ORIGINAL ARTICLE

IMPAIRED FASTING GLUCOSE AND METABOLIC SYNDROME IN AN INDIGENOUS SIBERIAN POPULATION

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ABSTRACT

Objectives. This study investigated the lifestyle and anthropometric correlates of impaired fasting glucose and the presence of metabolic syndrome (MetS) among an Indigenous high-latitude herding population from north-eastern Siberia.
Study Design. Cross-sectional study of Yakut (Sakha) adult volunteers.
Methods. We collected health, lifestyle and anthropometric data among 166 Yakut adults (≥18 years old; 101 females, 65 males) from the rural village of Tyungyulyu (62°N, 130°E; population 2,500), Sakha Republic (Yakutia), Russia. Measurements of fasting glucose, triglycerides, HDL cholesterol, blood pressure and waist circumference were used to document the presence of MetS based on the updated Adult Treatment Panel (ATP) III definition.
Results. Metabolic syndrome was relatively uncommon among study participants, with only 10% of participants classified as having MetS, including 8% of females and 12% of males. Elevated blood pressure and low HDL cholesterol were the most common features of MetS in Yakut men and women, while elevated fasting glucose and high triglycerides were uncommon in both sexes. Relatively low mean fasting glucose concentrations were documented among Yakut women (4.46±0.65 mmol/L) and men (4.41±0.76 mmol/L); no participants were classified as diabetic.
Conclusions. Fasting glucose and MetS are at relatively low levels in this population; however, rising rates of obesity are likely to lead to future increases in MetS and impaired fasting glucose in this population. Further, increasing consumption of market foods, many high in refined sugars, is likely to contribute to an increased presence of impaired fasting glucose and MetS.
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Keywords: cardiovascular disease, diabetes, obesity, anthropometry, market integration, Russia

INTRODUCTION

Metabolic syndrome (MetS) is characterized by a constellation of risk factors of metabolic origin, including abdominal obesity, insulin resistance, elevated blood pressure and dyslipidemia, that contribute to the development of cardiovascular disease (CVD) and type 2 diabetes (T2D) (1–4). Obesity-related insulin resistance and inflammation are generally considered to be central elements in the pathogenesis of MetS (5–7). While questions linger about its etiology, whether it represents a discrete condition and how its measurement should be standardized across populations, MetS is generally recognized as a useful long-term predictor of adverse health outcomes (8). Further, MetS has been recognized as a growing global public health problem (9).

The presence of MetS, as well as its individual components shows considerable variation between populations, with extremely high prevalence in the United States (both among Native Americans and Americans of European origin), along with sizeable and growing rates in much of the world, including Asia (9–12). A major impediment to comparative population studies stems from the use of multiple measurement definitions which, in some populations, yield pronounced differences in prevalence rates (9). Despite the lack of consensus on universal measurement criteria, the increasing availability of published data from population-level research using the Adult Treatment Panel (ATP) III definition (2) and its updated version (3) now allows informative intergroup comparisons (9). These data have revealed substantial population differences in prevalence rates of MetS (e.g., less than 10% in rural Chinese [13] to over 40% in urban South Asians [9], according to ATP III criteria), as well as interpopulation variation in the clustering of individual components of MetS (14). This almost certainly reflects the influence of environmental factors (such as diet, physical activity, age and smoking), which are known to influence the development of MetS and its components, as well as genetic factors.

Within the past several years, information on the prevalence and risk factors associated with MetS has become increasingly available for Indigenous circumpolar groups in Greenland and North America (15–17). Although data are sparse, these studies have documented a generally low level of MetS among circumpolar Natives in Alaska, Canada and Greenland (16,18); however, there is a growing risk as these populations experience the effects of urbanization and lifestyle change (19,20). Virtually no data on the prevalence of MetS and its risk factors exist for Indigenous Siberians. Furthermore, extremely limited information on glucose metabolism and insulin resistance are available for these populations. This is unfortunate, since a growing body of research has documented a pattern of cardiovascular risk factors among Native Siberians that contrasts with that seen in other populations undergoing market integration and lifestyle change (21); in particular, Indigenous Siberians display extremely high blood pressure levels, yet relatively favourable blood lipid profiles. This set of health changes that come with economic development likely reflects the combined effects of the distinct social and political history of Native Siberians and genetic factors related to population history and regional adaptive patterns (21,22).

