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*Original Research Article*

# Health Consequences of Postsocialist Transition: Dietary and Lifestyle Determinants of Plasma Lipids in Yakutia

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*ABSTRACT* The rapid social and cultural changes introduced by the collapse of the Soviet Union have resulted in important differences in cardiovascular health for indigenous Siberians. This study investigated diet and lifestyle determinants of plasma lipids in the Yakut, an indigenous Siberian herding population. The study used a cross-sectional design with data on 201 subjects in three urbanized towns and three rural communities in northeastern Siberia. Data on sociodemographic characteristics, dietary intake, and material lifestyle were collected, and lipids were analyzed from venous whole blood. Diet was analyzed using patterns of dietary intake based on principal components analysis of a dietary intake (food frequency) questionnaire. We identified three diet patterns: a traditional subsistence diet, a market foods diet, and a mixed diet. The effect of lifestyle on cardiovascular risk factors was measured using an ethnographically defined lifestyle index, with two orthogonal dimensions: subsistence lifestyle and modern lifestyle. Total cholesterol (TC) and low-density lipoprotein (LDL) were significantly higher among those consuming a traditional subsistence diet of meat and dairy products. A modern lifestyle was associated with lower TC and LDL but higher adiposity and higher risk of obesity. LDL and TC were higher in rural communities and lower in urbanized towns. The significantly higher lipid levels associated with a subsistence diet and indirectly with a subsistence lifestyle indicate the emergence of a significant health problem associated with the social and cultural changes occurring in Yakutia today. These findings underscore the need for dietary modification and promotion of physical activity among those most at risk for cardiovascular disease (CVD). Moreover, these results differ from those commonly seen in "modernizing" populations, in that elements of subsistence lifestyle are associated with an elevated rather than reduced risk of CVD. Such variable responses to lifestyle change emphasize the need to better understand the distinct social and historical events that may influence health changes among populations in transition. Am. J. Hum. Biol. 17:576–592, 2005. © 2005 Wiley-Liss, Inc.

A number of studies of cardiovascular risk factors among circumpolar groups, in both North America and Siberia, documented a strong, positive association between adoption of an acculturated lifestyle and the population burden of plasma lipids and other risk factors. Several authors noted a shift from traditional to market sources of food as an important determinant of the increased prevalence of cardiovascular disease (CVD) found as these groups undergo acculturation (Rode and Shephard, 1995b; Young et al., 1995; Leonard et al., 2002a).

Among the Yakut, despite relatively low levels of plasma lipids (Sorensen et al., 2000), mortality from cardiovascular disease is the leading cause of death, followed by mortality from injuries and accidents (Sorensen, 2003). In 1999, among the specific cardiovas-

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cular causes of death, the age-standardized death rate from ischemic heart disease was highest, at 254.2 per 100,000, followed by cerebrovascular disease, at 86.9 per 100,000 population (Ministry of Health of the Republic of Sakha, 2000). The total mortality rate in 1999 from all cardiovascular diseases was 390.7 per 100,000. This rate is considerably higher than the mortality rate from all cardiovascular diseases of 268.5 per 100,000 in Yakutia in 1985 (Klimova, 2001). Despite the burden of CVD mortality among the Yakut, few studies have been undertaken to investigate the distribution of cardiovascular risk factors and their dietary and lifestyle correlates in this population (Tsukanov et al., 1999; Mironova et al., 2001).

This paper presents findings from an investigation of major cardiovascular risk factors and their association with diet and lifestyle factors in Yakutia. We describe the analysis of dietary intakes, anthropometric status, lifestyle, and variation in plasma lipids in 201 adult male and female indigenous residents of the Republic of Sakha (Yakutia). We apply a diet-pattern approach to the analysis of diet intake and associations with lipids, focusing on patterns of food consumption as opposed to specific nutrients or foods (Hu et al., 1999, 2000; Fung et al., 2001).

We develop an ethnographically defined measure of lifestyle and apply this measure to the analysis of cardiovascular risk in a population undergoing rapid social and cultural transition. This measure allows for an investigation of heterogeneity in lifestyle within and between communities and households, and relationships with plasma biomarkers of cardiovascular risk.

## HEALTH AND CULTURE CHANGE IN SIBERIA

The health effects of rapid social, economic, and cultural change have long been of interest to human biologists. Mode-rnization and acculturation are central concepts for studying the health of indigenous peoples in transition to a modern way of life (Sampath, 1974; Berry, 1984; Baker et al., 1986; McGarvey and Schendel, 1986; McGarvey et al., 1989; Shephard and Rode, 1996; Chin-Hong and McGarvey, 1996; Dressler and Bindon, 1997). These concepts are particularly salient for understanding the social, economic, and political changes experienced by indigenous Siberians prior to the collapse of the Soviet Union. From 1945 until the early 1990s, these groups experienced a transition from a nomadic, traditional existence to residence in large permanent villages and a shift to a wage and welfare economy. Concomitantly, there were important changes in health status and health behaviors, including a diet composed increasingly of market foods high in saturated fats and refined sugars (Rode et al., 1995; Mamleeva et al., 1998), decreased physical activity (Shephard and Rode, 1996; Leonard et al., 1996), increased prevalence of alcoholism and cigarette smoking (Lisenko and Richards, 1994), increased cardiovascular mortality (Argunov, 1996; Borisov and Tikhonov, 2001; Klimova, 2001), and declines in general health status (Shadrin, 1995).

In post-Soviet Siberia, modernization and acculturation are problematic concepts in that the health effects of culture change are expected to operate in the opposite direction, with acculturative stress introduced by the process of “demodernization” that occurred following the breakup of the Soviet Union. The sweeping social and economic transformation in post-Soviet Siberia had a profound impact on the health status of the Sakha (Yakut) (Sorensen et al., 2000; Sorensen, 2003) and other Siberian populations (Leonard et al., 2002b). The previous decade witnessed increased regional economic differentiation. In rural communities, there has been a shift from a society where most individuals were employed on large state collective farms to a society characterized by traditional subsistence behavior and inconsistent linkages with a cash economy and outside markets. Following the abrupt collapse of collective farms after 1991, rural residents were forced to return to small-scale herding of horses, cattle, and occasionally pigs, and by hunting, fishing, and gathering in the boreal forest. Residents of larger towns and district administrative centers are increasingly integrated into regional and global markets, and engaged in wage employment. Despite the community-level differences, there is a high degree of heterogeneity within communities, with some households pursuing mixed subsistence strategies of wage employment and small-scale herding, hunting, and fishing. One purpose of this investigation is to capture this variability at the household level using a quantitative, ethnographically defined measure of lifestyle.

## MATERIALS AND METHODS

### *Study population*

The Sakha (Yakut) are a Turkic language-speaking population of nearly 400,000 residing in the Sakha (Yakutia) Autonomous Republic in northeastern Siberia (56–73° North and 107–172° East). Traditionally, the Yakut subsist by herding cattle and horses in the Lena River Valley, and by hunting and fishing in more remote parts of the boreal forest (Tokarev and Gurvich, 1956). In the extreme north, the Yakut practice nomadic reindeer herding, similar to their Evenki and Yukaghir neighbors. There are three ethnographically defined Yakut groups, based on subsistence patterns and clan origins: North reindeer herders, Viliui cattle-breeders, and Central Sakha (*Kangalas*) (Tokarev, 1940). The present study was conducted among the Central Sakha, who practice cattle and horse breeding and reside primarily in the Lena River Valley, its tributaries, and surrounding regions.

Prior to the collapse of the Soviet political and economic system, nearly all Yakut were employed by the state. In rural areas, this took the form of wage employment on state collective farms. The collective farms were enormous agricultural and animal husbandry complexes with a highly rationalized, industrial form of agricultural production. During this period, the Yakut were employed as highly educated and skilled workers in a range of specialized professions, with positions such as agronomist, agricultural technician, and various types of mechanics whose job was to maintain the collective farm machinery. During Soviet times, and especially by the late 1980s, most of these enterprises were operating in the negative and were sustained by financial subsidies from the government. By 1991–1992, the subsidies abruptly evaporated, and many collectives went bankrupt. Others were "privatized" and continued to operate with funds from high-interest loans. The result of this transition for the Yakut has been a return to subsistence, characterized by small-scale herding. In many cases, the livestock and material resources of the bankrupt collectives were divided up among the workers, with the proportional share being determined by the individual's position in the collective farm and Communist party hierarchy (Crate, 2003). This process, while it gave a few head of cattle and horses to most households, served to introduce a degree of socioeconomic stratification that had been largely mitigated under the collective system.

