Original Article

Coexistence of anaemia and the metabolic syndrome in adults in Jiangsu, China

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Objective: To determine the prevalence of anaemia and the metabolic syndrome with special interest in the co-existence of these two problems as well as the possible links. **Research design and method:** In a cross-sectional household survey, 1294 men and 1522 women aged 20 years and above were interviewed; anthropometric measurements and blood samples were taken. Metabolic syndrome was defined according to IDF 2005 standard. Anaemia was defined as haemoglobin level below 13 g/dL for men and 12 g/dL for women. **Results:** The age-adjusted prevalence of metabolic syndrome was 11.2% and of anaemia 24.4%. About 3 percent of the participants had both anaemia and metabolic syndrome. Women had a higher prevalence of both the metabolic syndrome and anaemia than men (14.0 vs 8.4%, 31.5% vs 16.1%). Anaemia coexisted significantly with all the individual components of the metabolic syndrome. Only 7.0% of the sample had anaemia without any individual component of metabolic syndrome. In women, the prevalence of combined anaemia and metabolic syndrome peaked in the age group 50-59 years (9.9%). Women in the highest quartile of serum ferritin had a higher risk of only the metabolic syndrome and coexistence of anaemia and metabolic syndrome. **Conclusion:** The high prevalence of the metabolic syndrome and anaemia in the area show the urgent need to develop comprehensive strategies aimed at prevention and treatment. In women this coexistence may be related to inflammation but further research is needed.

Key Words: Anaemia, metabolic syndrome, ferritin, adults, China

INTRODUCTION

Anaemia is a health problem mainly affecting developing countries.[1, 2] In China, the prevalence of anaemia in 2002 was 15.2%, implying a decrease of about 20% during the decade from 1992-2002.[3] With economic growth and associated sociodemographic changes, the burden from undernutrition and infectious diseases has diminished. Concomitantly, changes in diet and other lifestyle factors have led to an increase in life expectancy but also to an increased prevalence of cardiovascular disease and other chronic diseases.[4] The metabolic syndrome characterised by a clustering of cardiovascular risk factors[5-10] and being a powerful determinant of type 2 diabetes [11-14] has been reported to be increasing in China, especially in urban areas. [15-17]

An association between inflammation and the metabolic syndrome has been found.[18] As inflammation is associated with anaemia,[19] theoretically there could be a connection between anaemia and the metabolic syndrome if the anaemia is mainly caused by inflammation. To our knowledge, no previous studies have reported on the prevalence of coexisting anaemia and the metabolic syndrome. It is thus of interest to assess the prevalence and possible coexistence of the two conditions in a population based survey. A country with a high prevalence of anaemia like China, especially Jiangu province having the highest in the country, would be a good place to investigate in order to determine if this association exists. Such information could be important for understanding the aetiology of the metabolic syndrome and the influence of nutrition transition on disease. The objective of this study is to assess the prevalence of anaemia and the metabolic syndrome (as defined by the International Diabetes Federation - IDF 2005 definition[20]) in adults in eastern China with special interest in the coexistence of anaemia and metabolic syndrome in the area and in the same individual. Another objective is to look at risk according to sociodemographic factors.

MATERIALS AND METHODS

Sample and data collection

The 2002 national nutrition and health survey was carried

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out under the approval of the Chinese Ministry of Health. The study was approved by the ethical committee in Chinese National Centre for Disease Control and Prevention. Written consents were obtained from all the participants. The data presented in this article are based on a subsample from Jiangsu province, one of the economically booming areas in eastern China with a population of 73.6 million. The survey was carried out in households in both urban and rural areas. A multistage cluster sampling method was used. The detail of the sampling procedure, data collection and measurement of sociodemographic factors have been described elsewhere.[21] The results presented here are based on data for adults aged ≥20 years. Pregnant women were excluded from the analysis. The current study is based on secondary analysis of the national nutrition survey. The final sample consisted of 1451 households, 1294 men and 1522 women. The response rate was 88.0%.

Measurement

Blood pressure and anthropometric measurements were obtained by trained and certified field workers by use of standard protocols and techniques. Two blood pressure measurements were obtained with the participant in seated position after 5 min of rest. Body weight and height were measured during the examination. Weight was measured in light indoor clothing without shoes to the nearest 100 g. Height were measured without shoes to the nearest mm with a stadiometer. Waist circumference was measured at midway between the inferior margin of the last rib and the crest of the ilium in a horizontal plane. Overnight fasting blood specimens were obtained early in the morning in the study sites for measurement of serum lipids and plasma glucose during 3 days follow up. Concentrations of total cholesterol, HDL-cholesterol, and triglycerides were assessed enzymatically with commercially available reagents. Serum ferritin was analysed using commercially available radioimmunoassay kit (Beijing North Institute of Biological Technology).