The present study was designed as a preliminary step towards remedying this data gap by investigating MetS and its components and risk factors among a high-latitude herding population (the Yakut) from north-eastern Siberia. The goals of the present study are threefold: (1) to estimate fasting glucose levels and the presence of MetS among Yakut adults; (2) to document the clustering pattern of characteristics that comprise MetS in this population; and (3) to examine lifestyle and anthropometric correlates of impaired fasting glucose and the presence of MetS in this population.

MATERIAL AND METHODS

Study population

The Yakut (Sakha) are a large Indigenous group concentrated in the Sakha Republic (Yakutia) of north-eastern Siberia (23,24). Traditionally, their subsistence economy was largely dictated by regional ecological conditions; in the remote parts of the boreal forest (*taiga*), hunting and fishing were the dominant activities, whereas transhumant horse and cattle pastoralism was the subsistence focus in the Lena River Valley. Although the Yakut are part of the Turkic language family, genetic studies indicate they have closer links with other Indigenous Siberian groups (such as the Evenki and Buryat) than with other Turkic populations (25,26). Yakut ways of life were dramatically altered during the period of Soviet collectivization; rural groups were forced to abandon traditional land use patterns and were settled into fishing villages, farms and fur-trapping collectives (23,24). Following the collapse of the Soviet Union in 1991, economic and political transformations had devastating effects for the Yakut, who were dependent on the government for wages along with the delivery of food and essential goods. Like other Indigenous Siberians, most Yakut returned to traditional subsistence practices in order to meet needs no longer met by the government. Today, most rural Yakut populations rely on a mixture of subsistence activities (e.g., herding, fishing and foraging), government wages and pensions, private-sector salaries and profits from “cottage” industries.

Participants

We collected health, lifestyle and anthropometric data from 166 Yakut adult volunteers (≥18 years old; 101 females, 65 males) who live in the rural village of Tyungyulyu (62°N, 130°E; population 2,500), in the Sakha Republic of the Russian Federation. Although conditions in this remote part of Siberia prevented us from obtaining a random sample of participants, we made every effort possible to enrol a sample of participants that was representative of the community in terms of age, sociodemographics and lifestyle. All data collection took place at the Tyungyulyu Medical Center during August 2007, with participants in a post-absorptive condition (after a 12-hour fast). All participants were ethnically Yakut (based on self-definition) and were healthy at the time of measurement. Women who were pregnant or lactating were excluded from the study.

Ethical approval

The Office for Protection of Human Subjects at the University of Oregon approved the research protocol, and verbal consent was obtained from all participants.

Health measures

A trained nurse collected by venepuncture 7 ml of venous blood from each participant into an EDTA-treated Vacutainer tube (Franklin Lakes, NJ). Blood samples were collected with participants in a post-absorptive condition (after a 12-hour fast). Glucose concentrations (mmol/L) and blood lipid (total cholesterol [mmol/L], HDL cholesterol [mmol/L], triglycerides [mmol/L] and calculated LDL cholesterol [mmol/L]) values were immediately obtained using 15μL and 40μL samples, respectively, of venous blood using a CardioChek PA analyzer and PTS Panels (Polymer Technology Systems, Indianapolis, IN). This professional glucose and lipid testing system meets standard clinical guidelines for accuracy and precision. Individuals with triglycerides below 0.56 mmol/L (50 mg/dL) were classified as "low" by the CardioChek PA with no numeric value provided; in these cases, LDL cholesterol could not be calculated.

