RESEARCH

Open Access

CrossMark

Different lipid profiles, insulin sensitivity, and insulin resistance among Han, Uygur, and Kazak men with normal glucose tolerance in Xinjiang, China

Yan Wang[1*†], Jun Zhang[2†], Yanrong Ma[1†], Xiangxin Song[1†], Suli Li[1], Xianqin Zhan[3] and Lan Wu[1]

Abstract

Background: This study aimed to determine the differences in clinical parameters among Han, Uygur, and Kazak men with normal glucose tolerance.

Methods: Participants' data from the China National Diabetes and Metabolic Disorders Study pertaining to Han, Uygur, and Kazak men from the Xinjiang province were used ($n = 930$). Pearson's correlation was used to examine the relationship between HOMA-IR, Matsuda Index, and clinical characteristics.

Results: HOMA-IR of Han men was significantly higher than in Uygurs and Kazaks ($P < 0.001$). The Matsuda Index of Kazaks was significantly higher than that of Hans and Uygurs ($P < 0.001$). While Kazaks had the highest BMI, WC, SBP, and DBP; they also had the highest HDL-C and lowest TG ($P < 0.001$). TG of Uygurs was significantly higher than that of Hans and Kazaks ($P < 0.001$). In Hans and Kazaks, the TG/HDL-C ratio increased with HOMA-IR quartiles; there was no association in Uygurs. In Hans and Kazaks, the TG/HDL-C ratio decreased with Matsuda index quartiles; there was no association in Uygurs. Multivariate linear regression showed that HOMA-IR was independently associated with ethnicity, BMI and TG/HDL-C ratio ($P < 0.01$), while Matsuda index was independently associated with ethnicity, BMI, LDL-C levels ($P < 0.001$) and TG/HDL-C ratio ($P < 0.001$).

Conclusions: In conclusion, Han, Uygur, and Kazak men had different lipid profiles, BMI, and WC. Han men had the highest insulin resistance while Kazak men had the highest insulin sensitivity.

Keywords: Lipid metabolism, Glucose metabolism, Insulin sensitivity, Insulin resistance, Epidemiology, Ethnic differences, Han, Uygur, Kazak

Background

Diabetes and prediabetes are major public health issues in China. According to the studies by the China National Diabetes and Metabolic Disorders Study Group (CNDMDS) performed from 2007 to 2008 in 46,239 adults from 14 provinces in China, the prevalence of diabetes in China was 9.7% [1]. Furthermore, the prevalence of prediabetes in men was 15.5% and 16.6% in urban and rural areas, respectively [2]. Finding and controlling risk factors such as

lipid profile disorders before the occurrence of diabetes are critical to control this epidemic.

In previous studies by our group and others, we observed that the lipid profiles of Han, Uygur, and Kazak people with prediabetes were very different [3–6]. Interestingly, Kazaks were found to have a lower prevalence of diabetes compared with Uygurs, while Hans had the highest risk of diabetes even after adjustment for body mass index (BMI) or waist circumference (WC). Kazaks were more prone to hypertension than the other two populations [7].

The index of insulin resistance in homeostasis model assessment (HOMA-IR) [8] and the Matsuda index [9] are good predictors of diabetes mellitus development

* Correspondence: wang_yan1996@163.com
†Yan Wang, Jun Zhang, Yanrong Ma and Xiangxin Song contributed equally to this work.
[1]Endocrinology Department of Xinjiang Uygur Autonomous Region People's Hospital, Urumqi, Xinjiang 830001, China
Full list of author information is available at the end of the article

Wang et al. Lipids in Health and Disease (2018) 17:209

Page 2 of 7

even in individuals with normal glucose tolerance [10]. The HOMA-IR reflects hepatic insulin sensitivity and basal hepatic glucose production [8], while the Matsuda Index combines both hepatic and peripheral tissue insulin sensitivity [9]. Furthermore, among the lipid parameters, the triglycerides (TG) to high-density lipoprotein cholesterol (HDL-C) ratio is associated with HOMA-IR and Matsuda index, and is also an independent predictor of cardiometabolic events [11, 12]. This ratio is easier to measure in a day-to-day clinical setting than HOMA-IR and the Matsuda index. Since tools exist to detect insulin resistance in people with normal glucose tolerance, the early recognition of the disorder is very important in order to take early lifestyle and/or medical actions and limit the risk of diabetic complications.

Nevertheless, the differences in lipid profiles before prediabetes of those three populations are not known exactly. Therefore, the purpose of this study was to determine the differences in clinical parameters among Han, Uygur, and Kazak men with normal glucose tolerance, and to examine the relationship between HOMA-IR and the Matsuda index with clinical characteristics in these three populations. Men were studied because they have a higher cardiovascular risk than women and because the menopausal status is a confounding factor [13]. The present study is the first to observe and compare the lipid profiles in the Han, Uygur, and Kazak populations with normal glucose tolerance in Xinjiang, China.