All the blood samples were analysed for plasma glucose and haemoglobin (Hb) in the local centres for disease control and prevention under quality control performed by the National Centre for Disease Control and Prevention. Hb was measured by the cyanmethemoglobin method. [22]

Anaemia was defined as Hb level <13 g/dL for men and <12 g/dL for women.[2] Iron deficiency anaemia (IDA) was defined as the presence of both anaemia and serum ferritin level <15μg/L. The metabolic syndrome was defined according to the IDF 2005 standard: central obesity (waist circumference: men ≥90 cm, women ≥80 cm) plus two or more of the following four factors[20] : 1) raised concentration of triglycerides: ≥150 mg/dL or specific treatment for this lipid abnormality; 2) reduced concentration of HDL cholesterol: <40 mg/dL in men and <50 mg/dL in women or specific treatment for this lipid abnormality; 3) raised blood pressure: systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or using antihypertensive treatment; and 4) raised fasting plasma glucose concentration ≥100 mg/dL or previously diagnosed type 2 diabetes. Coexistence of anaemia and metabolic syndrome was defined as having both anaemia and the metabolic syndrome. High serum ferritin was defined as gender specific highest quartile of serum ferritin measured in the sample.

Statistical analyses

Prevalence of anaemia and the metabolic syndrome was age adjusted using the Chinese national population data in 2000 as a reference. Chi square test was used to compare difference between categorical variables. Logistic regression was used to determine the association between sociodemographic factors and isolated anaemia, isolated metabolic syndrome and coexistence of anaemia and the metabolic syndrome. All the analyses were performed by using SPSS 12.0.

RESULTS

General characteristics of the study population are presented in Table 1. Using the IDF definition, the unadjusted and age-adjusted prevalence of the metabolic syndrome were 14.1% (men 9.4%; women 18.0%) and 11.2% (men 8.4%; women 14.0%); while the unadjusted and age-adjusted prevalence of anaemia were 25.3% and 24.4% respectively. About 3 percent of participants had both anaemia and the metabolic syndrome (unadjusted). As shown in table 2, women had a higher prevalence of only anaemia, only metabolic syndrome, and combined anaemia and the metabolic syndrome than men (26.9 vs. 17.2%, 13.7 vs. 8.2%, and 4.3% vs. 1.2%, respectively). In total, 9.1% had serum ferritin concentrations of <15μg/L. The prevalence of iron deficiency anaemia was 6.3% in women and 0.7% in men. In women across age groups of 20-30, 31-40, 41-50, 51-60, and 61-, the prevalence of iron deficiency anaemia was 13.9, 7.5, 7.1, 3.2, and 1.1%. In both genders, the prevalence of non-iron deficiency anaemia increased with age. In the highest serum ferritin quartile, mean serum ferritin was 257.4 μg/L (min 175.6 max 500.4 μg/L) in men, and 170.2 μg/L (min 95.6 max 504.4 μg/L) in women.

In men, there were urban - rural differences in prevalence of the three conditions; only anaemia was 10.6% vs 19.5%, only metabolic syndrome was 16.7% vs 5.3%, and combined anaemia and metabolic syndrome were 2.7% vs 0.6% (Table 2). However in women, these urban - rural differences were not significant.

Age was positively associated with metabolic syndrome and combined anaemia and metabolic syndrome in both genders. In women, the prevalence of combined anaemia and metabolic syndrome peaked in the age group 50-59 years (9.9%). The prevalence rates of only anaemia and only metabolic syndrome were above 20% in women aged 50 years and above. Less than 50% of the women aged 50 years and above had neither anaemia nor the metabolic syndrome (Table 2).

Education was negatively associated with anaemia, metabolic syndrome, and the combined condition in both genders. The opposite was true in regard to income. Only half of the high income women had normal health status.