### *Study design*

This research was conducted in collaboration with the Ministry of Health of the Republic of Sakha (Yakutia) and the Institute of Health of the Academy of Sciences of the Republic of (Sakha) Yakutia. In 2001, the Ministry of Health conducted a representative, cross-sectional household survey of health and economic status in the republic. The study used a multistage cluster design. Two administrative districts were selected at random from within each of four ecogeographic "zones:" north, west, south, and central, for a total of eight districts (clusters). The capital district, Yakutsk, was included as a ninth cluster. Two villages were selected at random from within each district in addition to the district administrative center, for a total of three villages perdistrict. In ethnically heterogeneous districts, matched samples of indigenous and immigrant (Russian) communities were selected, based on census data. The sampling frame was based on a sample of 70 randomly selected households in each village, based on the household census register. In total, 24 villages were included in the study.

For the present substudy, six villages in two districts were selected for investigation of lipids, blood pressure, and other physiological parameters. The two districts are in the central region of the republic, adjacent to the capital district, and are likely to be broadly similar to other rural districts of low to medium population density. Gorny *Ulus* is a rural district (45,600 km$^2$) located in the Viliuisk watershed, with a total population of 11,500 and an economy based on herding of cattle, horses, and reindeer. The population was predominantly ethnic Yakut in the study villages. The three study villages in this district were Dikimdye (population 850), Asyma (population 1,000), and Berdygestiakh (population 4,000). Megino-Kangalassky *Ulus* is a district in the Lena and Aldan River watersheds, with a mixture of rural and urbanized towns, a population of 32,900, and a size of 11,200 km$^2$. Study villages in Megino-Kangalassky were Khorobut (population 650), Maia (population 11,000), and Nizhny Bestakh (population 5,000). The district is primarily rural, with an economy based on cattle and horse herding. Milk production is a key economic activity in the district. This district was more developed commercially, with a higher population density than the Gorny district. There were several paved highways and a water pipeline project to deliver water to the city of Maia (population 11,500), the administrative center of the district.

Data collected by questionnaire and interview included basic sociodemographic and household economic characteristics, and detailed measures of diet, lifestyle, well-being, and health-related quality of life. For the substudy, data on diet and lifestyle were collected from 201 subjects, and data on lipids, blood pressure, and anthropometric characteristics were collected from 309 subjects. The analysis presented here is based on the 201 subjects for whom diet and lifestyle data were available. We explored the probability that missing diet and lifestyle data were associated with one or more independent measures or outcomes. There was an association with study location, with missing values significantly more likely for Dikimdye and Khorobut. We found no association with sex, age, or serum lipids. Subjects with missing data were leaner, with significantly lower body mass index (BMI) (22.8 vs. 25.2, $P < 0.001$) and biceps skinfolds (8.1 vs. 10.5, $P = 0.005$), but not percent body fat, or triceps, suprailiac, or subscapular skinfolds.

Informed consent was obtained upon study recruitment. This project was approved by the Office for the Protection of Human Subjects Institutional Review Board at Northwestern University, and by the Ministry of Health of the Republic of Sakha (Yakutia).

### *Protocol*

After an overnight fast, blood samples for analysis of plasma lipids were collected by venipuncture. Blood samples were separated in the field by centrifugation and frozen for storage and transport to the United States. Lipid fractions were analyzed at the Clinical Diagnostic Laboratory at the Northwestern University Feinberg School of Medicine. Lipid fractions (total, high-density lipoproteins (HDL), and triglycerides) were determined using standard enzymatic techniques with a Beckman-Coulter Synchron CX-7 clinical chemistry system. The laboratory is accredited by the College of American Pathologists. Low-density lipoprotein (LDL) fractions were estimated using the Freidewald equation: $LDL = TC - HDL - TG/5$. Desirable plasma lipid levels recommended by the National Cholesterol Education Program (NCEP) are values $<200$ mg/dl, $\geq 35$ mg/dl, and $<160$ mg/dl for TC, HDL , and LDL, respectively (National Institutes of Health, 1999).

### *Anthropometry*

Anthropometric measurements were taken using standard techniques (Lohman et al., 1988; Gibson, 1990). Stature was measured to the nearest 1 mm, using a GPM anthropometer (Seritex, Inc., East Rutherford, NJ). Weight was measured to the nearest 100 g, using an electronic scale (Tanita Corp., Tokyo, Japan). Skinfold measurements (triceps, biceps, subscapular, suprailiac, and periumbilical) were taken to the nearest 0.5 mm, using Lange calipers (Beta Technology, Inc., Santa Cruz, CA). Clothing and shoes were removed for these measurements. Derived indices include percent body fat, calculated using four skinfolds (triceps, biceps, subscapular, and suprailiac), and age- and sex-specific equations presented by Durnin and Womersely (1974) and BMI (kg/m$^2$). The sum of four skinfolds was computed as the algebraic sum of the triceps, biceps, subscapular, and suprailiac skinfolds.

### *Dietary intake*

Dietary intake was assessed using the Harvard Food Frequency questionnaire, a semiquantitative food frequency instrument consisting of 131 food items (Rimm et al., 1992). Serving sizes were indicated by the use of natural units (e.g., one apple, one glass of milk), or by the use of standard weight and volume measures and "typical" serving sizes determined from previous research (e.g., 4–6 ounces of meat) (Rimm et al., 1992).

Study participants were asked how often, on average, they had consumed each of the food items during the past year, using nine multiple-choice response categories, ranging from "never" to "six or more times per day." The completed questionnaires were sent to the Harvard School of Public Health for analysis. Nutrient values were calculated using the US Department of Agriculture database (cf. Adams, 1975; Rimm et al., 1992). Nutrient values for additional food items consumed by indigenous Yakut (e.g., horse meat) were determined using the World Health Organization Food Consumption Tables for Asia (Leung, 1972).

Patterns of diet intake were calculated from the food frequency questionnaire (FFQ), using principal components analysis of the 131 food items (PROC FACTOR, SAS Institute, 1999). The purpose of this analysis was to determine if there were patterns of consumption of specific foods that could be identified and, if so, to explore associations between the patterns and plasma lipids. The diet patterns are based on frequency of consumption of specific foods as opposed to estimated nutrient intake values, and account for the correlation structure of foods in the diet. There is increasing interest in the application of this technique in nutritional epidemiological research (Hu et al., 1999, 2000; Fung et al., 2001).

The criteria for extraction of diet factors were factor eigenvalues, the scree test, and interpretability of factors (Stevens, 1996; SAS Institute, 1999). The percent of variance explained was not used due to its dependence on the number of variables included in the analysis (Stevens, 1996). These criteria suggested a solution of three factors, with eigenvalues of 5.6, 3.1, and 2.7. A correlation of 0.30 or greater was used as the cutoff for interpreting a significant loading of a food item on a factor. Once a three-factor solution was decided upon, food items with a loading of between $-0.30$ and $+0.30$ were dropped, and the analysis was repeated with a forced solution of three factors. The factors were computed using the correlation matrix of the items, and rotated using varimax (orthogonal) rotation. Factor scores were estimated for each individual by computing the sum of the factor loadings weighted by the reported consumption value for each food item. The data were treated as ordinal, using the frequency categories for each food item as reported. To ensure that the inherent distance between response categories did not inflate or diminish the findings, a sensitivity analysis was conducted where the responses for each item were converted to a daily intake. For example, the response "2–4 times per week" was recoded to 0.43 ($3/7 = 0.43$). Foods not consumed in Yakutia (e.g., celery, lima beans, kale, or peanut butter) were excluded from the analysis, and food items consumed by the Yakut (e.g., horsemeat) were included.

The factor scores were recoded into quintile groups for some analyses. For others, the factor scores were analyzed as continuous variables. The analysis units used are noted where appropriate.

The diet pattern factors are presented in Table 1. Three orthogonal diet factors were extracted through the principal components analysis: a "market foods" factor, characterized by consumption (i.e., high factor loadings) of market products (e.g., market sources of fruits, including bananas and oranges, vegetables, market poultry, processed meats, and carbonated soft drinks), a "subsistence foods" factor, characterized by consumption of meat and dairy products from livestock (e.g., dairy products, fish, meats, and cereals), and a "mixed diet" factor, characterized by consumption of a mixture of subsistence food products and market sources of food (e.g, dairy products, vegetables, fish, and some meats). Because the diet patterns are based on the empirically determined correlation structure of frequency of consumption of specific foods, many food items load on more than one factor. For example, items that load high on the subsistence diet factor (e.g., milk, dairy products, and meat) may also be consumed by individuals consuming primarily a market foods diet.