Methods

Study population
The present study is a subset study using the Xinjiang participants and data from the CNDMDS, which was a multistage, stratified sampling study conducted from 2007 to 2008 in 46,239 adults from 14 provinces in China [1]. The exact recruitment strategy has been published [1].

The present study was approved by the ethics committee each participating institutions in the Xinjiang province. Written informed consent was obtained for the main study and for eventual substudies [1]. The need for individual consent for this subset study was waived by the committee.

The 1999 World Health Organization diagnostic criteria were used to diagnose diabetes and prediabetes [14]. Subjects with fasting glucose levels ≥6.1 mmol/L (≥110 mg/dL), 2-h glucose levels ≥7.8 mmol/L (≥140 mg/L), diagnosed diabetic, or using antihypertensive, antidiabetic, or lipid-lowering drugs were excluded.

Data collection
Study personnel was trained to measure blood pressure and obtain anthropometric measurements and blood specimens according to a standard protocol [15]. All participants of ≥20 years of age were instructed to maintain their usual physical activity and diet for at least three days before the oral glucose tolerance test. After an 8–10-h overnight fast, venous blood samples were collected in a vacuum tube containing sodium fluoride for the measurement of plasma glucose. Participants with no history of diabetes were given a standard 75-g glucose solution. Blood samples were drawn at 0, 30, and 120 min after the glucose load to measure glucose and insulin levels. Plasma glucose levels were measured with the use of a hexokinase enzymatic method. Serum cholesterol and triglyceride levels were assessed enzymatically using commercially available reagents.

Definitions
The HOMA-IR was calculated as [8]:

HOMA-IR = $(I_0 \times G_0)/22.5$.

where I_0 is the fasting plasma insulin concentration (mIU/L) and G_0 is the fasting plasma glucose concentration (mmol/L).

The Matsuda index was calculated as [9]:

$$= \frac{10000}{\sqrt{G0 \times 10 \times Gmean \times Imean}}$$

Matsuda Index.

where I_0 is the fasting plasma insulin concentration (mIU/L), G_0 is the fasting plasma glucose concentration (mg/dl), G_{mean} is the mean plasma glucose concentration during OGTT (mIU/l), and I_{mean} is the mean plasma insulin concentration during OGTT test (mg/dl).

The TG/HDL-C ratio was calculated as TG (mmol/L) divided by HDL-C ratio (mmol/L).

Statistical analysis
No sample size was performed since it a cohort substudy that included all available patients who met the eligibility criteria. All patients are from the original CNDMDS cohort [1]. The clinical characteristics of the study population were analyzed using one-way ANOVA with the LSD post hoc test. The relationships between HOMA-IR and Matsuda Index with the clinical characteristics were examined using Pearson's correlations. In order to normalize their distribution, $\log_2$ HOMA-IR and $\log_2$ Matsuda index were used. TG/HDL-C ratio, $\log_2$ HOMA-IR, and $\log_2$ Matsuda index were stratified into quartiles. The four quartiles of $\log_2$ HOMA-IR were (in Hans, Uygurs, and Kazaks, respectively): Q1: < 0.385, < 0.137, and < 0.123; Q2: 0.385–0.632, 0.137–0.434, and 0.123–0.185; Q3: 0.632–0.946, 0.434–0.756, and 0.185–0.518; and Q4: > 0.946, > 0.756, > 0.518. The four quartiles of $\log_2$ Matsuda index were (in Hans, Uygurs, and Kazaks, respectively): Q1: < 1.533, < 1.921, and < 2.163; Q2: 1.533–1.892, 1.921–2.263, and 2.163–2.484; Q3: 1.892–2.293, 2.263–2.564,

Wang et al. Lipids in Health and Disease (2018) 17:209

Page 3 of 7

and 2.484–2.776; and Q4: > 2.293, > 2.564, and > 2.776. Multiple linear regression was performed (forward method; candidate variables were age, gender, BMI, WC, SBP, DBP, and lipid profile; non-normally distributed variables were ln transformed) to identify the factors independently associated with HOMA-IR and the Matsuda index. All analyses were conducted using SPSS 19.0 for Windows (IBM, Armonk, NY, USA). Two-sided P-values < 0.05 were considered statistically significant.