Anaemia coexisted with individual components of the metabolic syndrome (Table 3). The prevalence rates of coexistence with central obesity, high blood pressure, low HDL, high TG, high FPG were 6.4, 9.3, 10.4, 3.3 and 1.9%, respectively. Only 7.0% of the sample had anaemia

Table 1. Jiangsu Province: sample characteristics

	Men		Women	
	n	%	n	%
Participants, n	1294	46.0	1522	54.0
Age group, y				
20-29	139	10.7	168	11.0
30-39	303	23.4	373	24.5
40-49	314	24.3	378	24.8
50-59	262	20.3	303	19.9
60-	276	21.3	300	19.7
Residence				
Urban	329	25.4	374	24.6
Rural	965	74.6	1,148	75.4
Education				
Primary	466	36.0	878	57.7
Junior	561	43.4	457	30.1
Senior	212	16.4	163	10.7
University	55	4.3	23	1.5
Income				
Low	415	32.4	490	32.5
Medium	411	32.1	495	32.8
High	456	35.6	523	34.7
Obesity (BMI>30Kg/m^2)	104	8.0	193	12.7
Central obesity †	253	19.6	582	38.2
High TG ‡	203	15.7	180	11.8
Low HDL§	283	21.9	740	48.6
High BP ¶	609	47.1	573	37.7
High FPG ††	128	9.9	148	9.7

Abbreviations: BMI, body mass index calculated as weight in kilograms divided by the square of height in meters; TG, triglyceride; HDL, high density lipoprotein; FPG, fasting plasma glucose.
† Defined as waist circumference: men ≥90 cm, women ≥80 cm
‡ Defined as triglycerides: ≥150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality.
§ Defined as concentration of HDL cholesterol: <40 mg/dL (1.03 mmol/L) in men and <50 mg/dL (1.29 mmol/L) in women or specific treatment for this lipid abnormality.
¶ Defined as systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or using antihypertensive treatment.
†† Defined as fasting plasma glucose concentration ≥100 mg/dL (5.6 mmol/L) or previously diagnosed type 2 diabetes.

without any individual component of the metabolic syndrome.

In women, the percentage of high serum ferritin was 42% both in the metabolic syndrome only group and in the group with coexisting anaemia and the metabolic syndrome; while the figures were 20% in the normal and only anaemia group (p<0.001) (Fig 1). No such association was found among men except a slightly higher percentage in the highest quartile of serum ferritin in the metabolic syndrome only group.

In multivariate analysis (Table 4), age and urban residence were positively associated with the metabolic syndrome only, and with combined anaemia and the metabolic syndrome in men. The risk of only the metabolic syndrome and combined anaemia and the metabolic syndrome was much lower in rural than urban men. No significant associations were found between high serum ferritin and all these conditions. In women, age was positively associated with coexisting anaemia and the metabolic syndrome, while education showed the opposite trend. Compared with the 20-39 age group, ORs of coexistence of anaemia and the metabolic syndrome among women in the 40-49, 50-59, 60- age groups were 6.02(p=0.007), 19.92(p<0.001) and 12.96 (p<0.001; p for linear trend <0.001). Compared with levels of serum ferritin, women in the highest quartile of serum ferritin had higher risk of only metabolic syndrome (OR 1.66, p=0.006). The same trend was observed for coexistence of anaemia and the metabolic syndrome although it was not statistically significant.

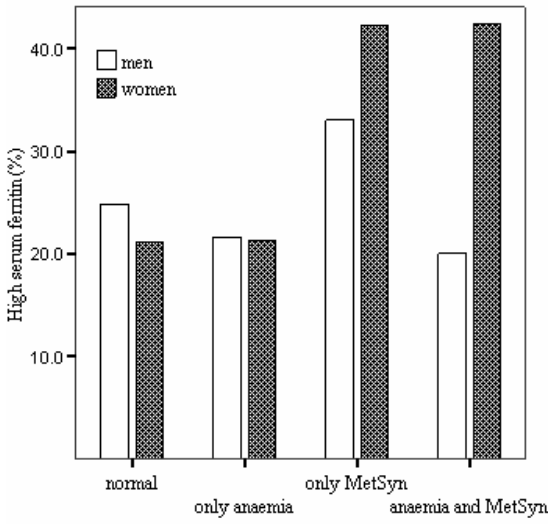

Fig 1. Association between the metabolic syndrome (MetSyn) and anaemia and high serum ferritin (4th quartile) in adults in Jiangsu Province China

Table 2. Prevalence of anaemia and the metabolic syndrome by sociodemographic factors in adults in Jiangsu Province China

