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Body mass index, waist circumference, waist-hip ratio, and glucose intolerance in Chinese and Europid adults in Newcastle, UK

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Abstract

Objective **– To compare the prevalence of glucose intolerance (impaired glucose tolerance and diabetes), and its relationship to body mass index (BMI) and waist-hip ratio in Chinese and Europid adults.**

Design **– This was a cross sectional study.**

Setting **– Newcastle upon Tyne.**

Subjects **– These comprised Chinese and Europid men and women, aged 25–64 years, and resident in Newcastle upon Tyne, UK.**

Main outcome measures **– Two hour post load plasma glucose concentration, BMI, waist circumference, and waist-hip ratio.**

Methods **– Population based samples of Chinese and European adults were recruited. Each subject had a standard WHO oral glucose tolerance test.**

Results **– Complete data were available for 375 Chinese and 610 Europid subjects. The age adjusted prevalences of glucose intolerance in Chinese and Europid men were 13.0% v 13.6% (p=0.85), and corresponding values in women were 20.2% v 13.3% (p=0.04). Mean BMIs were lower in Chinese men (23.8 v 26.1) and women (23.5 v 26.1) than in the Europids (p values <0.001), as were waist circumferences (men, 83.3 cm v 90.8, p<0.001; women, 77.3 cm v 79.2, p<0.05). Mean waist-hip ratios were lower in Chinese men (0.90 v 0.91, p=0.02) but higher in Chinese women (0.84 v 0.78, p<0.001) compared with Europids. In both Chinese and Europid adults, higher BMI, waist circumference, and waist-hip ratio were associated with glucose intolerance.**

Conclusions **– The prevalence of glucose intolerance in Chinese men and women, despite lower BMIs, is similar to or higher than that in local Europid men and women and intermediate between levels found in China and those in Mauritius. It is suggested that an increase in mean BMI to the levels in the Europid population will be associated with a substantial increase in glucose intolerance in Chinese people.**

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There are large differences in the prevalences of diabetes and impaired glucose tolerance (IGT) between Chinese populations living in different parts of the world. For example, in Da Quing, an industrial city in the north west of China, the prevalence of diabetes in 1986 in both men and women aged 30 to 64 years was 1.6%.[1] By contrast, in Chinese men and women of the same age in Mauritius, the prevalences of diabetes in 1987 were 16% and 10.1% respectively.[1 2] Studies on Chinese people in Hong Kong and Singapore have found levels between those in China and Mauritius.[1–3] There are, however, no published data on the prevalence of diabetes or IGT in Chinese populations in Europe.

We set out to measure the prevalence of glucose intolerance (impaired glucose intolerance and diabetes) in Chinese and Europid adults in Newcastle upon Tyne. For the purposes of this study, Chinese refers to residents of the UK who on the basis of name, self-definition, and appearance have ancestral origins in China, and includes those born in this country and those who have migrated here via other places. Europid refers to people whose ancestry lies in the European continent. The pragmatic nature of these terms is acknowledged. Our aims were twofold. Firstly, by comparing the Chinese with the local Europid population we sought to examine how differences in the prevalence of glucose intolerance between these populations related to differences in the prevalence of known and putative risk factors. Secondly, we aimed to determine the health care needs of Chinese people with regard to glucose intolerance.

Higher body mass index (BMI) and abdominal fat distribution have both been associated with the incidence and prevalence of diabetes.[5 6] In this paper we present comparisons in relation to both waist circumference and the waist-hip ratio as alternative proxies for abdominal obesity.

Our objectives in this paper are as follows: to compare the prevalence of glucose intolerance in Chinese and Europid adults in Newcastle; to describe the relationships between glucose intolerance and BMI, waist circumference, and waist-hip ratio in men and women in these two populations; and to discuss the extent to which differences in glucose intolerance between the Chinese and Europids are likely to be due to differences in BMI, waist circumference, or the waist-hip ratio.