Results

Clinical characteristics of the Han, Uygur, and Kazak men

The characteristics of the participants are shown in Table 1. All subjects had normal serum glucose values. HOMA-IR of Han men was significantly higher than in Uygurs and Kazaks (2.08 vs. 1.82 vs. 1.40, $P < 0.001$; Han > Uygur>Kazak), while the Matsuda Index of Kazaks was significantly higher than that of Hans and Uygurs (7.67 vs. 10.25 vs. 13.04, P < 0.001; Kazak>Uygur>Han).

BMI: body mass index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; TG: triglycerides; HDL-C: high-density lipoprotein cholesterol; HOMA-IR: index of insulin resistance in homeostasis model assessment.

Normal values: TG < 2.26 mmol/L; TC < 6.22 mmol/L; HDL-C > 1.04 mmol/L. All subjects had normal serum glucose values.

Kazaks were significantly older than Hans ($P < 0.01$), while Uygurs were significantly older than Hans ($P < 0.05$). BMI (P < 0.01), WC (P < 0.01), and systolic and diastolic blood pressure (SBP and DBP) ($P < 0.001$) of Kazaks were significantly higher than those of Hans and Uygurs (Kazak>Uygur>Han).

While Kazaks had the highest BMI, WC, SBP, and DBP, they also had the highest HDL-C (Kazak>Han > Uygur) and lowest TG ($P < 0.001$). TG of Uygurs was significantly higher than that of Hans and Kazaks (P < 0.001; Uygur>Han > Kazak). There were no significant differences in LDL-C among the three populations.

Correlations of HOMA-IR and Matsuda index with clinical characteristics

Interestingly, we found that the data were different among the three populations. In Hans, BMI ($r = 0.271$, $P < 0.001$), WC ($r = 0.245$, $P < 0.001$), TC ($r = 0.129$, $P = 0.020$), TG ($r = 0.142$, $P = 0.010$), HDL-C ($r = -0.153$, $P = 0.006$), LDL-C ($r = 0.195$, $P < 0.001$), and TG/HDL-C ($r = 0.180$, $P = 0.001$) were correlated with HOMA-IR, while BMI ($r = -0.295$, $P < 0.001$), WC ($r = -0.327$, P < 0.001$), SBP ($r = -0.125$, $P = 0.024$), TC ($r = -0.199$, $P < 0.001$), TG ($r = -0.263$, P < 0.001$), HDL-C ($r = 0.304$, $P < 0.001$), LDL-C ($r = -0.368$, $P < 0.001$), and TG/HDL-C ratio ($r = -0.327$, $P < 0.001$) were correlated with the Matsuda index (Table 2).

Table 1 Clinical characteristics of Han, Uygur, and Kazak men from the Xinjiang province ($n = 930$)

Mean (95% CI)	Han ($n = 325$)	Uygur ($n = 423$)	Kazak ($n = 182$)
Age (years)	41.2 (39.7–42.6)	44.0 (42.7–45.3)	45.5 (43.5–47.5)
BMI (kg/m^2)	24.3 (24.0–24.7)	24.6 (24.3–24.9)	26.1 (25.5–26.7)
WC (cm)	82.7 (81.7–83.8)	85.7 (84.8–86.7)	87.9 (86.2–89.7)
SBP (mmHg)	116 (114–118)	113 (111–115)	132 (129–135)
DBP (mmHg)	77 (76–78)	75 (73–76)	86 (84–88)
Serum glucose (mmol/l)			
Fasting	5.03 (4.97–5.09)	5.36 (5.32–5.40)	4.52 (4.47–4.58)
30 min	8.26 (8.05–8.47)	7.50 (7.33–7.67)	7.22 (6.99–7.46)
120 min	5.41 (5.30–5.53)	5.21 (5.11–5.31)	5.14 (5.03–5.26)
Serum insulin (U/l)			
Fasting	9.32 (8.87–9.77)	7.34 (6.98–7.69)	6.97 (6.42–7.53)
30 min	60.97 (54.55–67.40)	35.48 (32.69–38.28)	27.42 (23.66–31.18)
120 min	30.20 (26.89–33.50)	17.79 (16.17–19.41)	15.29 (13.49–17.09)
TC (mmol/l)	4.58 (4.47–4.69)	4.98 (4.89–5.08)	5.09 (4.96–5.23)
TG (mmol/l)	1.47 (1.34–1.60)	2.01 (1.95–2.08)	0.92 (0.83–1.01)
HDL-C (mmol/l)	1.34 (1.31–1.37)	1.16 (1.13–1.19)	1.71 (1.69–1.74)
TG/HDL-C ratio	1.14(1.05–1.02)	1.82(1.75–1.90)	0.54 (0.49–0.59)
HOMA-IR	2.08 (1.98–2.18)	1.74 (1.66–1.83)	1.40 (1.29–1.51)
Matsuda index	7.67 (7.21–8.12)	10.25 (9.82–10.68)	13.04 (12.17–13.91)