	n	Normal	Only anaemia †	Only metabolic syndrome ‡	Combined metabolic syndrome and anaemia	*p* value
Total						
Unadjusted	2816	63.5	22.4	11.2	2.9	
Age-adjusted		66.4	22.3	9.1	2.1	
Men						
Unadjusted	1294	73.4	17.2	8.2	1.2	
Age-adjusted		76.6	15.1	7.4	1.0	
Age group						
20-29	139	85.6	10.8	3.6	0.0	
30-39	303	82.8	7.9	8.3	1.0	
40-49	314	73.3	18.2	7.3	1.3	<0.001
50-59	262	66.4	20.6	11.5	1.5	
60-	276	63.8	26.5	8.3	1.5	
Residence						
Urban	329	69.9	10.6	16.7	2.7	<0.001
Rural	965	74.6	19.5	5.3	0.6	
Education						
Primary	466	68.2	23.8	7.3	0.6	
Junior	561	75.8	14.4	8.4	1.4	0.003
Senior	212	77.4	12.3	9.0	1.4	
University	55	78.2	9.1	10.9	1.8	
Income						
Low	415	79.5	12.5	7.0	1.0	
Medium	411	71.5	20.2	7.1	1.2	0.027
High	456	70.4	18.2	10.1	1.3	
Women						
Unadjusted	1522	55.1	26.9	13.7	4.3	
Age-adjusted		57.8	28.3	10.8	3.2	
Age group						
20-29	168	63.7	35.1	1.2	0.0	
30-39	373	66.8	26.5	5.9	0.8	
40-49	378	58.5	27.5	10.9	3.2	<0.001
50-59	303	46.5	21.8	21.8	9.9	
60-	300	40.3	27.0	25.7	7.0	
Residence						
Urban	374	53.5	25.7	16.6	4.3	0.309
Rural	1148	55.7	27.3	12.7	4.4	
Education						
Primary	878	51.8	25.1	17.1	6.0	
Junior	457	58.4	29.5	9.2	2.8	
Senior	163	60.7	31.3	8.0	0.0	<0.001
University	23	73.9	13.0	13.0	0.0	
Income						
Low	490	63.1	16.5	16.1	4.3	
Medium	495	51.7	31.7	11.9	4.7	<0.001
High	523	50.9	31.9	13.2	4.0	

† Anaemia was defined as haemoglobin level below 13 g/dL for men and 12 g/dL for women.
‡ The metabolic syndrome was defined according IDF 2005 definition: central obesity (waist circumference: men ≥90 cm, women ≥80 cm) plus two or more of the following four factors: 1) raised concentration of triglycerides: ≥150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality; 2) reduced concentration of HDL cholesterol: <40 mg/dL (1.03 mmol/L) in men and <50 mg/dL (1.29 mmol/L) in women or specific treatment for this lipid abnormality; 3) raised blood pressure: systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or using antihypertensive treatment; and 4) raised fasting plasma glucose concentration ≥100 mg/dL (5.6 mmol/L) or previously diagnosed type 2 diabetes.

DISCUSSION

In a cross sectional study of adults aged 20 years and above in Jiangsu Province we found a high prevalence of both anaemia and the metabolic syndrome. A small proportion (2.9%) had both anaemia and the metabolic syndrome. This coexistence was especially high among women older than 50 years. Socioeconomic factors were associated with these nutritional problems, but in a pattern opposite to Western countries.

The prevalence of anaemia was 25.3%, which is higher than the national average of 15.2 %.[3] In the same sample we have earlier found that anaemia is associated with specific food intake patterns.[21] A traditional food pattern consisting predominantly of rice and vegetables and a food pattern characterised by high intake of sweet foods and drinks were positively associated with anaemia; while a pattern containing 'healthy foods' according to the Chinese Nutrition Association was inversely associated with

Table 3. Unadjusted prevalence of the combination of anaemia and individual 5 components of the metabolic syndrome in adults in China

	Men		Women		Total	
	n	%	n	%	n	%
Central obesity †						
Normal	831	64.2	617	40.5	1,448	51.4
Anaemia only	210	16.2	323	21.2	533	18.9
Central obesity only	225	17.4	430	28.3	655	23.3
Both	28	2.2	152	10.0	180	6.4
High TG ‡						
Normal	891	68.9	921	60.5	1,812	64.4
Anaemia only	200	15.5	421	27.7	621	22.1
High TG only	165	12.8	126	8.3	291	10.3
Both	38	2.9	54	3.6	92	3.3
Low HDL§						
Normal	829	64.1	544	35.7	1,373	48.8
Anaemia only	182	14.1	238	15.6	420	14.9
Low HDL only	227	17.5	503	33.1	730	25.9
Both	56	4.3	237	15.6	293	10.4
High BP ¶						
Normal	558	43.1	626	41.1	1,184	42.1
Anaemia only	127	9.8	323	21.2	450	16.0
High BP only	498	38.5	421	27.7	919	32.6
Both	111	8.6	152	10.0	263	9.3
High FPG ††						
Normal	949	73.3	930	61.1	1,879	66.7
Anaemia only	217	16.8	444	29.2	661	23.5
High FPG only	107	8.3	117	7.7	224	8.0
Both	21	1.6	31	2.0	52	1.9
Any individual component of the metabolic syndrome						
Normal	359	27.7	234	15.4	593	21.1
Anaemia	82	6.3	116	7.6	198	7.0
Any one or more of five individual components	697	53.9	813	53.4	1,510	53.6
Both	156	12.1	359	23.6	515	18.3