Methods

THE CHINESE POPULATION IN NEWCASTLE UPON TYNE

Before the Second World War there were very few Chinese in Newcastle. The first Chinese restaurants opened in Newcastle in the late 1940s and early 1950s, and by 1960 there were 30 restaurants in the area.[7] The 1991 census identified 1114 Chinese in Newcastle.[8] Sixty five per cent were born in South East Asia (Hong Kong, Malaysia, and Singapore), 17% in China, and 10% in the United Kingdom, with the rest being born in other parts of the world including Vietnam and the Caribbean. Seventy three per cent of the total UK Chinese population who were born in South East Asia were born in Hong Kong.[9] Of the total Chinese population of the United Kingdom aged over 30, just under 4% were born in the UK.[9]

SAMPLING

Chinese adults

We aimed to study all Chinese adults aged 25–64 years normally resident in Newcastle upon Tyne. (An individual was accepted as Chinese if they described themselves as such, using the same approach taken to respondents' ethnicity in the 1991 UK census.) Students living in university halls of residence were excluded as most Chinese students in Newcastle are from overseas and so are not normally resident in Newcastle. In addition the vast majority of students are in halls of residence for their first year only and their addresses were known to be inaccurate after June of that year.

As there was no register of Chinese individuals, subjects were identified from a number of sources. Firstly a name analysis[10] of the Newcastle Family Health Services Authority (FHSA) register was conducted by one of us (JH) with the help of Jennifer Yuen, the Chinese project worker employed by the local health authority. All individuals with English sounding names were removed from the list and individuals with Chinese sounding names selected from the remainder. Secondly, subjects were recruited in response to publicity aimed at the Chinese community (radio, television, newspapers, and posters). Subjects were also recruited by the Chinese health link and the Chinese project worker by personal contact and through other Chinese organisations in Newcastle.

Europid adults

In the postal questionnaire-based Newcastle health and lifestyle survey,[11] every 30th person on the Newcastle Family Health Services Authority (FHSA) patient register aged between 16 and 74 years was chosen (representing 6448 adults). Men and women aged over 25 years from this sample were used as the sampling frame for the Europid adults in this study. Any Chinese or South Asian sounding names[12] were removed. The sampling frame was divided into 10 year age and sex bands, and the names within each band were randomly ordered. The first 180 names in each age and sex band formed the sample.

RECRUITMENT

Chinese adults

Chinese subjects were recruited and screened between June 1991 and March 1993. Subjects identified from the FHSA register were sent a letter giving information about the project, followed by a letter with an appointment for screening. Non-responders were first sent a reminder letter, and, if they did not make contact, followed up either by telephone or by home visiting. Three visits or telephone calls on different days of the week and at different times of the day were made to try to recruit non-responders.

Subjects recruited from other sources made appointments for screening either directly by telephone (a contact number was advertised), or via a Chinese health link worker, a Chinese project worker, or relatives or friends who came for screening.

Europid adults

Europid adults were recruited and screened between April 1993 and October 1994. Each subject was initially sent a letter informing them about the study, followed by an invitation to attend for screening. Up to three invitations were sent. Those with whom no contact was established after three invitations were sent a letter by recorded delivery mail.

All subjects attended the Clinical Research Centre at the Royal Victoria Infirmary in Newcastle between 8 and 10 am after fasting from 10 pm the night before. The study was approved by the local ethical committee. All subjects received written information about the measurements which would be made before they attended the Clinical Research Centre. This information was repeated verbally when they attended the centre and their consent was obtained before proceeding further.

BIOCHEMICAL MEASUREMENTS

After a fasting venous blood sample had been taken, each subject had an oral glucose load of 75 g of anhydrous glucose dissolved in 388 ml of water and drunk over a maximum period of five minutes. Venous blood samples were taken one and two hours later. Plasma was separated either immediately, by centrifugation, or within an hour (the sample having been refrigerated). Plasma glucose was measured by the glucose oxidase method[13] using an automated colorimetric method on a Hitachi 717 analyser. Diabetes and IGT were based on the value of the two hour sample following WHO definitions[14]: $\geq$11.1 mmol/l for diabetes; >7.8 and <11.1 mmol/l for IGT. In this paper, the category "glucose intolerance" includes all people with diabetes and IGT.

People who already had a diagnosis of diabetes were encouraged to contact a member of the project. If they were not on insulin and were able to attend the screening reasonably early (eg between 8 and 8.30 am) they were asked to fast from 10 pm the night before so that a fasting blood sample could be taken for the measurement of glucose and lipids (the lipid results are not described in this paper), after which they were given breakfast and took any treatment. People on insulin were not asked to fast. If the person reporting a diagnosis of diabetes described their treatment as "none" or "diet only" they were only classified as diabetic if the glucose level in the fasting plasma sample was ≥ 7.8 mmol/l. All people reporting a diagnosis of diabetes who described their treatment as either oral hypoglycaemic drugs or insulin were classified as diabetic irrespective of their blood glucose concentration.