### *Material lifestyle*

Material lifestyle was measured using a scale of 17 items related to "successful" material well-being (car, television, stereo, washing machine, bathhouse, motorcycle, video player, video camera, camera, cellar (*buluus*), barn, number of cows, number of horses, pigs, and chickens, tractor, and house). The item list was determined through interviews with key informants intended to capture a range of possessions ranging from items essential for subsistence to luxury/"modern" possessions that would distinguish the well-off. The importance of each item for a successful mate-

*TABLE 1. Rotated factor loadings for food frequency questionnaire*

| | Market diet | Mixed foods diet | Subsistence diet |
|---|---|---|---|
| *Dairy products* | | | |
| Milk | −0.13 | | 0.53 |
| Heavy cream | −0.19 | | 0.56 |
| Sour cream | −0.18 | 0.26 | 0.16 |
| Yogurt | 0.14 | −0.10 | 0.57 |
| Cottage cheese | 0.36 | | 0.27 |
| Other cheese | 0.61 | | |
| Margarine | 0.14 | −0.34 | |
| Butter | −0.16 | 0.30 | 0.24 |
| Mayonnaise | 0.58 | 0.14 | |
| *Fruits and fruit juice* | | | |
| Berries | | 0.53 | 0.15 |
| Banana | 0.61 | | |
| Apple | 0.66 | 0.13 | |
| Orange | 0.59 | | |
| Apple juice | 0.49 | −0.13 | 0.28 |
| Orange juice | 0.45 | | 0.13 |
| Other fruit juice | 0.43 | | 0.39 |
| *Vegetables* | | | |
| Tomato | 0.47 | 0.32 | |
| Cabbage | 0.35 | 0.13 | 0.36 |
| Carrots, raw | 0.39 | 0.36 | 0.12 |
| Carrots, cooked | 0.33 | | |
| Peas | 0.25 | 0.24 | −0.27 |
| Mixed vegetables | 0.11 | 0.18 | −0.29 |
| Zucchini | 0.19 | 0.38 | |
| Beets | 0.44 | 0.30 | 0.29 |
| Garlic | 0.15 | 0.16 | 0.19 |
| Fried potatoes | | 0.52 | |
| Boiled potatoes | −0.14 | 0.64 | −0.18 |
| *Meat and eggs* | | | |
| Eggs | 0.27 | 0.32 | |
| Chicken | 0.36 | −0.15 | 0.17 |
| Bacon, pork fat | | 0.20 | 0.50 |
| Sausages | 0.37 | | |
| Processed meats | 0.62 | 0.10 | |
| Beef | −0.15 | 0.51 | 0.22 |
| Stewed beef (canned) | | 0.24 | −0.21 |
| Horsemeat | | 0.39 | |
| Fish | 0.16 | 0.29 | 0.28 |
| *Grains and cereals* | | | |
| Cooked cereals/grains (kasha) | 0.12 | | 0.11 |
| White bread | | 0.10 | 0.21 |
| White rice | | 0.42 | |
| Pasta/noodles | −0.10 | 0.38 | |
| Whole grains | 0.29 | −0.15 | 0.37 |
| Pancakes | | −0.12 | 0.58 |
| Potato chips | 0.21 | −0.13 | −0.25 |
| Carbonated soft drinks | 0.40 | | |
| Coffee | 0.46 | | −0.15 |
| Tea | −0.31 | | 0.10 |
| *Sweets* | | | |
| Chocolate candy | 0.46 | | |
| Hard candy | 0.26 | | |
| Other candy | 0.21 | 0.23 | 0.20 |
| Cookies | 0.39 | | |

rial lifestyle was determined by asking subjects to assign a three-level rank that ranged from "nonessential" to "absolutely necessary" for each item. Analysis of the material lifestyle index was conducted using the consensus analysis routine in ANTHROPAC version 4.9 (Analytic Technologies, Natick, MA). The methodology and theoretical underpinnings of consensus analysis were described elsewhere

(Borgatti, 1996; Romney, 1999; Dressler and Bindon, 2000). Cronbach's coefficient alpha was computed to evaluate the internal consistency of the index. The answer key for each item was used to compute a lifestyle score by summing the number of culturally appropriate responses and dividing by the number of items in the dimension. The score for each individual ranges from 0–1, and is a measure of how closely an individual's ranking of the importance of items agrees with the underlying cultural model of which items are important for a successful material lifestyle. An important distinction in the approach employed in this paper is the use of individual subject *rankings* of the importance of items, as opposed to reported material possessions.

Two orthogonal dimensions of lifestyle emerged from the consensus analysis (Table 2). The first dimension was interpreted as a "modern" lifestyle characterized by a ranking of luxury items and consumer goods including stereo, camera, video camera, video player, and other items including automobile, motorcycle, and cellar. The second lifestyle dimension, referred to as a "subsistence" lifestyle, is characterized by a ranking of subsistence-related items including cows, horses, pigs, chickens, barn, tractor, cellar, and house. There were some items that loaded on both dimensions and were important to both lifestyle domains (e.g., automobile). This illustrates that some elements of lifestyle overlap in the Siberian context. The two dimensions have a moderate degree of internal consistency, as measured by Cronbach's alpha.

*TABLE 2. Material lifestyle scale*

| Lifestyle | Item total correlation |
|---|---|
| Modern | |
| Car | 0.34 |
| Television | 0.27 |
| Stereo | 0.49 |
| Washing machine | 0.34 |
| Video player | 0.50 |
| Video camera | 0.51 |
| Camera | 0.50 |
| Barn | 0.54 |
| Chickens | 0.20 |
| House | 0.31 |
| Alpha (standardized) | 0.74 |
| Subsistence (herding) | |
| Car | 0.28 |
| Bath house | 0.29 |
| Motorcycle | 0.41 |
| Cellar | 0.48 |
| Cows | 0.74 |
| Horses | 0.60 |
| Pigs | 0.53 |
| Chickens | 0.40 |
| Tractor | 0.64 |
| Alpha (standardized) | 0.79 |

### *Statistical analysis*

Statistical analyses were conducted using the SAS system (SAS Institute, Cary, NC). Bivariate associations were examined using Pearson correlation coefficients and *t*-tests. Potential confounding and effect modification of the associations between diet, lifestyle, and plasma lipids were evaluated by examining crude estimates of association and comparing these to stratified estimates (e.g., separate regressions for sex or age group), and by adjusting for potential confounders in the regression analyses. For example, in evaluating the association between diet pattern and plasma lipids, regressions were adjusted for age, sex, and adiposity.

Regression models were developed to examine relationships between age, sex, body composition, residence location, lifestyle, and diet pattern and plasma total and LDL cholesterol. To control for intercorrelations among individuals within households, a mixed-effects analysis of covariance model approach was used, with household and village as random effects (Littell et al., 1996; Brown and Prescott, 1999). Random effects were evaluated using the intraclass correlation coefficient, computed from the model covariance parameters and likelihood ratio tests. Separate models for cholesterol and LDL were estimated. The parameter estimates were similar using fixed-effects or mixed models, with larger standard errors and smaller significance levels in the models with random-effects terms included. Reported parameter estimates are based on the mixed models, as they provide slightly more conservative significance tests. Statistical tests for differences in least squares means, adjusted for age, sex, and percent body fat, between upper and lower quintiles of the diet pattern variables, were conducted.

The effect of lifestyle on plasma lipids was examined using both fixed (Proc GLM) and mixed-effects (Proc MIXED) regression models, as noted above. Age, sex, and percent body fat were included as covariates, and subsistence and modern lifestyle were included in the models, with total cholesterol and LDL as dependent variables. Subsistence and modern lifestyle were orthogonal measures, and their independent effects were evaluated by including each in the regression models. An indicator variable was included in the model to evaluate differences in the slope of lifestyle among older and younger subjects.

## RESULTS

Descriptive statistics for key dependent and independent measures are presented for males and females in rural and urban locations in Table 3. Males were significantly taller and heavier than females, and had significantly lower skinfolds and percent body fat. Plasma lipid levels were low among male and female Yakut of all ages relative to cutoffs recommended by the National Cholesterol Education Program (NCEP) (National Institutes of Health, 1999). Mean total cholesterol (TC) was 174 mg/dL for females and 170 mg/dL for males ($P = 0.392$). HDL levels were significantly higher for females than for males (48 vs. 44 mg/dL, $P = 0.005$). Triglyceride (TG) levels were 11 mg/dL lower for females (74 vs. 85, $P = 0.069$), but the difference was not significant at the 0.05 level. LDL levels were similar for females and males (112 vs. 109 mg/dL, $P = 0.706$).