Abbreviations: BMI, body mass index calculated as weight in kilograms divided by the square of height in meters; TG, triglyceride; HDL, high density lipoprotein; FPG, fasting plasma glucose.
† Defined as waist circumference: men ≥90 cm, women ≥80 cm
‡ Defined as triglycerides: ≥150 mg/dl (1.7 mmol/l) or specific treatment for this lipid abnormality;
§ Defined as concentration of HDL cholesterol: <40 mg/dl (1.03 mmol/l) in men and <50 mg/dl (1.29 mmol/l) in women or specific treatment for this lipid abnormality;
¶ Defined as systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or using antihypertensive treatment;
†† Defined as fasting plasma glucose concentration ≥100 mg/dl (5.6 mmol/l) or previously diagnosed type 2 diabetes.

anaemia. Thalassaemia is not a problem in this area with a prevalence of 0.09%.[23]

Although different definitions have been used since 1998, the prevalence of the metabolic syndrome has been found to vary between 10-20% in the Chinese population.[16, 17, 24] This is within the same range as that observed in this study (14.0%; men 9.4%; women 18.0%). The prevalence is lower compared with Western countries,[7, 8] but we found it to be above 30% in women >50 years. This could be partly due to a high prevalence of overweight/obesity among women in this age range, especially among urban women.[25] In our sample, central obesity prevalence in women was 38.2%. Another reason could be the high prevalence of low HDL cholesterol in women.

In the present study we found a high prevalence of combined anaemia and the metabolic syndrome and its individual components among women. This was due

Table 4. Results from multivariate logistic regression between anaemia, the metabolic syndrome and sociodemographic factors in adults in Jiangsu Province China

	Anaemia † only vs Normal			Metabolic syndrome ‡ only vs Normal			Combined anaemia and metabolic syndrome vs Normal		
	OR	95%CI	p value	OR	95%CI	p value	OR	95%CI	p value
Men									
Age group			<0.001			<0.001			0.043
20-39	1			1			1		
40-49	2.28	1.45-3.58	<0.001	1.24	0.69-2.23	0.480	2.57	0.56-11.81	0.224
50-59	2.40	1.49-3.88	<0.001	2.27	1.28-4.02	0.005	3.98	0.85-18.69	0.080
60-	3.42	2.12-5.54	<0.001	1.53	0.81-2.91	0.194	4.91	0.96-24.96	0.055
Residence									
urban	1			1			1		
rural	1.42	0.93-2.19	0.107	0.27	0.17-0.42	<0.001	0.19	0.06-0.59	0.004
Education			0.036			0.333			0.618
primary	1			1			1		
junior	0.76	0.52-1.10	0.143	0.89	0.52-1.53	0.679	2.29	0.53-9.92	0.267
Senior/university	0.61	0.37-1.01	0.055	0.72	0.38-1.39	0.333	1.66	0.31-9.00	0.558
Income			<0.001			0.454			0.558
low	1			1			1		
medium	2.07	1.39-3.08	<0.001	0.80	0.45-1.42	0.445	1.00	0.25-3.57	0.997
high	2.09	1.39-3.13	<0.001	1.16	0.68-1.99	0.578	0.90	0.23-3.57	0.877
Serum ferritin									
Quartile 1-3	1			1			1		
Quartile 4	0.82	0.56-1.19	0.288	1.16	0.73-1.84	0.521	0.50	0.13-1.89	0.308
Women									
Age group			0.024			<0.001			<0.001
20-39	1			1			1		
40-49	1.04	0.75-1.42	0.831	2.87	1.66-4.98	<0.001	6.02	1.65-21.97	0.007
50-59	1.03	0.69-1.54	0.866	6.38	3.65-11.13	<0.001	19.92	5.67-69.93	<0.001
60-	1.73	1.15-2.60	0.009	7.69	4.31-13.69	<0.001	12.96	3.49-48.10	<0.001
Residence									
urban	1			1			1		
rural	1.12	0.81-1.50	0.531	0.61	0.41-0.90	0.015	0.66	0.34-1.27	0.216
Education			0.436			0.186	0.47	0.26-0.85	0.013
primary	1			1			-	-	-
junior	0.99	0.71-1.37	0.946	0.97	0.61-1.54	0.903	-	-	-
Senior/university	0.83	0.54-1.27	0.386	0.60	0.31-1.15	0.125	-	-	-
Income			<0.001			0.484			0.783
low	1			1			1		
medium	2.61	1.88-3.63	<0.001	0.95	0.63-1.43	0.794	1.34	0.69-2.59	0.387
high	2.76	1.96-3.88	<0.001	0.86	0.55-1.32	0.482	1.10	0.55-2.22	0.785
Serum ferritin									
Quartile 1-3	1								
Quartile 4	0.780	0.57-1.07	0.127	1.66	1.15-2.38	0.006	1.56	0.88-2.77	0.127

