younger adults aged 18—59 years and 1494 elders aged ⩾ 60 years, Barreto et al. [8] showed an age and sex-adjusted OR of 6.33 for hypertension with coexistence of four or more risk factors (physical inactivity, overweight, hypercholesterolemia, hyperglycemia and hypertriglyceridemia) compared to absence of a risk factor. Nakanishi et al.'s study [7] followed 3784 Japanese male office workers aged 30—59 for five years (15,405 person-years), showing that coexistence of obesity, hyperlipidemia, hyperglycemia, hyperuricaemia and increased white blood cell count was associated with an increased incidence of hypertension. Tozawa et al. [9] studied the association between a cluster of family history of hypertension, obesity, diabetes mellitus, hypercholesterolemia and hypertriglyceridaemia and risk of hypertension in 9914 subjects aged 18—89, and found that the ORs of hypertension were 5.25, 8.71 and 24.48 for three, four and five risk factors, respectively, compared with no risk factor, after multivariate adjustment. In addition, the number of risk factors was positively associated with SBP and DBP after adjusting for age and sex in non-hypertensive subjects.

Hypertension often coexists with hyperlipidemia, hyperglycemia, overweight or obesity in an individual. The existence of three or four of these risk factors in an individual is called metabolic syndrome or insulin resistance syndrome [25,26]. Clustering of these risk factors not only increases the risk of hypertension, but also increases that of other cardiovascular diseases, such as coronary heart disease [27—29].

Alcohol drinking is also a well-defined risk factor of hypertension [19,30]. In our study, five factors including alcohol drinking were more significant in Mongolian people living in rural areas. Our analysis did not include cigarette smoking, because the relationship between smoking and the development of hypertension is still unclear and controversial [31], and our pre-study had revealed that cigarette smoking was not positively associated with hypertension.

In the past, it was generally believed that cardiovascular diseases including hypertension and lifestyle factors were mainly problems of urban populations or economically developed areas. Therefore, many studies on hypertension and risk factors focused on populations of cities or economically developed areas. In fact, many rural areas or economically undeveloped areas are experiencing rapid lifestyle changes, especially with dietary customs. As the economy develops rapidly, the prevalence of cardiovascular diseases including hypertension and associated risk factors is increasing continuously in China. Our study indicates that hypertension and clustering of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and obesity are threatening the health of the Mongolian population in rural areas. Therefore it is necessary to intervene on lifestyle risk factors in the population.

Table 4 Odd ratios (95% CI) of hypertension associated with hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity.

Risk factor	*n*	Hypertensive *n* (%)	Age—sex-adjusted (95% CI)	*P* value	Multivariate* adjusted OR (95% CI)	*P* value
Hyperlipidemia						
No	1656	547(33.0)	1.000		1.000	
Yes	876	395(45.1)	1.668(1.393, 1.998)	<0.001	1.362(1.128, 1.646)	0.010
Hyperglycemia						
No	2258	801(35.5)	1.000		1.000	
Yes	274	141(51.5)	1.674(1.276, 2.196)	<0.001	1.452(1.094, 1.921)	0.010
Alcohol consumption						
No	1691	526(31.1)	1.000		1.000	
Yes	841	416(49.5)	1.493(1.204, 1.852)	<0.001	1.507(1.208, 1.881)	<0.001
Overweight						
No	2019	666(33.0)	1.000		1.000	
Yes	513	276(53.8)	3.070(2.478, 3.804)	<0.001	2.366(1.820, 3.076)	<0.001
Central obesity						
No	1486	443(29.8)	1.000		1.000	
Yes	1045	498(47.7)	2.162(1.803, 2.592)	<0.001	1.342(1.073, 1.678)	0.003

Table 5 Odd ratios (95% CI) of hypertension associated with number in clusters of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity.

Number of factors	*n*	Hypertensive *n* (%)	Unadjusted OR (95% CI)	*P* value	Age—sex-adjusted OR (95% CI)	*P* value
0	644	136(21.1)	1.000		1.000	
1	846	62(31.0)	1.071 (0.712, 1.610)	0.742	1.029 (0.671, 1.578)	0.892
2	576	261(45.1)	1.958 (1.340, 2.862)	<0.0001	1.878 (1.262, 2.795)	<0.0001
3	327	197(60.2)	3.617 (2.493, 5.247)	<0.0001	3.735 (2.529, 5.516)	<0.0001
4 and more	139	86(61.9)	6.061 (4.099, 8.962)	<0.0001	4.361 (2.886, 6.589)	<0.0001

First, the inhabitants should be educated about the prevention of hypertension, so that they can manage their risk. Secondly, they should develop a healthy and reasonable diet, low in fat and salt, and with plentiful intake of fresh fruit and vegetables. Thirdly, alcohol consumption should be reduced. Body weight should be controlled, and hyperglycemia and hyperlipidemia should be treated.

There are some limitations in this study. First, it was a cross sectional study, therefore a causal relationship between the clustering of these risk factors and the risk of hypertension could not be observed directly. Secondly, approximately 25% of the eligible population from these villages chose not to participate, which may have introduced some selection bias. However we believe this bias is minimal because it is unlikely that participants chose not to participate due to their BP level, which they were unaware of.

In summary, clustering of hyperlipidemia, hyperglycemia, alcohol drinking, overweight and central obesity was associated with hypertension, and the risk of hypertension increased with the number of risk factors in the cluster in Mongolian people in rural areas. It is imperative that various risk factors be controlled at the same time for the primary prevention and early treatment of hypertension and cardiovascular disease.

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