Presence of metabolic syndrome was documented according to updated ATP III criteria (3). Any 3 of the following constituted diagnosis: elevated waist circumference (≥102 cm for men, ≥88 for women), elevated fasting glucose (≥5.6 mmol/L [or treatment]), elevated triglycerides (≥1.7 mmol/L [or treatment]), reduced HDL cholesterol (<1.0 mmol/L for men, <1.3 mmol/L for women [or treatment]) and elevated blood pressure (≥130 mmHg SBP and/or ≥85 mmHg DBP [or treatment]). These criteria for the recognition of MetS were used instead of alternatives for several reasons, including that the revised ATP III definition is the most widely used criterion and has been used extensively in Asian populations, it does not require an oral glucose tolerance test and it does not require ethnic-specific waist circumference cut-offs (which are not available for any circumpolar group).

Blood pressure (systolic blood pressure and diastolic blood pressure; mm Hg) was measured twice by a physician (IAP) using a manual sphygmomanometer following Chobanian et al. (27). All measurements were made on seated, fasted participants.

For fasting glucose analyses, we followed recent American Diabetes Association (ADA) guidelines (28) for classifying values: normal (<5.6 mmol/L), impaired fasting glucose (5.6–6.9 mmol/L) and diabetes (≥7.0 mmol/L).

Anthropometry

Anthropometric dimensions were recorded by 1 trained observer (SDH) following procedures outlined by Lohman et al. (29). Stature was recorded to the nearest 1.0 mm using an anthropometer (GPM, Zurich, Switzerland). Body weight was measured to the nearest 0.1 kg (with participants in light clothing) using a Tanita BF-558 electronic scale (Tanita Corporation, Tokyo, Japan). Body composition was assessed using 2 derived measures: BMI (kg/m^2) and percent body fat. Body fat was measured using the sum of 4 skinfolds (triceps, biceps, subscapular and suprailiac); skinfolds were repeated 3 times and measured to the nearest 0.5 mm with Lange skinfold calipers (Beta Technology, Santa Cruz, CA). All skinfold measurements were taken without clothing, and calculations were made using the Durnin and Womersely (30) equations. Three circumferences (mid-arm, waist [measured at its narrowest point] and hip) were recorded. Grip strength was assessed using a Jamar hand dynamometer (Sammons Preston Rolyan, Bolingbrook, IL); participants were seated with arm flexed at a 90-degree angle and had the grip strength of each hand measured 3 times. Grip strength was analyzed separately as the maximum of both hands and as the relative average of both hands (maximum grip strength/body mass).

In the present analysis, we considered measures of body composition (BMI, percent body fat from skinfolds and WC) and maximum grip strength (absolute and relative).

Lifestyle measures

Participants were queried about medical histories and asked about their use of alcohol and tobacco. Smoking questionnaires contained questions about current and past smoking habits (e.g., number of cigarettes smoked per day), and alcohol consumption amounts were based on the frequency of intake of vodka, beer, wine and other alcohol over the past several months (31). Each participant was also administered a questionnaire that asked about socio-economic status, subsistence lifestyles and their ownership of livestock and consumer goods.

In the present analysis, we considered 3 indicators of lifestyle: monthly income, market food consumption (i.e., the percent of total calories obtained from market sources) and subsistence lifestyle. Subsistence lifestyle was quantified using a 13-point scale, ranging from 0 (participating in no subsistence activities) to 12 (maximum participation in subsistence activities), according to the number of days per year spent in subsistence activities (foraging, hunting, fishing and hay-cutting), and whether participants were involved in other subsistence activities (tending domesticated animals and horticulture, Table I).

Statistical analyses

Student's t-tests (2-tailed) were used to assess differences between males and females for health, lifestyle and anthropometric variables. Pearson's correlations were used to assess the effects of lifestyle and anthropometric variables on fasting glucose. Multiple regression analysis was used to assess the effects of lifestyle and anthropometric variables on fasting glucose, and logistic regression analysis was used to examine the effects of lifestyle factors on the presence of MetS. Comparisons were considered statistically significant at $p<0.05$. All statistical analyses were performed using SPSS 12.0.

Table I. Subsistence scale for Yakut participants; sexes combined (n=143).