ANTHROPOMETRIC MEASUREMENTS

Height was measured without shoes to the nearest 0.5 cm and weight was measured with the subject lightly clothed on Avery 3306 AVB scales to the nearest 100 g. BMI was calculated as weight (in kg) divided by height (in m^2). Waist and hip circumference were measured to the nearest cm with a dressmaker's tape, at the mid point between the lower costal margin and the superior iliac crest, and over the greater trochanters of the hips with the subject standing. Waist circumference was measured with the waist fully exposed and hip circumference over the subject's underwear.

DATA ANALYSIS

The data were coded and then entered twice, to check for entry errors, onto computer. They were analysed using the *Statistical Package for Social Sciences (SPSS)*.[15] Confidence intervals on proportions were calculated using the normal approximation to the binomial distribution.[16] Confidence intervals on the difference between two groups were calculated using a standard error based on the combined variance of the two groups. Figures were directly age standardised (using the 1991 England and Wales population as standard) by applying weights within *SPSS* such that the age structures of the study populations were the same as that of the standard population but the overall size of each study population was unaffected.[15] Continuous variables were examined for kurtosis and skew, and because all closely approximated to a normal distribution differences in continuous variables between Chinese and Europid men and women, and between those with and without glucose intolerance, were assessed using the independent samples *t* test.

The statistically independent relationships of BMI and waist-hip ratio to glucose intolerance, while controlling for age, were assessed using multiple logistic regression in *SPSS*. For this analysis BMI and waist-hip ratio were divided into tertiles, the tertiles being defined separately for each sex and ethnic group. Regression coefficients and odds ratios were calculated separately for each middle and upper BMI and waist-hip ratio tertile compared with the lowest tertile. This analysis was not carried out for BMI and waist circumference because of high collinearity between waist circumference and BMI, with Pearson correlation coefficients between 0.83 (Chinese women) and 0.90 (Europid men and women, all p values <0.001). Waist-hip ratio and BMI were less strongly correlated: Pearson correlation coefficients were between 0.39 (Chinese women) and 0.62 (Europid men, all p values <0.001).

Results

Figure 1 illustrates the recruitment of the Chinese sample. From the FHSA register 1699 individuals aged 25–64 with Chinese sounding names and resident in Newcastle upon Tyne were identified. Six hundred and thirty eight individuals had addresses in student halls of