†Anaemia was defined as haemoglobin level below 13 g/dL for men and 12 g/dL for women.
‡Metabolic syndrome was defined according IDF 2005 definition: central obesity (waist circumstance: men ≥90 cm, women ≥80 cm) plus two or more of the following four factors: 1) raised concentration of triglycerides: ≥150 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality; 2) reduced concentration of HDL cholesterol: <40 mg/dL (1.03 mmol/L) in men and <50 mg/dL (1.29 mmol/L) in women or specific treatment for this lipid abnormality; 3) raised blood pressure: systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or using antihypertensive treatment; and 4) raised fasting plasma glucose concentration ≥100 mg/dL (5.6 mmol/L) or previously diagnosed type 2 diabetes.

to the fact that the prevalence rates of anaemia, central obesity, and low HDL cholesterol were consistently higher in women than in men.

Anaemia has been found to be negatively associated with diabetes in the sample[26]and with the metabolic syndrome,[27] while iron overload has shown a positive association.[28, 29] However, no study has reported a coexistence of anaemia and the metabolic syndrome at the population level. Although the prevalence of anaemia in diabetic patients can be high,[30, 31] it cannot appropriately explain our results. However, inflammation is related to both anaemia and the metabolic syndrome.[18, 19] In our sample, women with high serum ferritin were found to have higher risk of the metabolic syndrome and combined anaemia and the metabolic syndrome. Since serum ferritin is positively associated with inflammation,[32] it could be assumed that inflammation is associated with this combined condition in women. Education was negatively associated with coexisting anaemia and the metabolic syndrome in women. It could be that the level of inflammation is lower in women with higher education. Results from the Chinese second nutritional survey in 1982 showed that anaemia prevalence in the province was 54.8% in women and 43.2% in men.[33] This means that most of the older participants in our sample have been anaemic in the past two decades, implying that some of them may have developed the metabolic syndrome under the condition of anaemia. Furthermore, the prevalence of the hepatitis B virus marker is 42.6% and HBsAg carriage is10.2% indicating a high level of inflammation in China.[34] Latest research shows that the prevalence of helicobacter pylori (H. pylori) infection (a known cause of anemia[35]) was 62% in the province.[36] Iron deficiency anaemia prevalence was low (6.3% in women and 0.7% in men). The highest prevalence of iron deficiency anaemia was found to be 13.9% among women aged 20-30 years. Less than 3% of women aged above 50 years met the criteria of iron deficiency anaemia. Thus a great proportion of anaemia in the population may be due to inflammation and infection. Our previous studies from the same sample on the association between dietary factors and anaemia also support the hypothesis. Intake of tofu and magnesium was inversely associated with risk of anaemia due to a possible mechanism of anti-inflammation or infection.[37, 38]

Age was the most important determinant for coexistence of anaemia and the metabolic syndrome in both men and women. The prevalence peaked in the age group 50-59 years in women (9.9%). Rich and urban participants had more of these nutrition related problems than their poor and rural counterparts. It is surprising to note that only half of the high income women had normal health status. This difference may be explained by the fact that people from low SES seemed to have a more healthy diet, which has a preventive effect in regard to anaemia.[21]

In conclusion, our results showed a high prevalence of the metabolic syndrome and anaemia in eastern China. Health authorities should be aware of the challenge of the co-existence of these two conditions. The high prevalence of the metabolic syndrome and anaemia show the urgent need to develop comprehensive national strategies aimed at the prevention and treatment of both, especially among women aged 50 years above. High proportion of coexistence of anaemia and the metabolic syndrome in women may be related to inflammation but this needs further research. In a region with a high H. pylori infection level, to prevent both anaemia and the metabolic syndrome, research is urgently needed on whether priority should be given to the control of H. pylori infection given the fact that this infection is related to both anaemia and metabolic syndrome in other countries,[39] especially when iron intake and iron status is related to higher risk of diabetes.[26]

AUTHOR DISCLOSURES

Zumin Shi, Xiaoshu Hu, Baojun Yuan, Gang Hu Xiaoqun Pan and Gerd Holmboe-Ottesen, no conflicts of interest.