Wang *et al. Lipids in Health and Disease* (2018) 17:209

Page 4 of 7

Table 2 Pearson correlations of HOMA-IR and Matsuda index with clinical characteristic in Han, Uygur, and Kazak men (n = 930)

		BMI	WC	SBP	DBP	TC	TG	HDL-C	LDL-C	TG/HDL-C ratio
Han										
HOMA-IR	PCC	0.271†	0.245†	0.089	0.064	0.129*	0.142*	− 0.153†	0.195†	0.180†
Matsuda index	PCC	−0.295†	− 0.327†	− 0.125*	− 0.105	−0.199†	−0.263†	0.304†	−0.368†	−0.327†
				Uygur						
HOMA-IR	PCC	0.198†	0.234†	0.081	0.039	0.134†	0.055	0.066	0.111*	− 0.011
Matsuda index	PCC	−0.273†	−0.274†	− 0.088	−0.065	− 0.070	−0.065	− 0.072	−0.128†	− 0.004
				Kazak						
HOMA-IR	PCC	0.161*	0.074	−0.006	0.056	0.068	0.166*	0.046	−0.031	0.165*
Matsuda index	PCC	−0.306†	−0.233†	0.045	−0.098	− 0.110	−0.260†	− 0.104	−0.023	− 0.259†

*P < 0.05
†P < 0.01
Adjusted for age
BMI: body mass index; *WC*: waist circumference; *SBP*: systolic blood pressure; *DBP*: diastolic blood pressure; *TC*: total cholesterol; *TG*: triglycerides; *HDL-C*: high-density lipoprotein cholesterol; *HOMA-IR*: index of insulin resistance in homeostasis model assessment; *PCC*: Pearson correlation coefficient

In Uygurs, BMI ($r = 0.198$, $P < 0.001$), WC ($r = 0.234$, $P < 0.001$), TC ($r = 0.134$, $P = 0.006$), and LDL-C ($r = 0.111$, $P < 0.001$) were correlated with HOMA-IR, while BMI ($r = − 0.273$, $P < 0.001$), WC ($r = − 0.274$, $P < 0.001$), and LDL-C ($r = − 0.128$, $P = 0.008$) were correlated with the Matsuda index (Table 2).

In Kazaks, BMI ($r = 0.161$, $P = 0.031$), TG ($r = 0.166$, $P = 0.026$), and TG/HDL-C ratio ($r = 0.165$, $P = 0.027$) were correlated with HOMA-IR, while BMI ($r = − 0.306$, $P < 0.001$), WC ($r = − 0.223$, $P = 0.002$), TG ($r = − 0.260$, $P < 0.001$), and TG/HDL-C ratio ($r = − 0.259$, $P < 0.001$) were correlated with the Matsuda index (Table 2).

In all three populations, HOMA-IR was highly correlated with the Matsuda index ($P < 0.001$).

TG/HDL-C ratio according to quartiles of log$_2$ HOMA-IR and log$_2$ Matsuda index in Han, Uygur, and Kazak men

In Hans, the TG/HDL-C ratio increased with log$_2$ HOMA-IR quartiles and was the highest at Q3 (0.87 vs. 0.99 vs. 1.42 vs. 1.29, $P < 0.001$, $P < 0.05$ for Q1 and Q2 vs. Q3 and Q4). In Kazaks, the TG/HDL-C ratio increased with log$_2$ HOMA-IR quartiles and was the highest at Q4 (0.42 vs. 0.53 vs. 0.53 vs. 0.67, $P = 0.006$, $P < 0.05$ for Q4 vs. Q1, Q2, and Q3). There was no association between TG/HDL-C and log$_2$ HOMA-IR quartiles in Uygurs ($P = 0.77$) (Fig. 1).

In Hans, the TG/HDL-C ratio decreased with log$_2$ Matsuda index quartiles and was the highest at Q1 (1.47 vs. 1.32 vs. 1.12 vs. 0.66, $P < 0.001$, $P < 0.05$ for Q1 vs. Q3 vs. Q4 and for Q2 vs. Q4). In Kazaks, the TG/HDL-C ratio decreased with log$_2$ Matsuda index quartiles and was the highest at Q2 (0.61 vs. 0.64 vs. 0.47 vs. 0.43, $P = 0.004$, $P < 0.05$ for Q1 and Q2 vs. Q3 and Q4). There was no association between TG/HDL-C and log$_2$ Matsuda index quartiles in Uygurs ($P = 0.26$) (Fig. 1).