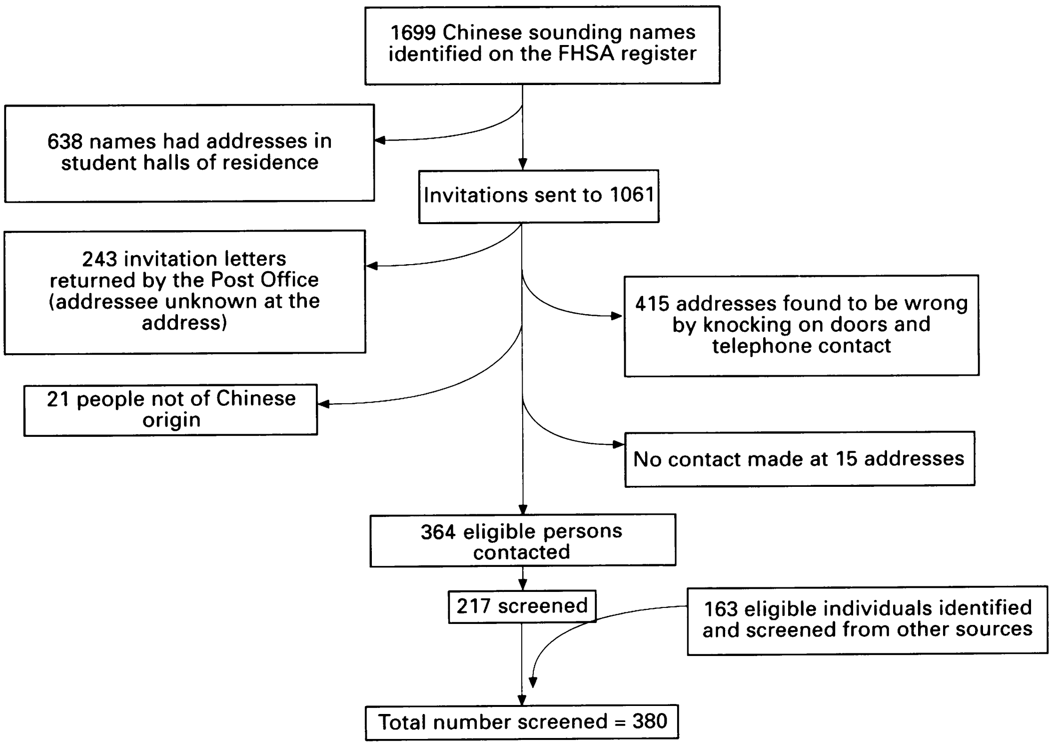

Figure 1 Identification and recruitment of the Chinese population sample.

Table 1 The number (%) of Europid and Chinese men and women in Newcastle upon Tyne with glucose intolerance in relation to age group

	No		Impaired glucose tolerance		Diabetes		All glucose intolerance	
	Chinese	Europids	Chinese	Europids	Chinese	Europids	Chinese	Europids
Men								
25–34	53	42	2 (3.8)	3 (7.1)	0	0	2 (3.8)	3 (7.1)
35–44	51	77	3 (5.9)	7 (9.1)	3 (5.9)	1 (1.3)	6 (11.8)	8 (10.4)
45–54	43	81	3 (7.0)	9 (11.1)	3 (7.0)	5 (6.2)	6 (14.0)	14 (17.3)
55–64	32	104	6 (18.8)	19 (18.3)	3 (9.4)	6 (5.8)	9 (28.1)	25 (24.0)
All	179	304	14 (7.8)	38 (12.5)	9 (5.0)	12 (3.9)	23 (12.8)	50 (16.4)
Age adjusted			8.0	10.7	5.0	2.9	13.0	13.6
(95% CI)			(4.0,12.0)	(7.2,14.2)	(1.8,8.2)	(1.0,4.8)	(8.1,17.9)	(9.7,17.5)
Women								
25–34	64	38	5 (7.8)	0	0	1 (2.6)	5 (7.8)	1 (2.6)
35–44	65	67	10 (15.4)	7 (10.4)	2 (3.1)	1 (1.5)	12 (18.5)	8 (11.9)
45–54	43	83	7 (16.3)	12 (14.5)	3 (7.0)	4 (4.8)	10 (23.3)	16 (19.3)
55–64	24	118	7 (29.2)	21 (17.8)	2 (8.3)	8 (6.7)	9 (37.5)	29 (24.3)
All	196	306	29 (14.8)	40 (13.1)	7 (3.6)	14 (4.6)	36 (18.4)	63 (17.3)
Age adjusted			16.1	9.7*	4.1	3.6	20.2	13.3*
(95% CI)			(11.0,21.2)	(6.4,13.0)	(1.3,6.9)	(1.4,5.6)	(14.6,25.8)	(9.4,17.0)

p values, Chinese v Europid: * <0.05.

residence and were excluded. Out of the remaining 1061 names, only 364 eligible individuals could be found at the address given on the FHSA register and of these 217 (60%) were screened. A further 163 eligible individuals were identified from other sources and screened. The final study sample consisted of 183 men and 197 women. Comparison of the final study sample with the numbers of Chinese in the 1991 census, excluding wards containing student halls of residence (and those in our sample resident in those wards), gives an estimate of the population screened as 72% for men and 73% for women.

The following comparisons were made of the characteristics of the Chinese subjects identified from the FHSA register and those identified from the other sources: male/female ratio, 105/109 v 78/88 ($p=0.69$); mean age, 41.4 v 41.3 years ($p=0.97$); mean BMI, 23.3 v 23.8 kg/m^2 ($p=0.11$); and mean waist-hip ratio 0.865 v 0.869 ($p=0.55$). The proportions with glucose intolerance were also similar – 14.6% v 17.3% respectively ($p=0.47$).

A total of 1260 invitations were sent to Europid population men and women aged 25–64 years. Three hundred and twenty six people were no longer resident at the address on the FHSA register. Thus 944 individuals (444 men and 500 women) received an invitation and 625 (66.2%) Europid adults attended for screening – 310 men (response rate 69.8%) and 315 women (response rate 63.0%).