Item	Score	Value label	%
Tending domesticated animals	0	No	39.3
	2	Yes	60.7
Horticulture	0	No	6.7
	2	Yes	93.3
Foraging	0	No	2.8
	1	Yes (1–9 d/yr)	47.6
	2	Yes (>9 d/yr)	49.7
Hunting	0	No	61.7
	1	Yes (1–9 d/yr)	16.1
	2	Yes (>9 d/yr)	22.1
Fishing	0	No	57.0
	1	Yes (1–6 d/yr)	18.8
	2	Yes (>6 d/yr)	24.2
Hay-cutting	0	No	47.3
	1	Yes (1–15 d/yr)	26.4
	2	Yes (>15 d/yr)	26.4

RESULTS

Descriptive statistics for health, lifestyle and anthropometric data for the total sample (101 females, 65 males) are presented in Table II. When participants were classified according to standard BMI categories (32), 32% and 17% of females and 30% and 3% of males were classified as overweight or obese, respectively. Among participants, 26% of females and 50% of males reported that they were current smokers. Males reported significantly greater total alcohol consumption (regular intake of vodka, beer, wine and other alcohol) than females ($p<0.001$). Males were also significantly more involved in the subsistence economy than females ($p<0.001$) (Table II).

All 5 measurements necessary for assessment of MetS according to ATP III criteria were available for 85 females and 57 males; 10% of the sample was classified as having MetS, including 8% of females and 12% of males. The most common MetS components among participants in this study were low HDL cholesterol (44%), elevated blood pressure (38%) and large waist circumference (33%) among females, and elevated blood pressure (56%) and low HDL cholesterol (31%) among males. Only 3% of females and 5% of males were classified as having high triglycerides.

Using logistic regression analysis, none of the lifestyle variables considered (age, smoking, alcohol consumption, income, market food consumption and subsistence participation) were significant predictors of the presence of MetS among females. Among males, both MF consumption ($p<0.05$; OR=1.07 [1.00-1.13]) and age ($p<0.05$; OR=1.13 [1.02–1.26]) were significant predictors of the presence of MetS.

Table II. Descriptive statistics for anthropometric, health and lifestyle data among Yakut participants. [a]

Characteristic	Females (n=101)	Males (n=65)
Age (years)	40.8 (13.2)	42.6 (12.7)
Height (cm)	155.5 (6.8)***	165.7 (5.8)
Weight (kg)	61.0 (11.7)*	65.3 (10.7)
BMI (kg/m^2)	25.2 (4.7)*	23.7 (3.5)
Sum of four skinfolds (mm)	73.6 (26.6)***	37.6 (17.1)
Waist circumference (WC; cm)	83.7 (13.1)	85.1 (10.9)
Maximum grip strength (kg)	23.1 (5.1)***	41.4 (8.7)
Maximum grip strength /body weight	0.39 (0.1)***	0.64 (0.13)
Fasting glucose (mmol/L)	4.46 (0.65)	4.41 (0.76)
Total cholesterol (mmol/L)	5.18 (1.25)*	4.73 (1.11)
HDL cholesterol (mmol/L)	1.41 (0.38)*	1.27 (0.42)
LDL cholesterol (mmol/L)	3.63 (1.16)[b]	3.26 (1.0)[b]
Triglycerides (mmol/L)	0.59[c]	0.62[c]
Systolic blood pressure (mmHg)	117.9 (18.7)**	128.8 (21.7)
Diastolic blood pressure (mmHg)	77.7 (12.1)**	83.8 (12.2)
Income (Rubles)	12,732 (7,858)	11,889 (8239)
Market foods (% in diet)	66.1 (20.2)	66.1 (20.7)
Subsistence score[d]	5.4 (1.9)***	8.3 (2.7)

[a]All values presented as mean (SD) unless otherwise noted.
[b]Mean (SD) only includes subset of cases where LDL cholesterol could be calculated (see text for details).
[c]Median (no mean available; see text for details).
[d]Subsistence scale from 0 (participating in no subsistence activities) to 12 (maximum participation in subsistence activities).