### *Residence location*

Mean LDL was 17 mg/dL higher for rural relative to urban males ($P = 0.047$), TC was 19 mg/dL higher ($P = 0.049$), and TG was 22 mg/dL higher ($P = 0.066$) (Table 3). HDL was similar for rural and urban males. Compared to urban females, LDL was 11 mg/dL higher for rural females ($P = 0.075$), TC was 5 mg/dL higher, and TG was 4 mg/dL higher. HDL was 5 mg/dL lower for rural females ($P = 0.091$). These differences are suggestive of higher lipid levels and a great burden of cardiovascular risk in rural communities. Rural subjects were significantly older, and these age differences may account in part for the higher lipid values observed in rural communities.

### *Diet intake*

Descriptive statistics for intake of total calories, protein, carbohydrates, and total fats are presented for Yakut males and females in Table 3. Mean caloric intake was 2,344 kcal/day for females and 2,352 kcal/day for males. Carbohydrate intake was 311 g/day for females and 300 g/day for males. Protein intake ranged from 81 g per day for females to 88 g per day for males. Total fat intake was 87 g/day for females and 89 g/day for males. Percent of calories from protein, carbohydrates, and fats was similar for males and females.

Total fat intake was higher for rural residents, particularly for females.

Saturated fat intake (not shown in Table 3) was significantly higher for rural residents (37 g/day rural vs. 31 g/day urban, $P = 0.004$). Polyunsaturated fat intake (not shown in Table 3) was significantly higher for residents of urbanized towns (12 g/day rural vs. 14 g/day urban, $P = 0.023$). Sex-specific estimates of total calories, carbohydrates, and protein were similar for rural and urban residents. Saturated fat intake was significantly higher for rural compared to urban females (7 g/day higher, $P = 0.006$) but not males. Polyunsaturated fat intake was significantly lower for rural vs. urban males (3 g/day lower, $P = 0.013$).

Diet pattern and lifestyle variable scores are presented in Table 3. Market diet score was higher for females, but subsistence and mixed diet pattern scores were similar by sex. Market diet scores were highest for urban residents, and subsistence and mixed diet pattern scores were higher for rural residents. Rural females had higher mixed diet pattern scores than males. Modern lifestyle scores were similar for rural and urban communities, but subsistence lifestyle scores were significantly higher in rural communities.

The diet patterns were associated with estimated macronutrient intake. Means and standard errors for estimated macronutrient values by diet pattern grouped into quintiles are shown in Table 4. The subsistence diet pattern was associated with increased intake of protein and saturated fats. The market diet was associated with increased carbohydrates, protein, polyunsaturated fats, and total fat, but not saturated fat intake. The mixed diet was associated with increased intake of carbohydrates, protein, saturated and polyunsaturated fats, and total fats.

Means and SEs for age- and energy-adjusted plasma lipids by diet pattern quintile are shown in Table 5. TC and LDL were signifi-

*TABLE 3. Sample descriptive characteristics*[1]

| | Females (n = 128), mean (SD) | Males (n = 73), mean (SD) | Rural village | | Urbanized town | |
|---|---|---|---|---|---|---|
| | | | Females (n = 52), mean (SD) | Males (n = 21), mean (SD) | Females (n = 76), mean (SD) | Males (n = 52), mean (SD) |
| *Anthropometric measures* | | | | | | |
| Age | 44.5 (13.6) | 46.1 (15.3) | 49.0 (15.9)** | 54.4 (15.8)** | 42.9 (13.2) | 42.4 (14.6) |
| Height (cm) | 154.4 (6.7)*** | 164.4 (7.7) | 153.01 (7.5) | 163.1 (5.7) | 154.8 (6.8) | 165.3 (7.6) |
| Weight (kg) | 60.6 (14.3)*** | 68.6 (14.5) | 60.21 (14.2) | 71.0 (11.2) | 63.4 (15.0) | 69.0 (14.3) |
| Triceps (mm) | 24.1 (9.8)*** | 11.0 (6.1) | 24.9 (11.4) | 12.5 (5.7) | 25.9 (9.7) | 10.7 (6.0) |
| Waist circumference (cm) | 100.0 (10.9) | 99.0 (8.9) | 101.0 (10.9) | 10.0 (6.6) | 102 (10.9) | 99.0 (9.3) |
| Body mass index (kg/m$^2$) | 25.3 (5.4) | 25.4 (5.1) | 25.6 (5.7) | 26.6 (3.4) | 26.4 (5.5) | 25.3 (5.4) |
| Percent body fat (four skinfolds) | 36.9 (6.1)*** | 22.8 (7.1) | 37.1 (6.0) | 26.1 (6.5)* | 38.4 (5.8) | 22.4 (7.2) |
| *24-hr nutrient intake* | | | | | | |
| Calories (kcal) | 2,344.0 (774) | 2,352.0 (784) | 2,294.0 (642.0) | 2,400.0 (619.4) | 2,225.0 (604.8) | 2,381.0 (802.2) |
| Protein (g) | 81.0 (29.3)* | 88.0 (33.9) | 80.4 (25.2) | 89.4 (32.8) | 78.4 (24.7) | 89.8 (35.3) |
| Carbohydrates (g) | 311.0 (110.9) | 300.0 (109.3) | 297.7 (94.2) | 304.9 (96.1) | 296.7 (93.1) | 306.1 (107.5) |
| Total fat (g) | 86.7 (36.9) | 89.0 (38.5) | 87.3 (30.9) | 91.3 (29.6) | 81.3 (30.3) | 89.0 (42.0) |
| *Diet pattern and lifestyle* | | | | | | |
| Subsistence diet score | 0.20 (0.9) | 0.21 (0.9) | −0.20 (1.2)* | 0.28 (1.1) | 0.03 (0.8) | 0.10 (0.8) |
| Mixed diet score | −0.13 (0.9) | −0.22 (0.7) | 0.42 (1.2)** | 0.02 (1.0) | −0.24 (0.8) | −0.31 (0.7) |
| Market foods diet score | 0.14 (0.9) | 0.04 (1.0) | −0.42 (0.8)*** | −0.75 (0.8)*** | 0.53 (1.0) | 0.27 (1.0) |
| Subsistence (herding) lifestyle | 0.84 (0.2) | 0.80 (0.2) | 0.74 (0.2)*** | 0.74 (0.2)*** | 0.54 (0.2) | 0.54 (0.2) |
| Modern lifestyle | 0.62 (0.2) | 0.60 (0.2) | 0.81 (0.2) | 0.81 (0.2) | 0.86 (0.2) | 0.79 (0.2) |
| *Plasma lipids* | | | | | | |
| Total cholesterol (mg/dl) | 174.4 (34.3) | 169.5 (38.6) | 182.1 (34.3) | 184.4 (33.9)* | 176.6 (39.0) | 164.8 (38.9) |
| High-density lipoprotein (mg/dl) | 48.4 (13.9)** | 43.8 (14.1) | 47.1 (14.3) | 41.9 (11.9) | 51.9 (15.5) | 44.3 (13.4) |
| Triglycerides (mg/dl) | 73.8 (39.3) | 84.9 (42.4) | 75.9 (32.3) | 106.1 (52.1) | 80.1 (47.7) | 84.0 (39.2) |
| Low-density lipoprotein (mg/dl) | 111.5 (29.6) | 108.7 (32.7) | 119.7 (29.4) | 121.3 (30.1)* | 109.2 (31.6) | 103.7 (32.3) |

[1]Statistically significant difference, *t*-test for male-female difference in overall sample; within-sex *t*-tests by residence location.
*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