Complete oral glucose tolerance test data were available on 304/310 (98%) and 179/183 (98%) Europid and Chinese men, and 306/315 (97%) and 196/197 (99%) Europid and Chinese women respectively. Data were missing largely as a result of unsuccessful venepuncture.

Table 2 Age adjusted means (SD) of anthropometric measurements in Chinese and Europid adults in Newcastle upon Tyne

	Men		Women	
	Chinese	Europids	Chinese	Europids
No	179	304	196	306
Height (cm)	166.3 (6.0)	174.2 (10.4)***	154.7 (5.2)	161.2 (6.7)***
Weight (kg)	65.9 (0.9)	79.4 (14.3)***	56.3 (8.4)	67.7 (13.4)***
BMI (kg/m^2)	23.8 (3.2)	26.1 (4.0)***	23.5 (3.3)	26.1 (5.0)***
Waist circumference (cm)	83.3 (8.3)	90.8 (11.0)***	77.3 (9.4)	79.2 (11.7)*
Hip circumference (cm)	92.7 (7.6)	99.9 (7.5)***	91.6 (8.4)	100.9 (9.3)***
Waist-hip ratio	0.896 (0.053)	0.907 (0.063)*	0.843 (0.059)	0.783 (0.062)***

p values, Chinese v Europid: * <0.05–0.01, *** <0.001.

Table 1 shows the numbers of men and women with diabetes, IGT, and glucose intolerance (diabetes and IGT) in relation to 10 year age groups. In each age group Chinese men had a lower prevalence of IGT and a higher prevalence of diabetes than Europid men, although none of these differences was significant. Overall, the age adjusted prevalences of glucose intolerance in Chinese and Europid men were similar – 13.0% v 13.6% (95% CIs on difference = −5.7%, 6.9%). The prevalence of IGT was higher in Chinese women than in Europid women in every age group, and the age adjusted prevalence was significantly higher – 16.1% v 9.7% (95% CIs on difference = 0.8%, 13.2%, $p=0.032$). The prevalence of diabetes in Chinese women in each age group was similar to that in Europid women. The age adjusted prevalence of glucose intolerance was significantly higher in Chinese than in Europid women – 20.2% v 13.3% (95% CIs on difference = 0.1%, 13.7%, $p=0.041$). Of the 16 cases of diabetes in the Chinese men and women, 6 (37.5%) had been previously diagnosed, and of the 26 cases in the Europid men and women, 11 (42.3%) had been previously diagnosed.

Table 2 shows the age adjusted means for anthropometric measurements in Chinese and Europid men and women. Chinese men and women were significantly shorter, lighter, and had lower BMIs than the Europid men and women. Waist and hip circumferences were also significantly smaller in Chinese men and women. In Chinese men, the mean waist-hip ratio was lower than in Europid men, yet in women the waist-hip ratio was higher in the Chinese – 0.843 v 0.783 (95% CIs on difference = 0.049, 0.071, $p<0.001$).

Table 3 shows age adjusted means for BMI, waist, and waist-hip ratio in relation to glucose tolerance status. In both Chinese and Europid men and women, BMI, waist circumference, and waist-hip ratio were significantly higher in those with glucose intolerance than in those with normal glucose tolerance. The mean BMIs of Chinese men and women with glucose intolerance were significantly lower (p values

Table 3 Age adjusted mean (SD) of body mass index, waist circumference, and waist-hip ratio in Chinese and Europid adults with and without glucose intolerance in Newcastle upon Tyne

	Men		*Women*	
	Chinese	*Europids*	*Chinese*	*Europids*
No	179	304	196	306
Body mass index:				
Normal glucose tolerance	23.5 (3.0)	25.6 (3.7)	23.1 (3.1)	25.5 (4.5)
Glucose intolerance	25.9 (3.8)**	29.5 (5.5)***	25.4 (3.2)**	30.8 (5.6)***
Waist circumference:				
Normal glucose tolerance	82.9 (8.4)	89.8 (10.1)	76.2 (8.9)	77.4 (9.8)
Glucose intolerance	87.1 (6.5)**	98.3 (14.7)***	82.2 (8.8)***	94.8 (13.1)***
Waist-hip ratio:				
Normal glucose tolerance	0.896 (0.055)	0.902 (0.061)	0.840 (0.058)	0.774 (0.055)
Glucose intolerance	0.913 (0.031)*	0.941 (0.064)***	0.867 (0.053)**	0.862 (0.056)***

p values, normal glucose tolerance v glucose intolerance: * <0.05–0.01, ** <0.01–0.001, *** <0.001.