Multivariate analysis

Multivariate analyses were performed to see whether the lipid profile played a role in the difference in insulin resistance of the different ethnic groups. The multivariate analysis of HOMA-IR showed that the TG/HDL-C ratio was independently associated with HOMA-IR ($P = 0.003$) (Table 3). On the other hand, the multivariate analysis of the Matsuda index showed that the LDL-C levels ($P < 0.001$) and TG/HDL-C ratio ($P < 0.001$) were independently associated with the Matsuda index (Table 3).

Discussion

The lipid profiles and diabetes risk indicators of Han, Uygur, and Kazak people with prediabetes are different [3–6], but the changes in lipid profiles before prediabetes of those three populations are unknown. Therefore, this study aimed to determine the differences in clinical parameters among Han, Uygur, and Kazak men with normal glucose tolerance. The results showed that Han, Uygur, and Kazak men had different lipid profiles, BMI, and WC. Han men had the highest insulin resistance while Kazak men had the highest insulin sensitivity among those three populations.

Many studies such as ACCORD, ADVANCE, and The Veterans Affairs Diabetes Trial [16–19] showed that intensive glucose control is beneficial to prevent the microvascular complications of diabetes, but those studies did not include macrovascular complications such as cardiovascular diseases and stroke. Nevertheless, if clinicians intervene when obesity, hypertension, dyslipidemia, and/or diabetes mellitus are diagnosed, it is already too late since some damage is already done. Therefore, the early recognition of glucose/insulin disorders is very important in order to take early lifestyle and/or medical actions and limit the risk of diabetic complications.

Wang *et al. Lipids in Health and Disease* (2018) 17:209

Page 5 of 7
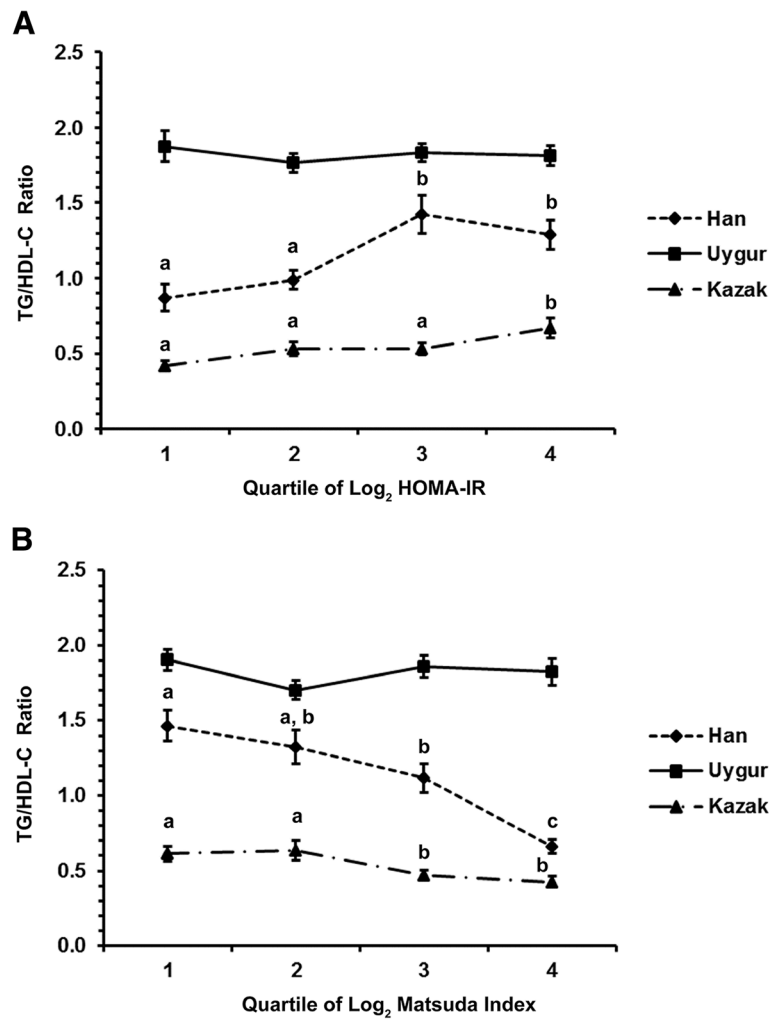
Fig. 1 a TG/HDL-C ratio according to HOMA-IR among Han, Uygur, and Kazak men. **b** TG/HDL-C ratio according to the Matsuda index among Han, Uygur, and Kazak men. TG/HDL-C ratio denoted by different letters indicated significant difference between quartiles