*TABLE 4. Mean (SD) estimated macronutrient intake by quintile of diet pattern*[1]

| *Subsistence diet* | *Q1: −1.5* | *Q3: 0.0* | *Q5: 1.4* | *P value* | *P value for trend* |
|---|---|---|---|---|---|
| Carbohydrates (g) | 294 (159) | 288 (83) | 337 (100) | 0.063 | 0.248 |
| Protein (g) | 79 (42) | 82 (28) | 99 (29) | 0.001 | 0.002 |
| Saturated fat (g) | 32 (20) | 33 (16) | 41 (13) | 0.008 | 0.005 |
| Polyunsaturated fat (g) | 12 (6) | 13 (6) | 13 (4) | 0.274 | 0.505 |
| Total fat (g) | 85 (48) | 87 (36) | 98 (29) | 0.096 | 0.232 |
| *Market diet* | *Q1: −1.3* | *Q3: −0.1* | *Q5: 1.5* | | |
| Carbohydrates (g) | 257.0 (110) | 332 (129) | 357 (102) | <0.001 | <0.001 |
| Protein (g) | 78 (40) | 90 (32) | 93 (29) | 0.017 | 0.040 |
| Saturated fat (g) | 30.3 (15) | 35 (17) | 38 (17) | 0.019 | 0.119 |
| Polyunsaturated fat (g) | 10.0 (4) | 13 (4) | 17 (7) | <0.001 | <0.001 |
| Total fat (g) | 75.0 (34) | 90 (38) | 104 (42) | 0.001 | 0.003 |
| *Mixed diet* | *Q1: −1.3* | *Q3: 0.0* | *Q5: 1.4* | | |
| Carbohydrates (g) | 234 (102) | 294 (68) | 378 (125) | <0.001 | <0.001 |
| Protein (g) | 56 (20) | 75 (26) | 112 (30) | <0.001 | <0.001 |
| Saturated fat (g) | 23 (10) | 28 (13) | 46 (18) | <0.001 | <0.001 |
| Polyunsaturated fat (g) | 11 (5) | 12 (4) | 14 (7) | 0.007 | 0.005 |
| Total fat (g) | 62 (27) | 75 (29) | 115 (44) | <0.001 | <0.001 |

[1]Mean diet pattern factor score for each quintile (1, 3, and 5) shown. *P* value is for difference in least squares means, upper vs. lower quintiles. Values shown are means and standard deviations.

*TABLE 5. Mean (SE) age- and energy-adjusted lipoprotein values by quintile of diet pattern*[1]

| *Subsistence diet* | *Q1: −1.5* | *Q3: 0.0* | *Q5: 1.4* | *P value* | *P value for trend* |
|---|---|---|---|---|---|
| Total cholesterol (mg/dl) | 167.3 (5.3) | 175.8 (5.2) | 179.3 (5.4) | 0.119 | 0.039 |
| High-density lipoprotein (mg/dl) | 46.9 (2.2) | 47.7 (2.2) | 44.7 (2.3) | 0.497 | 0.620 |
| Low-density lipoprotein (mg/dl) | 105.9 (4.5) | 111.7 (4.4) | 119.8 (4.6) | 0.034 | 0.020 |
| Triglycerides (mg/dl) | 72.9 (6.4) | 84.6 (6.2) | 76.4 (6.5) | 0.705 | 0.743 |
| *Market diet* | *Q1: −1.3* | *Q3: −0.1* | *Q5: 1.5* | | |
| Total cholesterol (mg/dl) | 171.8 (5.9) | 177.1 (5.3) | 166.8 (6.0) | 0.578 | 0.692 |
| High-density lipoprotein (mg/dl) | 48.4 (2.4) | 49.6 (2.2) | 46.0 (2.5) | 0.509 | 0.449 |
| Low-density lipoprotein (mg/dl) | 108.7 (5.0) | 112.3 (4.5) | 106.0 (5.1) | 0.721 | 0.728 |
| Triglycerides (mg/dl) | 73.8 (6.9) | 75.8 (6.2) | 76.8 (7.0) | 0.778 | 0.849 |
| *Mixed diet* | *Q1: −1.3* | *Q3: 0.0* | *Q5: 1.4* | | |
| Total cholesterol (mg/dl) | 161.8 (5.8) | 166.0 (5.3) | 179.3 (5.7) | 0.050 | 0.124 |
| High-density lipoprotein (mg/dl) | 45.2 (2.5) | 45.3 (2.2) | 48.1 (2.4) | 0.434 | 0.829 |
| Low-density lipoprotein (mg/dl) | 102.0 (5.0) | 104.6 (4.5) | 115.4 (4.9) | 0.078 | 0.149 |
| Triglycerides (mg/dl) | 74.7 (7.0) | 80.7 (6.4) | 78.0 (6.8) | 0.759 | 0.975 |

[1]Mean diet pattern factor score for each quintile (1, 3, and 5) shown. *P* value is for difference in least squares means, upper vs. lower quintiles. Q values shown are means and standard errors.

cantly higher for the subsistence diet pattern. The market and mixed diet patterns were not associated with lipid levels. TC and LDL were higher across quintiles of the subsistence diet pattern than the other diet patterns, but were also high for the mixed diet pattern.

The association between each diet pattern and plasma TC and LDL cholesterol was examined using regression models. Standardized regression coefficients for age, sex, percent body fat, residence location, and diet pattern are presented in Table 6. The standardized coefficients show the relative magnitude of each predictor variable on the dependent variable. The results are presented for analyses with cholesterol and LDL as dependent variables. Separate regressions were run for each diet pattern, with the covariates age, sex, residence location, and percent body fat. In these analyses,

*TABLE 6. Standardized regression coefficients for predictors of TC and LDL, with separate regressions run for each dependent variable and each diet factor*

| Variable | Low-density lipoprotein (LDL), estimate (SE) | Cholesterol (TC), estimate (SE) |
|---|---|---|
| Age | 0.24 (0.07)*** | 0.27 (0.07)*** |
| Sex | 0.22 (0.21)* | 0.13 (0.21) |
| Subsistence diet | 0.18 (0.07)** | 0.16 (0.07)* |
| Body fat | 0.39 (0.10)*** | 0.30 (0.09)*** |
| Age | 0.21 (0.08)** | 0.26 (0.08)*** |
| Sex | 0.27 (0.20)*** | 0.18 (0.20) |
| Market diet | −0.08 (0.07) | −0.09 (0.18) |
| Body fat | 0.44 (0.09)*** | 0.35 (0.01)*** |
| Age | 0.25 (0.07)*** | 0.28 (0.07)*** |
| Sex | 0.26 (0.20)*** | 0.17 (0.06) |
| Mixed diet | 0.01 (0.06) | 0.01 (0.06) |
| Body fat | 0.42 (0.09)*** | 0.33 (0.09)*** |

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

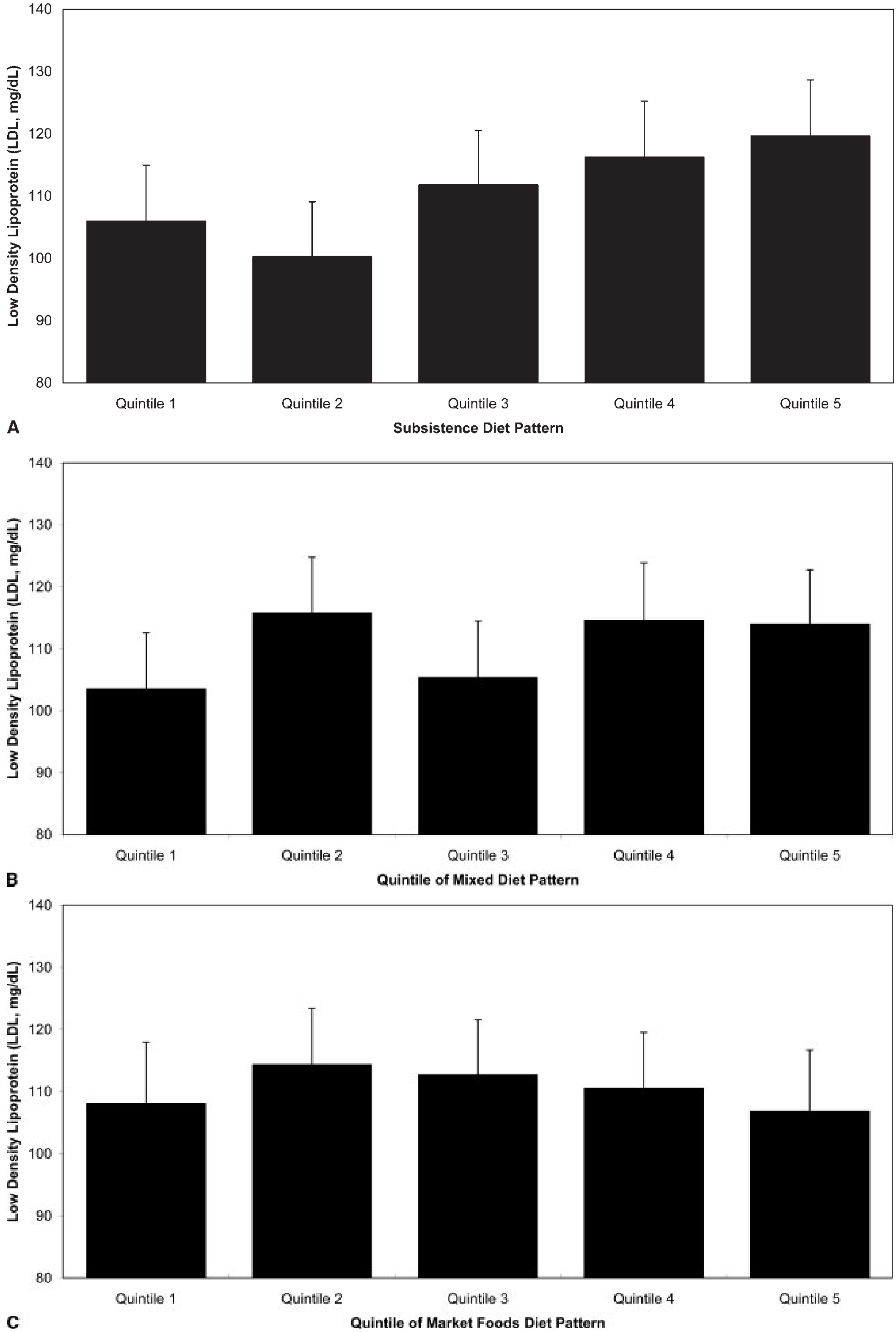
age, sex (higher in males), subsistence diet, and percent body fat were significant predictors of LDL, but not a market foods diet or mixed diet. Sex was not associated with TC in these models. The results illustrate the strong effect of adiposity on LDL and TC, independent of age and sex. The subsistence diet pattern had significant independent effects on both LDL and TC. This may be due to the fatty acid composition of foods in the diet patterns, with the subsistence diet high in saturated fats, contributing to higher plasma lipids, and the market foods and mixed diets higher in polyunsaturated fats.