Table 4 Regression coefficients (B), odds ratios (95% confidence intervals) from multiple logistic regression for the presence of glucose intolerance in Chinese and Europid men and women

		Chinese		*Europids*	
		B	*Ex B (odds ratio) (95% CI)*	*B*	*Ex B (odds ratio) (95% CI)*
Men:					
BMI tertile (a)	(reference = first tertile)				
Middle	Unadjusted	0.7	2.1 (0.5,8.7)	0.9	2.6 (1.0,7.0)
	Adjusted†	0.6	1.7 (0.4,8.1)	0.7	2.0 (0.7,5.9)
Top	Unadjusted	1.8	5.8 (1.6,21.4)**	1.9	6.6 (2.6,16.8)***
	Adjusted†	1.6	4.9 (1.2,20.2)*	1.5	4.6 (1.5,14.0)**
Waist-hip ratio tertile (b)	(reference = first tertile)				
Middle	Unadjusted	0.8	2.1 (0.7,6.1)	1.2	3.2 (1.2,8.6)*
	Adjusted‡	0.2	1.2 (0.4,3.9)	0.4	1.5 (0.5,4.6)
Top	Unadjusted	0.2	1.3 (0.4,4.2)	1.7	5.6 (2.2,14.3)***
	Adjusted‡	−0.5	0.6 (0.2,2.3)	0.5	1.7 (0.5,5.6)
Women:					
BMI tertile (c)	(reference = first tertile)				
Middle	Unadjusted	1.6	5.1 (1.4,18.7)*	0.4	1.6 (0.6,4.0)
	Adjusted†	1.4	4.1 (1.1,15.7)	0.0	1.0 (0.4,2.6)
Top	Unadjusted	2.2	9.2 (2.6,32.7)***	1.8	5.9 (2.6,13.5)***
	Adjusted†	1.8	6.0 (1.5,23.1)**	0.8	2.3 (0.9,5.6)
Waist-hip ratio tertile (d)	(reference = first tertile)				
Middle	Unadjusted	0.2	1.3 (0.5,3.3)	1.2	3.3 (1.0,10.7)*
	Adjusted‡	−0.3	0.7 (0.3,2.0)	1.0	2.8 (0.9,9.2)
Top	Unadjusted	1.2	3.2 (1.3,8.0)*	2.7	14.7 (5.0,43.2)***
	Adjusted‡	0.6	1.8 (0.7,4.8)	2.1	8.5 (2.7,27.0)***

†Adjusted for age and waist-hip ratio. ‡Adjusted for age and BMI.
Middle tertiles (Chinese, Europid) – (a): 22.3–24.9, 24.3–27.4; (b): 0.88–0.92, 0.89–0.94; (c): 21.6–24.6, 23.8–27.4; (d): 0.82–0.87, 0.76–0.81.
p values: * <0.05–0.01, **<0.01–0.001, *** <0.001.

<0.01) than those in the Europid men and women with glucose intolerance.

Table 4 shows the results in both ethnic groups and sexes of multiple logistic regression with glucose tolerance status (tolerant and intolerant) as the dependent variable and BMI and waist-hip ratio tertiles as the independent variables, while controlling for age. The odds ratios for glucose intolerance increased in relation to BMI tertile in all the groups. The CIs are wide and the relationship with BMI in Europid women when controlling for age and waist-hip ratio is not statistically significant. The only strong and significant relationship independent of age and BMI with waist ratio is seen in Europid women. This analysis was also carried out excluding those with previously known diabetes and the results were little different, with no difference in which relationships were or were not statistically significant.