The present study is the first study to observe the lipid characteristics in Han, Uygur, and Kazak populations with normal glucose tolerance in Xinjiang, China. Although Kazaks had the highest BMI, WC, SBP, and DBP, they also had the highest HDL-C and lowest TG. TG levels of Uygurs were significantly higher than that of Hans and Kazaks. The exact reasons for those differences are unknown, but genetic and environmental factors (diet, stress, and physical activity) could be, at least in part, responsible for those differences. Possibly as a consequence of differences in lipid profiles, HOMA-IR of Hans was the highest, while Kazaks' was the lowest, and an inverse relationship was observed for the Matsuda index. Those observations are in line with the prevalence of diabetes mellitus of 8.0%, 6.0%, and 3.5% in Hans, Uygurs, and Kazaks, respectively [7]. HOMA-IR [8] and the Matsuda index [9] are good predictors of diabetes mellitus development even in individuals with normal glucose tolerance [10], but it is

important to highlight that they do not represent exactly the same biological processes. Indeed, the HOMA-IR reflects hepatic insulin sensitivity and basal hepatic glucose production [8], while the Matsuda Index combines both hepatic and peripheral tissue insulin sensitivity [9].

Based on a previous study by our group, the diagnosis of metabolic syndrome (MS) is based on WC cut-off of 85 cm for Hans and 90 cm for Uygurs and Kazaks [20]. In the present study, WC was not independently associated with HOMA-IR and Matsuda index, but BMI was. According to an African descent study, it was shown that even though insulin resistance, cardiovascular diseases, and type 2 diabetes are associated with hypertriglyceridemia, African descent individuals with these conditions usually have normal TG levels [1], suggesting the presence of the "TG paradox" [21]. A previous study showed that non-diabetic African-American adults had a more favorable lipid profile despite high rates of

Wang *et al. Lipids in Health and Disease* (2018) 17:209

Page 6 of 7

Table 3 Multivariate analysis of factors associated with HOMA-IR and Matsuda index

Variables	Beta	Lower 95%CI	Upper 95%CI	P
HOMA-IR				
Ethnicity (Han)[a]	0.224	0.182	0.266	< 0.001
Ethnicity (Uygur)[a]	−0.035	−0.091	0.020	0.208
BMI	0.023	0.015	0.032	< 0.001
TG/HDL-C	0.090	0.031	0.148	0.003
Matsuda index				
Ethnicity (Han)[a]	−0.318	−0.360	−0.276	< 0.001
Ethnicity (Uygur)[a]	0.099	0.043	0.154	< 0.001
Age	0.004	0.002	0.007	< 0.001
BMI	−0.034	−0.042	−0.025	< 0.001
LDL-C	−0.124	−0.173	−0.076	< 0.001
TG/HDL-C	−0.127	−0.189	−0.066	< 0.001

[a]Reference = Kazak
BMI: body mass index; *LDL-C*: low-density lipoprotein cholesterol; *TG*: triglycerides; *HDL-C*: high-density lipoprotein cholesterol

cardiovascular disease [22]. It seems that TG levels below the current MS threshold criterion are associated with insulin resistance in African-Americans [22]. As syndromes are formulated to identify individuals at high risk for conditions such as cardiovascular disease, MS, or type 2 diabetes, ethnic differences in plasma lipid levels have to be considered [23].

The present study showed that BMI, WC, HOMA-IR, and Matsuda index of Han's are associated with the lipid profile, while those parameters are only associated with TC among Uygurs and only with TG among Kazaks. A TG/HDL-C ratio > 3.5 is a simple mean of identifying insulin resistance in dyslipidemic patients who are likely to be at increased risk of cardiovascular disease [24]. In addition, in the Korean population, high TG/HDL-C ratio is associated with insulin resistance according to WC [25]. Interestingly, in the present study, TG/HDL-C ratio was associated with HOMA-IR and the Matsuda index in Hans and Kazaks, but not in Uygurs. Based on these results, it could be hypothesized that in Hans, a TG/HDL-C ratio of 1 means a higher risk of insulin resistance. Nevertheless, those parameters are different in Uygurs and Kazaks, which is consistent with previous reports indicating that Uygurs had a significantly greater risk of diabetes than Kazak [2, 26].

In the present study, SBP and DBP were associated with BMI and WC in all three populations, but these correlations included TG, LCL-C, and TC in Hans, and only TC in Uygurs and Kazaks. According to a study by Zhang Jun et al. [27], at the same BMI, Uygurs have greater waist to hip ratio values, abdominal visceral fat content, and diabetes risk than Kazaks. These differences were mainly associated with the distribution of adipose tissue in the body, changes in metabolic activity, and

adipokine secretion by the adipose tissue [27, 28]. Once again, genetics and lifestyle habits could play roles in those differences, but additional studies are necessary.