Least squares estimated means (adjusted for age, sex, and percent body fat) for LDL by quintile of subsistence diet are presented in Figure 1a. There was a difference of 14 mg/dl in the estimated means between the upper and lower quintiles of subsistence diet pattern ($P = 0.027$), indicating that after adjusting for variation in LDL by age, sex, and body fatness, the upper quintile of subsistence diet was associated with significantly higher LDL levels, and hence greater cardiovascular risk. For the mixed diet pattern, a model was estimated with age, sex, and quintiles of mixed diet. In this model, the difference in LDL between upper and lower quintiles of the mixed diet pattern was not significant ($P = 0.100$, Fig. 1b). There was some suggestion of an increase in mean values across quintile (Q) groups, with adjusted mean LDL for Q1 and Q5 of 104 and 114 mg/dl, respectively. A separate model with LDL as the dependent variable and age, sex, and quintile of market foods diet pattern was estimated. There were no significant differences between the upper and lower quintiles of the market foods diet pattern (Fig. 1c). Mean LDL for Q1 was 108 mg/dl, and for Q5 it was 107 mg/dl. Both values are close to the mean LDL at the lowest quintile of the subsistence foods diet pattern (105.5 mg/dl).

### *Material lifestyle*

Material lifestyle was associated with diet patterns. Modern lifestyle was positively correlated with both the market ($r = 0.32$, $P < 0.001$) and mixed diet ($r = 0.17$, $P = 0.030$) patterns, but not with the subsistence diet pattern. Subsistence lifestyle was negatively associated with the market diet pattern ($r = -0.24$, $P = 0.002$), and positively associated with both the mixed diet ($r = 0.23$, $P = 0.004$) and subsistence diet ($r = 0.17$, $P = 0.029$) patterns. Dietary saturated fat intake was significantly associated with a subsis-

Fig. 1. **a**: Least squares mean LDL (± 2 SE), adjusted for age, sex, and percent body fat by quintile of subsistence diet pattern. **b**: Least squares mean LDL (± 2 SE), adjusted for age, sex, and percent body fat by quintile of mixed diet pattern. **c**: Least squares mean LDL (± 2 SE), adjusted for age, sex, and percent body fat by quintile of market diet pattern.


140
130
120
110
100
90
80
Low Density Lipoprotein (LDL, mg/dL)
Quintile 1
Quintile 2
Quintile 3
Quintile 4
Quintile 5
A
Subsistence Diet Pattern
140
130
120
110
100
90
80
Low Density Lipoprotein (LDL, mg/dL)
Quintile 1
Quintile 2
Quintile 3
Quintile 4
Quintile 5
B
Quintile of Mixed Diet Pattern
140
130
120
110
100
90
80
Low Density Lipoprotein (LDL, mg/dL)
Quintile 1
Quintile 2
Quintile 3
Quintile 4
Quintile 5
C
Quintile of Market Foods Diet Pattern

tence (r = 0.19, $P = 0.015$) but not modern (r = 0.10, $P = 0.107$) lifestyle.

The association between the mixed diet pattern and subsistence lifestyle was stronger than that seen between the subsistence diet pattern and subsistence lifestyle. This was unexpected, since few dairy products had significant loadings for the mixed diet factor, although there were significant loadings for a number of subsistence foods, including potatoes and meat from livestock, including horsemeat. In contrast, the subsistence diet factor had high loadings for *salo* (smoked pork fat) and for all dairy products. The primary difference between the mixed diet and subsistence diet factor was that for the mixed diet, there were more summer vegetables consumed, such as tomatoes, zucchini, and carrots, and fewer dairy products. These vegetables did not load on the subsistence diet factor. For the subsistence diet, the vegetables with significant loadings were cabbage and beets.

We estimated the effect of modern lifestyle on TC and LDL after adjusting for age and key covariates by fitting linear regression models. Standardized regression coefficients for modern lifestyle, adjusted for age, sex, and percent body fat, are shown in Table 7. Subsistence lifestyle was included as a covariate to ensure that the independent effect of modern lifestyle was captured, and was not variance due to a generalized "lifestyle" measure. We included an indicator variable to estimate the effect of modern lifestyle on TC above and below the median age (43 years). The coefficient for modern lifestyle was negative and significant, indicating lower lipid levels with increasing modern lifestyle score ($\beta = -0.27$ for TC and $-0.20$ for LDL). The interaction term indicates significantly higher lipid levels among older subjects. Figure 2 shows TC at the upper and lower quartiles of modern lifestyle for younger and older subjects at the mean of the covariates. At high modern lifestyle levels, TC was 20 mg/dl lower for both younger and older males and females. The effect of modern lifestyle on lipids was unchanged when market foods diet or mixed products diet variables were included in the analysis.

*TABLE 7a. Standardized regression coefficients for effects of lifestyle on plasma total cholesterol*

| | Estimate | SE | *t*-value | *P*-value |
|---|---|---|---|---|
| Age | 0.17 | 0.11 | 1.50 | 0.135 |
| Sex | 0.36 | 0.22 | 1.63 | 0.105 |
| Percent body fat | 0.33 | 0.11 | 3.03 | 0.003 |
| Subsistence lifestyle | 0.11 | 0.08 | 1.42 | 0.157 |
| Modern lifestyle | −0.27 | 0.10 | −2.58 | 0.011 |
| Modern lifestyle * age | 0.21 | 0.10 | 2.15 | 0.033 |

*$R^2 = 0.31$, estimated from fixed-effects model.

*TABLE 7b. Standardized regression coefficients for effects of lifestyle on plasma LDL*

| | Estimate | SE | *t*-value | *P* value |
|---|---|---|---|---|
| Age | 0.19 | 0.11 | 1.65 | 0.101 |
| Sex | 0.57 | 0.22 | 2.58 | 0.011 |
| Percent body fat | 0.42 | 0.11 | 3.83 | 0.000 |
| Subsistence lifestyle | 0.08 | 0.08 | 0.99 | 0.324 |
| Modern lifestyle | −0.20 | 0.10 | −1.91 | 0.057 |
| Modern lifestyle * age | 0.21 | 0.10 | 2.10 | 0.037 |

*$R^2 = 0.33$, estimated from fixed-effects model.

## DISCUSSION

We present an analysis of the effects of diet pattern and material lifestyle on plasma lipids among the indigenous Yakut. Mean lipoprotein values for males and females were below median values for the US population (NHANES III), and were below U.S. National Cholesterol Education Program (NCEP) cutpoints for hyperlipidemia. LDL and TC were higher for rural residents, with the largest urban-rural differences found for males. Saturated and total fat intakes were both significantly higher for rural residents, while polyunsaturated fat intake was higher for urban residents.