Discussion

This is the first study to report the prevalence of glucose intolerance in a Chinese population living in Europe. The paucity of research on Chinese populations in the UK has often been noted and research on this group has been identified as a priority.[17] The lack of research is at least partly explained by the difficulties in accessing study populations and gaining the cooperation needed for high quality work. A recent survey of the health care experience of the Chinese in Hull used a random sample of Chinese "takeaway" restaurants to identify Chinese workers, and compared them with

Table 5 Age adjusted (to a standard world population) prevalences of diabetes and impaired glucose tolerance (IGT) in Chinese populations around the world

	Men		*Women*	
Area (reference) description of subjects (no)	*Diabetes (%) (95% CI)*	*IGT (%) (95% CI)*	*Diabetes (%) (95% CI)*	*IGT (%) (95% CI)*
Newcastle upon Tyne, residents 30–64 y (322)	5.5 (1.95,9.01)	10.0 (4.8,15.3)	4.8 (1.2,8.4)	17.9 (11.8,24.0)
Da Quing (1), residents 30–64 y, industrial city in NW China (92 187)	1.6 (1.3,1.8)	0.9 (0.7,1.0)	1.6 (1.3,1.8)	0.9 (0.7,1.1)
Mauritius (1,2), rural and urban residents 30–64 y (305)	16.0 (10.5,21.5)	16.5 (11.0,22.1)	10.1 (5.3,15.3)	21.7 (15.2,28.1)
Singapore (1,4), residents 30–64 y (894)	6.9 (4.2,9.5)	0.8 (0.2,2.2)	7.8 (4.4,11.2)	0.3 (0.0,1.2)
Hong Kong (3), hospital and public utility company employees (1168)	8.9 (5.9,11.9)	11.1 (8.2,14.0)	6.3 (3.3,9.2)	8.7 (5.5,11.9)

Confidence intervals for Hong Kong calculated following method in (1).

workers in fish and chip shops.[18] Our target sample was the entire Chinese population in Newcastle aged 25 to 64 years. In the absence of an accurate and comprehensive sampling frame for Chinese people in Newcastle, two distinct sampling strategies were used: identification of subjects from the FHSA register and recruitment following advertising the study and word of mouth within the Chinese community. We compared the subjects recruited from the FHSA register with those recruited by publicity within the community. There was very little difference in age, male/female ratio, BMI, waist-hip ratio, and the proportion with glucose intolerance between these two groups. This consistency is reassuring but does not exclude the possibility that people recruited by both methods remain systematically different from the total Newcastle Chinese population.

Because of the lack of an adequate sampling frame we cannot give an accurate response rate for the Chinese sample in this survey. Comparison with population size data from the 1991 census suggests that we screened over 70% of the target Chinese population. However, we do not know how accurate the census is with regard to the size of the Chinese population in Newcastle. We identified a total of 530 eligible Chinese men and women (367 via the FHSA register and 163 from other sources – see figure 1) and screened 72% (380), a figure very similar to the response calculated by the comparison with the census described in the results. However, of those identified from the FHSA register only 60% (217 out of 367) were screened. If 70% of the target population were screened, as suggested by comparison with the census, the 163 individuals identified from other sources would need to represent close to 100% of the Chinese population who were not on the FHSA register. This seems unlikely. Our best estimate of the response rate is therefore necessarily imprecise and we estimate that between 60 and 70% of the target population was screened. In the Europid population we screened 66% of those who received an invitation.

The proportion of all people with diabetes in whom the diabetes had not previously been diagnosed was a little higher, although of a similar order of magnitude, in both the Chinese (62.5%) and Europid (57.7%) populations than the 50% generally reported from studies in Europe and North America.[19 20] It is possible that people with a diagnosis of diabetes may have been slightly less inclined to take part than those without a diagnosis. In the information given out about the study people with a diagnosis of diabetes were encouraged to contact a member of the study team for advice. The need to take this action may have acted as a disincentive to some.

It is theoretically possible in a cross sectional study such as this that associations between BMI and glucose intolerance could be a result of BMI increasing after the onset of glucose intolerance. However, prospective data from several different ethnic groups continues to accumulate and are consistent in finding that both a higher BMI and central obesity predispose to the development of glucose intolerance.[5] It seems reasonable to suggest therefore that the facts that a higher BMI was associated with glucose intolerance in both Chinese and Europids and this relationship was statistically independent of waist-hip ratio and age in all but the Europid women are a reflection of the role played by BMI in the development of glucose intolerance in the populations described here. It is therefore noteworthy that Chinese men and women, both with and without glucose intolerance, had markedly lower mean BMIs than the Europids but that Chinese women had a significantly higher prevalence of glucose intolerance than the Europid women (20.2% v 13.3%) and Chinese men had a similar prevalence (13.0% v 13.6%).