The present study is not without limitations. First, the study population was relatively small and from a single geographical area. The available data were limited to those originally collected for the CNDMDS study. The sample size was unequal among the three ethnic groups because the SNDMDS study was originally designed to represent the demographic distribution of the ethnic groups in China [1]. Finally, the main limitation of the present study is that no dietary evaluation was performed. Nevertheless, those three ethnic groups are known to have different dietary habits in terms of fat and salt consumption [29], which could have explained, at least in part, some of the results observed here. Additional studies are still necessary to comprehensively understand the differences of cardiovascular and diabetes risks in Hans, Uygurs, and Kazaks.

Conclusions

Control of BMI and WC is vital to avoid metabolic diseases [30–33]. In conclusion, Han, Uygur, and Kazak men had different lipid profiles, BMI, and WC. Han men had the highest insulin resistance while Kazak men had the highest insulin sensitivity. Therefore, it is possible that interventions of TG/HDL-C should be the main focus in Han men, while TC control could be more important to Uygur and Kazak men. Strict blood pressure control could be a key point in Kazak men to prevent cardiovascular diseases. Future interventional studies are necessary to examine these possibilities.

Wang *et al. Lipids in Health and Disease* (2018) 17:209

Page 7 of 7

for the main study and for eventual substudies The need for individual consent for this subset study was waived by the committee.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details
[1]Endocrinology Department of Xinjiang Uygur Autonomous Region People's Hospital, Urumqi, Xinjiang 830001, China. [2]School of Medicine, Shihezi University, Shihezi, Xinjiang 832000, China. [3]Xinjiang Medicine University, Urumqi, Xinjiang 830001, China.