REFERENCES

1. ACC/SCN. Fourth report on the world nutrition situation. Geneva: ACC/SCN in collaboration with IFPRI; 2000.
2. WHO. Iron Deficiency Anaemia. Assessment, Prevention and Control: A Guide for Programme Managers: WHO/ NHD/01.3; 2001.
3. Wang L. Report of Chinese national nutrition and health survey in 2002. Beijing: People's Medical Publishing House; 2005.
4. Popkin BM, Horton S, Kim S, Mahal A, Shuigao J. Trends in diet, nutritional status, and diet-related noncommunicable diseases in China and India: the economic costs of the nutrition transition. Nutr Rev. 2001;59(12):379-390.
5. Isomaa B, Almgren P, Tuomi T, Forsen B, Lahti K, Nissen M, Taskinen MR, Groop L. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care. 2001;24(4):683-689.
6. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, Salonen JT. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA. 2002;288(21):2709-2716.
7. Ford ES, Cogswell ME. Diabetes and serum ferritin concentration among U.S. adults. Diabetes Care. 1999;22(12):1978-1983.
8. Hu G, Qiao Q, Tuomilehto J, Balkau B, Borch-Johnsen K, Pyorala K, The DECODE Study Group. Prevalence of the metabolic syndrome and its relation to all-cause and cardiovascular mortality in nondiabetic European men and women. Arch Intern Med. 2004;164(10):1066-1076.
9. Malik S, Wong ND, Franklin SS, Kamath TV, L'Italien GJ, Pio JR, Williams GR. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. Circulation. 2004; 110(10):1245-1250.
10. Hunt KJ, Resendez RG, Williams K, Haffner SM, Stern MP. National Cholesterol Education Program versus World Health Organization metabolic syndrome in relation to all-cause and cardiovascular mortality in the San Antonio Heart Study. Circulation. 2004;110(10):1251-1257.
11. Hanson RL, Imperatore G, Bennett PH, Knowler WC. Components of the "metabolic syndrome" and incidence of type 2 diabetes. Diabetes. 2002;51(10):3120-3127.
12. Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT, Lakka TA. Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. Am J Epidemiol. 2002;156(11): 1070-1077.