Table 5 compares these prevalences of diabetes and IGT in Chinese populations aged 30–64 years with data from four different parts of the world. The figures are all age adjusted to a standard world population, as has been recommended for this type of comparison.[1] The low prevalences of both diabetes and IGT (IGT) in Da Quing, a large industrial city in the north west of China, and the high prevalences in Mauritius are striking. The prevalences of diabetes and IGT in the Chinese in Newcastle are between the levels in Da Quing and Mauritius and about the same or lower than in the employees surveyed in Hong Kong, and the Chinese population in Singapore. The very low prevalence of IGT in Chinese in Singapore is striking and reasons for this not clear. It has been suggested that the ratio of IGT to total glucose intolerance is a population indicator of higher future diabetes prevalence in populations.[21] If this is right it would suggest that of those populations represented in table 5 the greatest potential for future increases are in Chinese men and women in Newcastle and the lowest in Singapore. Interestingly the differences in the prevalence of glucose intolerance between these Chinese populations are not associated with differences in BMI. For example, in Mauritius mean BMIs were 23.7 and 23.3 in men and women respectively,[22] and in the Hong Kong employees they were 23.3 and 23.4 respectively.[3] Within each of these populations the higher BMI was associated with glucose intolerance, as it was in the Chinese and Europid populations reported here, but the differences in glucose intolerance are not explained by variations in BMI between populations and other explanations, such as differences in environmental factors, should be sought.

We can only speculate why, despite lower BMIs, Chinese men had similar and Chinese women higher prevalences of glucose intolerance compared to Europids. BMI, and waist-hip ratio and waist circumference tend to be used as proxies for obesity and abdominal obesity respectively. However, there is a dearth of published information on the comparability of these measures between different ethnic groups. Examination of American skeletal material from the 19th and early 20th centuries kept by the Smithsonian Institute suggests that the pelvic dimensions of African Americans are different to those of white Americans.[23] Thus the waist-hip ratio may not be a valid method of comparing abdominal obesity between these groups, although as the author indicates "modern samples . . . should be tested before reaching a statistical decision based on the results of this study".[23] We have been unable to find any reliable data assessing the validity of different anthropometric measures for comparing obesity and abdominal obesity between Chinese and Europid adults. A paper published in 1934 presented data on pelvic dimensions of "100 unselected" women in Canton[24] and concluded (without directly comparable data on Europid women) that Chinese women tend to have more slender hips than Europid. If correct this could mean that the waist-hip ratio is not a valid means if comparing abdominal obesity between Chinese and Europid adults.

Our data illustrate the importance of such methodological issues. For example, the higher mean waist-hip ratio in Chinese compared with Europid women is striking and might be interpreted as a higher prevalence of abdominal obesity despite lower mean BMI. Interestingly, however, waist-hip ratio was not related glucose intolerance in Chinese women when controlling for BMI in logistic regression analysis. Waist circumference, if used as a proxy for abdominal obesity, suggests the opposite conclusion to waist-hip ratio – ie, a lower prevalence of abdominal obesity in Chinese compared with Europid women (we did not attempt to identify associations with waist independent of BMI because of the strong correlation between these two variables).

There is a need for anthropometric validation studies for abdominal and generalised obestiy across ethnic groups. While acknowledging this, it seems reasonable to suggest on the basis of our results that differences in abdominal obesity are unlikely (because of lower waist circumferences and lack of statistically independent relationship with waist-hip ratio) to account for the difference in glucose intolerance between Chinese and Europid women. Other factors, such as differences in physical activity levels, poorer nutrition in utero and infancy (perhaps partly accounting for the shorter stature of the Chinese compared with the Europids), and differences in genetic susceptibility to glucose intolerance should also be considered.

In conclusion we have found that Chinese men and women in Newcastle had significantly lower BMIs than Europid adults yet the prevalence of glucose intolerance in Chinese and Europid men was similar, and was higher in Chinese women. Understanding which factors cause variations in glucose intolerance in relation to ethnic group could provide valuable insights into its aetiology. The results also have important public health implications for Chinese people in the UK, including assessing the need for the provision of appropriate services. The data presented here invite and support the prediction that should the BMI distribution in the Chinese population shift towards that in the Europid population, the prevalence of glucose intolerance would rise markedly, perhaps to levels currently found in South Asian and Afro-Caribbean populations in the UK.[25 26] Effective strategies to prevent this happening ought to be developed now.

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