We found a significant positive association between a traditional subsistence diet, but not a market foods or mixed diet, and LDL and total cholesterol. LDL was significantly higher among individuals consuming a traditional diet. Subsistence lifestyle was not directly associated with lipid levels, but was associated with greater saturated fat intake and consumption of a traditional subsistence diet. These in turn were positively and significantly associated with plasma LDL and TC. In contrast, a modern lifestyle was associated with lower LDL and TC. This may be due to consumption of a market diet high in polyunsaturated fats with a modern lifestyle. A modern lifestyle was associated with higher adiposity, particularly in females, suggesting a positive energy balance.

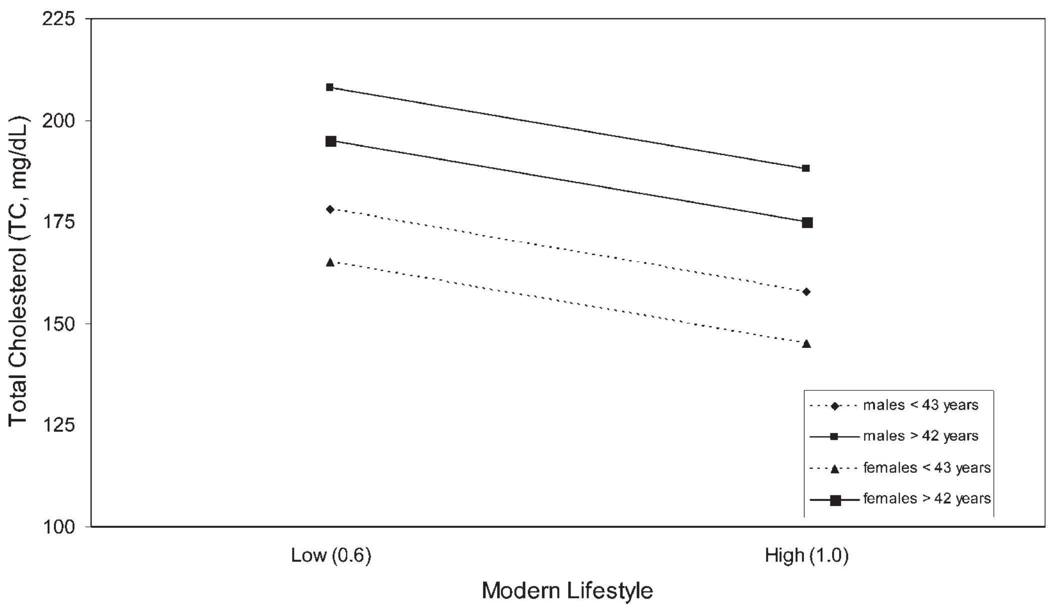



Fig. 2. Mean total cholesterol by modern lifestyle score adjusted for age, sex, percent body fat, and subsistence lifestyle score.

A number of studies among circumpolar groups documented an increase in serum lipids following the adoption of a modern lifestyle, characterized by wage employment, residence in urbanized locations, declines in physical activity, and changes in diet (Leonard et al., 1994, 2002c; Young et al., 1995; Rode and Shephard, 1995a,b; Shephard and Rode, 1996). Among North American circumpolar groups, the traditional sources of fats are a mixture of polyunsaturated and monounsaturated fatty acids. The consumption of cold-water fish (e.g., arctic char, salmon) results in high omega-3 fatty acids in the diet, producing an anti-atherogenic effect and lower levels of LDL and TC (Bang and Dyerberg, 1972; Connor and Connor, 1997). Among the Yakut, the consumption of saturated fats from meat and dairy products was higher among those pursuing a subsistence herding lifestyle and in rural villages.

A market diet included many imported foods such as soda pop, potato chips, and other snack foods, but also included many fruits, vegetables, and chicken. The latter foods have not been typically associated with a "modern" or market-based diet. This study suggests that lifestyle and market integration are useful concepts for investigating culture change and risks for CVD. Our findings suggest that individuals consuming a market diet use their cash income to purchase imported foods, whereas those consuming a subsistence diet have little integration into the market. A mixed diet was associated with consumption of market foods, but also with subsistence products.

Our ethnographic data indicate a variety of subsistence and dietary strategies among households. In some cases, a mixed diet was associated with mixed household subsistence strategies, including wage employment, cattle and horse herding, gathering of forest products, and hunting. In others, cash income from wages was used to purchase meat, milk, and forest products (e.g., berries, mushrooms) from households engaged almost exclusively in traditional subsistence (herding). Many traditional herding households earn cash from selling subsistence products in larger villages. Other traditional households are oriented away from a herding lifeway and subsistence diet, and toward the market.

The findings in this paper highlight the health consequences of the postsocialist transition among the Yakut. This process, whereby the Soviet political and economic system abruptly collapsed, has led to increased cardiovascular mortality. The rapid dissolution of the collective farm system magnified the health effects and has led to a return to a traditional herding lifeway for many Yakut. An important consideration of the herding lifestyle among the Yakut is that herding is today a reemerging lifestyle. Families have had less than a decade to accumulate livestock holdings. Based on the average numbers of cows and horses reported per household, this lifestyle is still rather marginal at best. In addition, the distribution of livestock holdings is uneven, with disparities introduced during the parceling out of resources of the collective farms.

## CONCLUSIONS

The rapid social and cultural changes introduced by the collapse of the Soviet Union have resulted in important differences in cardiovascular health among residents of Siberian communities. These changes have resulted in differences in lifestyle, diet, and subsistence behavior within and between communities. The breakup of the collective farm system and transition to a market economy has occurred unevenly, with rural communities becoming more isolated. Many Yakut have become reliant on traditional subsistence lifeways, characterized by herding of horses and cattle, hunting, and foraging in the boreal forest. Inhabitants of larger towns are increasingly oriented toward markets and engaged in a "modern" lifestyle of wage employment and consumption of market foods and consumer goods. Within communities, we found a high degree of variability in response to these social, economic, and cultural changes.

The diet-pattern approach is an emerging method based on consumption of food items as opposed to analysis of specific nutrients. This method allows for the investigation of intracultural variation in food choices, patterns of eating, and relationships with health and disease risk. The approach overcomes threats to validity associated with the use of a food database that is not developed on the foods consumed by the population under investigation, and has great potential for use in field settings. More work is needed to evaluate the validity of this approach and to refine the method for use in the field. Further research is also needed to develop culturally appropriate measures of lifestyle among Siberian groups.

In conclusion, the results of the lipid analysis indicate a greater risk among those consuming a traditional diet and in rural communities. LDL and TC were higher for rural communities and lower for urbanized towns. A modern lifestyle was associated with lower serum lipids but higher adiposity and thus a higher risk of obesity. These findings underscore the need for dietary modification and promotion of physical activity among those most at risk for CVD and obesity.

Additionally, these results differ from those commonly seen in "modernizing" populations, in that the elements of subsistence lifestyle are associated with an elevated rather than reduced risk of CVD. These variable responses to lifestyle change emphasize the need to better understand the distinct social and historical events that may influence health changes among populations in transition.

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## LITERATURE CITED

Adams CF. 1975. The nutritive value of American foods. Handbook no. 456. Washington, DC: US Department of Agriculture.

Argunov VA. 1996. Predvestniki i rannie stadii ateroskleroza v aorte i koronarnikh arteriakh u detei i lits molodova vozrasta korennogo naselenia Iakutii i ikh znachenie v progressirovanii ateroskelroza [Precursors and early stages of atherosclerosis in the aorta and coronary arteries in children and subadult indigenous Yakut and their significance for the progression of atherosclerosis]. Ph.D. dissertation, Russian State Medical University, Moscow, Russia.

Baker PT, Hanna JM, Baker TS, editors. 1986. The changing Samoans: behavior and health in transition. Oxford: Oxford University Press.

Bang HO, Dyerberg J. 1972. Plasma lipids and lipoproteins in Greenlandic west coast Eskimos. Acta Med Scand 192:85–94.

Berry JW. 1984. Acculturation and mental health among circumpolar peoples. In: Fortuine R, editor. Circumpolar health 1984. Proceedings of the Sixth International Symposium on Circumpolar Health. Seattle: University of Washington Press. p 305–312.

Borgatti SP. 1996. ANTHROPAC 4.0 methods guide. Natick, MA: Analytic Technologies.

Borisov EE, Tikhonov DG. 2001. O Reformirovanii sistemy zdravokhranenia v Respublike Sakha (Yakutia) [On the reform of the public health system in the Republic of Sakha (Yakutia)]. Zdrav Ross Fed 3:29–31.

Brown H, Prescott R. 1999. Applied mixed models in medicine. New York: John Wiley & Sons.

Chin-Hong PV, McGarvey ST. 1996. Lifestyle incongruity and adult blood pressure in western Samoa. Psychosom Med 58:130–137.