13. Lorenzo C, Okoloise M, Williams K, Stern MP, Haffner SM. The metabolic syndrome as predictor of type 2 diabetes: the San Antonio Heart Study. Diabetes Care. 2003;26(11):3153-3159.
14. Wang JJ, Hu G, Miettinen ME, Tuomilehto J. The Metabolic Syndrome and Incident Diabetes: Assessment of Four Suggested Definitions of the Metabolic Syndrome in a Chinese Population with High Post-prandial Glucose. Horm Metab Res. 2004;36(10):708-715.
15. Zhang G, Zhu ZM, Zhao ZG, Ni GX, Yan ZC, Li Q, Liu HY. Comparative study of different diagnostic criteria of metabolic syndrome. Zhonghua Yi Xue Za Zhi. 2005;85(7):490-491.
16. Li ZY, Xu GB, Xia TA. Prevalence rate of metabolic syndrome and dyslipidemia in a large professional population in Beijing. Atherosclerosis. 2006;184(1):188-192.
17. Gu D, Reynolds K, Wu X, Chen J, Duan X, Reynolds RF, Whelton PK, He J. Prevalence of the metabolic syndrome and overweight among adults in China. Lancet. 2005;365 (9468):1398-1405.
18. Haffner SM. The metabolic syndrome: inflammation, diabetes mellitus, and cardiovascular disease. Am J Cardiol. 2006; 97(2A):3A-11A.
19. Roy CN, Andrews NC. Anemia of inflammation: the hepcidin link. Curr Opin Hematol. 2005;12(2):107-111.
20. International Diabetes Federation. The IDF consensus worldwide definition of the metabolic syndrome. Available fromhttp://www.idf.org/webdata/docs/Metabolic_syndrome_definition.pdf. Accessed 3 September 2005.
21. Shi Z, Hu X, Yuan B, Pan X, Dai Y, Holmboe-Ottesen G. Association between dietary patterns and anaemia in adults from Jiangsu Province in China. Br J Nutr. 2006;96:906-912.
22. Dallman PR. Diagnosis of anemia and iron deficiency: analytic and biological variations of laboratory tests. Am J Clin Nutr. 1984;39(6):937-941.
23. Zeng YT, Huang SZ. Disorders of haemoglobin in China. J Med Genet. 1987;24(10):578-583.
24. Chuang SY, Chen CH, Chou P. Prevalence of metabolic syndrome in a large health check-up population in Taiwan. J Chin Med Assoc. 2004;67(12):611-620.
25. Pan XQ, Yuan BJ, Shi Z, Dai Y. The distribution of body mass index among adults in Jiangsu Province. Jiangsu Prev Med. 2004;15(3):13-14. (in Chinese)
26. Shi Z, Hu X, Yuan B, Pan X, Meyer HE, Holmboe-Ottesen G. Association between serum ferritin, hemoglobin, iron intake, and diabetes in adults in Jiangsu, China. Diabetes Care. 2006;29(8):1878-1883.
27. Lao TT, Ho LF. Impact of iron deficiency anemia on prevalence of gestational diabetes mellitus. Diabetes Care. 2004; 27(3):650-656.
28. Jiang R, Manson JE, Meigs JB, Ma J, Rifai N, Hu FB. Body iron stores in relation to risk of type 2 diabetes in apparently healthy women. JAMA. 2004;291(6):711-717.
29. Bozzini C, Girelli D, Olivieri O, Martinelli N, Bassi A, De Matteis G, Tenuti I, Lotto V, Friso S, Pizzolo F, Corrocher R. Prevalence of body iron excess in the metabolic syndrome. Diabetes Care. 2005;28(8):2061-2063.
30. Thomas MC, Cooper ME, Tsalamandris C, MacIsaac R, Jerums G. Anemia with impaired erythropoietin response in diabetic patients. Arch Intern Med. 2005;165(4):466-469.
31. Thomas S, Rampersad M. Anaemia in diabetes. Acta Diabetol. 2004;41 Suppl 1:S13-17.
32. Baynes RD. Assessment of Iron Status. Clin Biochem. 1996; 29(3):209-215.
33. Chang S, Ge K, Zhai F, Jia F, Xu X. The analysis of nutritional factors on anemia in Chinese adults. Acta Nutrimenta Sinica. 1998;20(2):132-137.
34. Yao GB. Importance of perinatal versus horizontal transmission of hepatitis B virus infection in China. Gut. 1996;38 Suppl 2:S39-42.
35. Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet. 2007;370(9586):511-520.
36. Shi R, Xu S, Zhang H, Ding Y, Sun G, Huang X, Chen X, Li X, Yan Z, Zhang G. Prevalence and risk factors for Helicobacter pylori infection in Chinese populations. Helicobacter. 2008;13(2):157-165.
37. Shi Z, Hu X, Yuan B, Pan X, Dai Y, Holmboe-Ottesen G, Byles JE. Strong Negative Association between Intake of Tofu and Anemia among Chinese Adults in Jiangsu, China. J Am Diet Assoc. 2008;108(7):1146-1153.
38. Shi Z, Hu X, He K, Yuan B, Garg M. Joint association of magnesium and iron intake with anemia among Chinese adults. Nutrition.2008;24(10):977-984.
39. Longo-Mbenza B, Nkondi Nsenga J, Vangu Ngoma D. Prevention of the metabolic syndrome insulin resistance and the atherosclerotic diseases in Africans infected by Helicobacter pylori infection and treated by antibiotics. Int J Cardiol. 2007; 121(3):229-238.

Original Article

Coexistence of anaemia and the metabolic syndrome in adults in Jiangsu, China

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贫血和代谢综合征在江苏成人中并存

目的: 描述贫血和代谢综合征的患病率，重点关注这两者在同一个体中的共存及可能的联系。研究设计和方法: 在一横断面的家戶調查中，共計訪視1294 名成年(20 岁及以上)男性和 1522 名成年女性，並进行体格测量和血液检测。代谢综合征采用 IDF2005 标准，贫血定义为血红蛋白在男性低於 13 g/dL，女性低於 12 g/dL。结果: 年龄调整的代谢综合征和贫血盛行率分别为11.2%和 24.4%。约 3%的被调查对象同时有贫血和代谢综合征。女性代谢综合征和贫血患病率均高于男性（14.0%比 8.4%及 31.5%比 16.1%）。贫血与代谢综合征的各成分都共存，僅有 7.0%的对象只患贫血而没有代谢综合征的任何一个成分。在女性 50-59 岁年龄组，贫血与代谢综合征共存的比例最高（9.9%）。血清铁蛋白水平高（第四等份）的女性，單患代谢综合征或贫血与代谢综合征共存的風險較高。结论: 该地区贫血和代谢综合征的患病率很高，需儘速發展有效政策以进行預防与治療。在女性，这种共存现象可能与炎症有关，但需要进一步研究。

關鍵字：貧血、代謝症候群、血清鐵蛋白、成人、中國