Fasting glucose levels were low among both women (4.46 ±0.65 mmol/L) and men (4.41±0.76 mmol/L) (Table III), with none of the participants classified as diabetic (≥7.0 mmol/L). Only 5% of women and 4% of men were classified as having impaired fasting glucose. Fasting glucose was not significantly different between smokers and non-smokers, and was not significantly correlated with age in either females or males. Among females, fasting glucose was not significantly associated with any measure of body composition or lifestyle considered in this study (Table IV). Among males, fasting glucose was positively associated with WC ($p<0.05$) and showed positive trends with body weight ($p=0.05$) and BMI ($p=0.06$) (Table V). Fasting glucose among males was significantly positively correlated with market food consumption ($p<0.05$) but not income or subsistence participation. Among men, there was a negative trend with fasting glucose and relative grip strength ($p=0.06$), as well as with self-reported total alcohol consumption ($p=0.09$).

Multiple regression analysis was used to estimate the relative contribution of lifestyle and anthropometric variables to variation in fasting glucose levels (dependent variable). In a regression model, fasting glucose among females was not significantly associated with any lifestyle factor considered here (i.e., income, MF consumption and subsistence participation) or anthropometric dimensions. Among males, fasting glucose was significantly positively associated with WC ($p=0.02$; $\beta=0.305$) and MF consumption ($p=0.02$; $\beta=0.303$), but not other lifestyle and anthropometric variables considered here; this model explained 18% of the variation in fasting glucose concentration among males.

Table III. Fasting glucose in adults from selected circumpolar groups; sexes combined unless noted. All values are presented as mean (SD).

Ethnic group	Glucose (mmol/L)	Reference
Siberia		
Khanty	4.61 (0.73)	(20)
Komi-Izhems	4.45 (0.87)	(20)
Mansi	4.62 (0.66)	(20)
Buryat	4.30 (0.69)	(20)
Nenet (males)	4.51 (0.24)	(33)
Chukchi (males)	4.50[a]	(20)
Yakut	4.44 (0.70)	this study
Yakut (males)	4.41 (0.76)	this study
Yakut (females)	4.46 (0.65)	this study
North America		
Alaskan Yup'ik	5.23 (0.74)	(17)
Alaskan Yup'ik (males)	5.24 (0.60)	(17)
Alaskan Yup'ik (females)	5.22 (0.84)	(17)
Canadian Inuit	5.1 (0.35)	(16)
Greenland		
Greenland Inuit (males)	5.8 (0.88)	(48)
Greenland Inuit (females)	5.7 (1.3)	(48)
Europe		
Saami	4.38 (0.81)	(20)

[a]No SD presented

Table IV. Correlation matrix for anthropometric and lifestyle variables for indigenous Siberian females[a,b].

	Glucose mmol/L	Weight kg	WC cm	BMI kg/m²	BF %	RGS	MF %	Income Rubles	Subsistence
Glucose (mmol/L)	1	0.047	0.012	0.036	0.053	-0.161	0.128	-0.001	0.034
Weight (kg)		1	0.855***	0.894***	0.685***	-0.590***	-0.094	0.105	0.048
WC (cm)			1	0.902***	0.804***	-0.595***	0.046	0.117	0.079
BMI (kg/m²)				1	0.797***	-0.643***	-0.643***	0.019	0.101
BF (%)					1	-0.521***	0.054	0.133	0.134
RGS						1	0.092	0.119	0.052
MF (%)							1	0.200	-0.217
Income (Rubles)								1	-0.088
Subsistence									1

[a]Abbreviations: WC, waist circumference; BMI, body mass index; BF, body fat; RGS, relative grip strength; MF, market foods.
[b]Correlations are statistically significant at: *p<0.05; **p<0.01; ***p<0.001.