Connor WE, Connor SL. 1997. Omega-3 fatty acids from fish: primary and secondary prevention of cardiovascular disease. In: Bendich A, Deckelbaum RJ, editors. Preventive nutrition: a comprehensive guide for health professionals. Totowa, NJ: Humana Press, Inc. p 225–244.

Crate SA. 2003. Viliui Sakha post-Soviet adaptation: a subarctic test of Netting's smallholder-householder theory. Hum Ecol 31:499–528.

Dressler WW, Bindon JR. 1997. Social status, social context, and arterial blood pressure. Am J Phys Anthropol 102:55–66.

Dressler WW, Bindon JR. 2000. The health consequences of cultural consonance: cultural dimensions of lifestyle, social support, and arterial blood pressure in an African American community. Am Anthropol 102:244–260.

Durnin JV, Womersley J. 1974. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr 32:77–97.

Fung TT, Rimm EB, Spiegelman D, Rifai N, Tofler GH, Willett WC, Hu FB. 2001. Association between dietary patterns and plasma biomarkers of obesity and cardiovascular disease risk. Am J Clin Nutr 73:61–67.

Gibson R. 1990. Principles of nutritional assessment. New York: Oxford University Press.

Hu FB, Rimm E, Smith-Warner SA, Feskanich D, Stampfer MJ, Ascherio A, Sampson L, Willett WC. 1999. Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. Am J Clin Nutr 69:243–249.

Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D, Willett WC. 2000. Prospective study of major dietary patterns and risk of coronary heart disease in men. Am J Clin Nutr 72:912–921.

Klimova TM. 2001. Dinamika rasprostranennosti arterialnoi gipertonii i ee sviaz s fakitorami riska sredi muzhskogo naseleniia g. Iakutska za period c 1984–1986 po 1998–2000 gody [Dynamics of the distribution of hypertension and its relation to risk factors among the male population of Iakutsk from 1984–1986 to 1998–2000. Ph.D. dissertation, Novosibirsk State Medical Academy, Novosibirsk, Russia.

Leonard WR, Crawford MH, Comuzzie AG, Sukernik R. 1994. Correlates of low serum lipid levels among the Evenki herders of central Siberia. Am J Hum Biol 6:329–338.

Leonard WR, Katzmarzyk PT, Crawford MH. 1996. Energetics and population ecology of Siberian herders. Am J Hum Biol 8:275–289.

Leonard WR, Galloway VA, Ivakine E, Osipova L, Kazakovtseva M. 2002a. Ecology, health and lifestyle change among the Evenki herders of Siberia. In: Leonard WR, Crawford MH, editors. Human biology of pastoral populations. Cambridge: Cambridge University Press. p 206–235.

Leonard WR, Spencer GJ, Galloway VA, Osipova L. 2002b. Declining growth status of indigenous Siberian children in post-Soviet Russia. Hum Biol 74:197–209.

Leonard WR, Sorensen MV, Galloway VA, Spencer GJ, Mosher MJ, Osipova, L, Spitsyn VA. 2002c. Climatic influences on basal metabolic rates among circumpolar populations. Am J Hum Biol 14:609–620

Leung W-TW. 1972. Food composition table for use in East Asia. A research project sponsored by National Institute of Arthritis, Metabolism, and Digestive Diseases, and Nutrition Program, and Food and Agriculture Organization of the United Nations, Food Policy and Nutrition Division. DHEW publication no. (NIH) 73–465. Bethesda: National Institutes of Health.

Lisenko VP, Richards B. 1994. Substance abuse problems in the Magadan region of the Russian Far East. Alaska Med 36:168–172.

Littell RC, Milliken GA, Stroup WW, Wolfinger RD. 1996. The SAS system for mixed models. Cary, NC: SAS Institute, Inc.

Lohman TG, Roche AF, Martorell R. 1988. Anthropometric standardization reference manual. Abridged edition. Windsor, Ontario: Human Kinetics Publishers.

Mamleeva FR, Efendieva JB, Nikitin YP. 1998. Dietary fat and disease patterns in Chukotka native adults. Int J Circumpolar Health [Suppl] 57:325–328.

McGarvey ST, Shendel DE. 1986. Blood pressure of Samoans. In: Baker PT, Hanna JM, Baker TS, editors. The changing Samoans: behavior and health in transition. Oxford: Oxford University Press. p 327–349.

McGarvey ST, Bindon JR, Crews DE, Schendel DE. 1989. Modernization and adiposity: causes and consequences. In: Little MA, Haas JD, editors. Human population biology: a transdisciplinary science. New York: Oxford University Press. p 263–279.

Ministry of Health of the Republic of Sakha. 2000. Osnovnie pokazateli po seti, kadram, deyatelnosti Uchrezhdenia Zdravokhranenie Respubliki Sakha (Iakutia) za 1997–1999 [Primary indicators by network, cadre, of the activities of the institution of public health of the Republic of Sakha (Yakutia) from 1997–1999]. Yakutsk: Ministry of Health Republic of Sakha.

Mironova GE, Krivoshapkina ZN, Olesova LD. 2001. Nekotorye parametery pischevogo statusa korennogo naselenia krajnego severa [Several parameters of the nutritional status of the indigenous population of Far North]. Vopr Pitan 70:3–6.

National Institutes of Health. 1999. National Cholesterol Education Program (NCEP). Second report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. National Heart Lung and Blood Institute, National Institutes of Health publication no. 93–3095. Bethesda, MD: National Institutes of Health.

Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB, Willett WC. 1992. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. Am J Epidemiol 135:1114–1126.

Rode A, Shephard RJ. 1995a. Modernization of lifestyle, body fat content, and body fat distribution: a comparison of Igloolik Inuit and Volochanka nGanasan. Int J Obes 19:709–716.

Rode A, Shephard RJ. 1995b. A comparison of physical fitness between the Igloolik Inuit and the Volochanka n Ganasan. Am J Hum Biol 7:623–630.

Rode A, Shephard RJ, Vloshinsky PE, Kuksis A. 1995. Plasma fatty acid profiles of Igloolik Inuit and Siberian nGanasan. Arctic Med Res 54:10–20.

Romney AK. 1999. Cultural consensus as a statistical model. Curr Anthropol 40:103–115.

Sampath HM. 1974. Acculturation and mental health among circumpolar peoples. In: Fortuine R, editor.

Circumpolar health 1984. Proceedings of the Sixth International Symposium on Circumpolar Health. Seattle: University of Washington Press. p 379–389.

SAS Institute, Inc. 1999. SAS software release 8.2. Cary, NC: SAS Institute, Inc.

Shadrin FE. 1995. O sostoyanii zdorovya malochislenikh narodov iakutii. In: Nikolaev NI, editor. Russian Academy of Sciences, 70-Letie Ekspeditsii AN SSSR v Iakutskoi ASSR I Malochislennye Narody Severa (Materiali po Nauchno-Prakticheskoi Konferentsii) [On the health status of the minority populations of Yakutia]. Yakutsk: Izdatelstvo Severoved. p 59–60.

Shephard RJ, Rode A. 1996. The health consequences of modernization: evidence from circumpolar peoples. Cambridge: Cambridge University Press.

Sorensen MV. 2003. Social and biological determinants of cardiovascular risk among rural and urban Yakut: the impact of socioeconomic upheaval. Ph.D. dissertation, Northwestern University, Evanston, IL.

Sorensen MV, Spitsyn VA, Tarskaya LA. 2000. Health effects of political and economic transition on indigenous Siberian populations. Am J Hum Biol 12:269.

Stevens J. 1996. Applied multivariate statistics for the social sciences. 3rd ed. Mahwah, NJ: Lawrence Erlbaum.

Tokarev SA. 1940. Ocherki istorii Iakutskogo Naroda. Moscow: Gosudarstvennoye Sotsialno-Ekonomicheskoye Izdatelstvo.

Tokarev SA, Gurvich IS. 1956. The Yakuts. In: Levin MG, Potapov LP, editors. Peoples of Siberia. Chicago: University of Chicago Press. p 243–304.

Tsukanov VV, Tonkikh IL, Bronnikova EP, Manchuk VT. 1999. Mekhanizm normolipidemii u severnikh narodnostei [The mechanism of normolipidemia among northern populations]. Klin Med (Mosk) 2:38–39.

Young TK, Nikitin YP, Shubnikov EV, Astakhova TI, Moffatt MK, O'Neil JD. 1995. Plasma lipids in two indigenous Arctic populations with low risk for cardiovascular diseases. Am J Hum Biol 7:223–236.