References
1. Yang W, Lu J, Weng J, Jia W, Ji L, Xiao J, et al. Prevalence of diabetes among men and women in China. N Engl J Med. 2010;362:1090–101.
2. Robbins PF, Morgan RA, Feldman SA, Yang JC, Sherry RM, Dudley ME, et al. Tumor regression in patients with metastatic synovial cell sarcoma and melanoma using genetically engineered lymphocytes reactive with NY-ESO-1. J Clin Oncol. 2011;29:917–24.
3. Wang Y. [study on insulin and action in Xinjiang Han and Uygur subjects with impaired fasting glucose and impaired glucose tolerance]. Chin. J Diabetes. 2014;21:880–3.
4. Wang Y, Ma YR, Li SL, Ma YN, Wu L, Zhao LM, et al. Secretion and action of insulin among Han and Uygur subjects with impaired fasting glucose and impaired glucose tolerance from Xinjiang. Zhonghua Liu Xing Bing Xue Za Zhi. 2012;33:961–3.
5. Quan L, Hu L, Zhang L, Jiang S. Differences of prevalence of dyslipidemia and risk factors related to LDL-c in the patients with abnormal fasting glucose between Uygur and Han in Xinjiang. Int J Clin Exp Med. 2015;8: 22403–10.
6. Yang YN, Xie X, Ma YT, Li XM, Fu ZY, Ma X, et al. Type 2 diabetes in Xinjiang Uygur autonomous region, China. PLoS One. 2012;7:e35270.
7. Liu F, Ma YT, Yang YN, Zhen YJ, Xie X, Li XM, et al. The prevalence of isolated systolic hypertension in adult populations from the Han, Uygur and Kazakh ethnic groups in Xinjiang, China. Blood Press. 2014;23:154–9.
8. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28:412–9.
9. Matsuda M, DeFronzo RA. Insulin sensitivity indices obtained from oral glucose tolerance testing: comparison with the euglycemic insulin clamp. Diabetes Care. 1999;22:1462–70.
10. Yang G, Li C, Gong Y, Fang F, Tian H, Li J, et al. Assessment of insulin resistance in subjects with normal glucose tolerance, hyperinsulinemia with normal blood glucose tolerance, impaired glucose tolerance, and newly diagnosed type 2 diabetes (prediabetes insulin resistance research). J Diabetes Res. 2016;2016:9270768.
11. Zoppini G, Targher G, Negri C, Stoico V, Gemma ML, Bonora E. Usefulness of the triglyceride to high-density lipoprotein cholesterol ratio for predicting mortality risk in type 2 diabetes: role of kidney dysfunction. Atherosclerosis. 2010;212:287–91.
12. Kannel WB, Vasan RS, Keyes MJ, Sullivan LM, Robins SJ. Usefulness of the triglyceride-high-density lipoprotein versus the cholesterol-high-density lipoprotein ratio for predicting insulin resistance and cardiometabolic risk (from the Framingham offspring cohort). Am J Cardiol. 2008;101:497–501.
13. Maas AH, Appelman YE. Gender differences in coronary heart disease. Neth Heart J. 2010;18:598–602.
14. Department of Noncommunicable Disease Surveillance. Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation.Part 1. Diagnosis and classification of diabetes mellitus. Geneva: World health organization; 1999.
15. Luepker RV, Evans A, McKeigue P. Cardiovascular survey methods. 3rd ed. Geneva: World Health Organization; 2004.
16. Hayward RA, Reaven PD, Wiitala WL, Bahn GD, Reda DJ, Ge L, et al. Follow-up of glycemic control and cardiovascular outcomes in type 2 diabetes. N Engl J Med. 2015;372:2197–206.
17. Woodward M, Patel A, Zoungas S, Liu L, Pan C, Poulter N, et al. Does glycemic control offer similar benefits among patients with diabetes in different regions of the world? Results from the ADVANCE trial. Diabetes Care. 2011;34:2491–5.
18. Calles-Escandon J, Lovato LC, Simons-Morton DG, Kendall DM, Pop-Busui R, Cohen RM, et al. Effect of intensive compared with standard glycemia treatment strategies on mortality by baseline subgroup characteristics: the action to control cardiovascular risk in diabetes (ACCORD) trial. Diabetes Care. 2010;33:721–7.
19. Look ARG, Wing RR. Long-term effects of a lifestyle intervention on weight and cardiovascular risk factors in individuals with type 2 diabetes mellitus: four-year results of the look AHEAD trial. Arch Intern Med. 2010;170:1566–75.
20. Wang Y. [recommendations for waist circumference cut-off points for metabolic syndrome diagnosis in Han, Uygur, and Kazak subjects in Xinjiang, China]. Chin. J Diabetes. 2012;20:907–9.
21. Yu SS, Castillo DC, Courville AB, Sumner AE. The triglyceride paradox in people of African descent. Metab Syndr Relat Disord. 2012;10:77–82.
22. Stein E, Kushner H, Gidding S, Falkner B. Plasma lipid concentrations in nondiabetic African American adults: associations with insulin resistance and the metabolic syndrome. Metabolism. 2007;56:954–60.
23. Sumner AE, Cowie CC. Ethnic differences in the ability of triglyceride levels to identify insulin resistance. Atherosclerosis. 2008;196:696–703.
24. McLaughlin T, Reaven G, Abbasi F, Lamendola C, Saad M, Waters D, et al. Is there a simple way to identify insulin-resistant individuals at increased risk of cardiovascular disease? Am J Cardiol. 2005;96:399–404.
25. Kang HT, Yoon JH, Kim JY, Ahn SK, Linton JA, Koh SB, et al. The association between the ratio of triglyceride to HDL-C and insulin resistance according to waist circumference in a rural Korean population. Nutr Metab Cardiovasc Dis. 2012;22:1054–60.
26. Yan W, Yang X, Zheng Y, Ge D, Zhang Y, Shan Z, et al. The metabolic syndrome in Uygur and Kazak populations. Diabetes Care. 2005;28:2554–5.
27. Zhang J, Zhang Z, Ding Y, Xu P, Wang T, Xu W, et al. Adipose tissues characteristics of normal, obesity, and type 2 diabetes in Uygurs population. J Diabetes Res. 2015;2015:905042.
28. Wang C, Ha X, Li W, Xu P, Gu Y, Wang T, et al. Correlation of A2bAR and KLF4/KLF15 with obesity-dyslipidemia induced inflammation in Uygur population. Mediat Inflamm. 2016;2016:7015620.
29. Guo H, Liu J, Zhang J, Ma R, Ding Y, Zhang M, et al. The prevalence of metabolic syndrome using three different diagnostic criteria among low earning nomadic Kazakhs in the far northwest of China: new cut-off points of waist circumference to diagnose MetS and its implications. PLoS One. 2016;11:e0148976.
30. Canadian Agendy for Drugs and Technologies in health. Obesity Management Interventions Delivered in Primary Care for Patients with Hypertension or Cardiovascular Disease: A Review of Clinical Effectiveness. Ottawa: Canadian Agendy for Drugs and Technologies in health; 2014.
31. Aveyard P, Lewis A, Tearne S, Hood K, Christian-Brown A, Adab P, et al. Screening and brief intervention for obesity in primary care: a parallel, two-arm, randomised trial. Lancet. 2016;388:2492–500.
32. Cuschieri S, Mamo J. Getting to grips with the obesity epidemic in Europe. SAGE Open Med. 2016;4:2050312116670406.
33. West DS, Coulon SM, Monroe CM, Wilson DK. Evidence-based lifestyle interventions for obesity and type 2 diabetes: the look AHEAD intensive lifestyle intervention as exemplar. Am Psychol. 2016;71:614–27.