Table V. Correlation matrix for anthropometric and lifestyle variables for Indigenous Siberian males.[a,b]

	Glucose mmol/L	Weight kg	WC cm	BMI kg/m²	BF %	RGS	MF %	Income Rubles	Subsistence
Glucose (mmol/L)	1	0.248	0.291*	0.239	0.039	-0.249	0.309*	0.185	-0.124
Weight (kg)		1	0.783***	0.891***	0.694***	-0.300*	0.257	0.373**	-0.011
WC (cm)			1	0.837***	0.828***	-0.498***	-0.018	0.263*	0.028
BMI (kg/m2)				1	0.781***	-0.388**	0.123	0.408**	0.015
BF (%)					1	-0.463***	-0.060	0.279*	0.025
RGS						1	-0.068	-0.065	0.168
MF (%)							1	0.050	-0.347**
Income (Rubles)								1	-0.149
Subsistence									1

[a]Abbreviations: WC, waist circumference; BMI, body mass index; BF, body fat; RGS, relative grip strength; MF, market foods.
[b]Correlations are statistically significant at: *p<0.05; **p<0.01; ***p<0.001.

DISCUSSION

A major limitation in our understanding of chronic disease patterns among Native Siberians in the post-Soviet period is that almost no information exists on the presence of Metabolic Syndrome in these populations. Further, surprisingly little data are available on diabetes prevalence and impaired fasting glucose either. Although a few recent studies have begun to address this issue (20,33), information on prevalence and risk factors for MetS among Indigenous Siberians is currently unavailable. The present study was designed to investigate lifestyle and anthropometric correlates of impaired fasting glucose and presence of MetS among the Yakut.

This preliminary investigation of impaired fasting glucose and MetS among an Indigenous Siberian herding population documented relatively low levels of MetS. The 10% of Yakut participants with MetS was a lower percentage than what has been reported in other circumpolar groups, including approximately 15% for Alaskan Yup'ik (17), 14–18% among Inuit from North America and Greenland (34) and 19–38% among a multi-ethnic population of Alaska Natives (35). Among females, 8% of

Yakut participants were classified as having MetS, which is lower than Alaskan Yup'ik females (21%) (17) and other Native Alaskan women (22–38%) (35). Among Yakut males, 12% of participants were classified as having MetS, which is similar to men in some other circumpolar populations, including Alaskan Yup'ik (10%) (17) and Greenland Inuit (13%) (36), but numbers were lower than those found among men from a recent study of Native Alaskans (19–35%) (35). Studies of MetS have consistently documented the significant role of age in the development of MetS, although recent increases in overweight and obesity percentages across ages have contributed to onset taking place at a younger age in many populations (37). The present study showed the role of age in the development of MetS among Yakut men but not women.

MetS prevalence among the Yakut is far lower than that of United States adults (32% in the NHANES 1999–2000, with 33% in females and 31% in males) (10) and Native Americans, whose prevalence of MetS typically exceeds 30%. The presence of MetS and its components at relatively low levels in circumpolar populations is often attributed to dietary factors (for example, diets high in polyunsaturated fatty acids from aquatic sources) and less extensive acculturative changes compared to lower latitude groups (38,39). However, this has not been systematically studied, and few studies have considered the heterogeneity in genetic and environmental factors among circumpolar populations. The present study documented a higher likelihood of MetS among men who consumed larger quantities of market foods, but surprisingly, this was not seen among women. Further, the present study did not detect a significant relationship in either sex between MetS and subsistence lifestyle, which may result from the subsistence scale not accurately quantifying variation in physical activity levels within this population.

In the present analyses, elevated blood pressure and low HDL cholesterol were the most common components of the MetS in Yakut men and women, while elevated fasting glucose and high triglycerides were uncommon in both sexes. This study was consistent with previous research that has documented extremely high blood pressure levels and hypertension rates among Indigenous Siberian populations (including the Yakut), as well as ethnic Russians (22,40). This finding contrasts with other circumpolar groups, such as the Inuit, whose blood pressure values are typically far lower (19). Hypertension appears to be the single most significant cardiovascular risk factor among Native Siberians, particularly among men, and in this respect is similar to that of other Russian populations and Eastern Europeans.

The low fasting glucose levels documented in the present study (4.44±0.70 mmol/L) are similar to those of several other Native Siberian groups, including the Buryat (4.30±0.69 mmol/L) and Khanty (4.61±0.73 mmol/L), recently published by Kozlov and colleagues (20) (Table III). However, these fasting glucose concentrations are considerably lower than those documented among the Canadian Inuit (5.10±0.35 mmol/L) (16) and Alaska Yup'ik (5.23±0.74 mmol/L) (17), as well as other North American circumpolar populations and U.S. adults. The limited, population-level data available for Native Siberians, including for the Chukchi, Khanty and Mansi, are consistent with the present study in documenting an extremely low prevalence of T2D and glucose intolerance, which are far below levels in Alaska and other circumpolar regions (20,38).

Studies of northern populations living a traditional lifestyle, such as the Inuit of North America, have documented relatively low rates of T2D and impaired fasting glucose (compared to lower latitude populations), but these 2 factors have shown dramatic increases over the past several decades as these groups have experienced market integration and lifestyle change (34,41). Recent research has reported relatively high prevalence rates of T2D among the Inuit – in some cases similar to those of Native American populations from lower latitudes – that likely reflects recent shifts in diet, activity patterns and alcohol consumption (41).

The only previous study of lifestyle and impaired fasting glucose among Indigenous Siberians was done by Kozlov and colleagues (20); this study documented higher fasting glucose with urbanization and with abandonment of traditional subsistence occupations among the Mansi and Khanty. The present study identified age and consumption of market foods as significant predictors of impaired fasting glucose among males, but not females. Fasting glucose concentration among men was higher among individuals with greater body fat and larger waist circumferences, and showed a trend among men with low muscular strength. Contrary to predictions, subsistence participation in both sexes was not significantly related to fasting glucose concentration. Further, none of the variables included in the study were significantly associated with the presence of MetS or impaired fasting glucose among female participants.

There are several limitations to this study. First, the small sample size and non-random selection of participants severely limits the power and generalizability of the findings of this research. Second, this study used lifestyle data based on self-report of participation in subsistence activities, yet these measures likely do not adequately capture all elements of lifestyle variation in this population. Future research should combine sociodemographic and subsistence participation data with detailed information on dietary composition and measured physical activity. Despite these limitations, this study does provide preliminary information on the presence and correlates of impaired fasting glucose and MetS among an Indigenous circumpolar population currently experiencing market integration and lifestyle change. This research and other studies among Indigenous Siberians document a pattern of cardiovascular risk factors that contrasts with what has been seen in other circumpolar populations undergoing market integration and lifestyle change. The prevalence of overweight and obesity among Native Siberians is generally lower than that seen in most other circumpolar groups, but appears to be increasing (42,43). Also, Native Siberian populations have extremely high blood pressure, yet cholesterol, triglycerides and fasting glucose are relatively low (21,40,44,45).

This distinctive set of health changes with economic development may reflect the diverse social and political history of Native Siberians and, specifically, the effects on Indigenous health of particular lifestyle changes in post–Soviet Russia (21). However, these cardiovascular risk factors may also be shaped by regional differences in adaptive patterns (21,46).

In summary, MetS and impaired fasting glucose are uncommon in this population, with the latter similar to other Siberian groups but considerably lower than circumpolar populations in North America and Greenland. However, recent increases in overweight and obesity among Indigenous Siberians (43) are likely to lead to future increases in the prevalence of MetS with long-term consequences for the development of cardiovascular disease and type 2 diabetes. The relatively low physical activity levels documented in this population (47), especially among women and individuals less dependent on the subsistence economy, are likely to lead to increases in MetS and its components. Further, dietary transition with increased consumption of market foods, many high in refined sugars, saturated fats and salt, along with decreased use of traditional foods (e.g., aquatic resources and lean hunted animals), is likely to contribute to an increased presence of MetS.

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Conflict of interest statement

None of the authors had a conflict of interest in relation to this study.

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