

The Emergence of Obesity among Indigenous Siberians

J. Josh Snodgrass^{1),2)}, William R. Leonard²⁾, Mark V. Sorensen³⁾, Larissa A. Tarskaia⁴⁾,
Vasili P. Alekseev⁵⁾ and Vadim Krivoschapkin⁵⁾

1) *Institute for Mind and Biology, The University of Chicago, USA*

2) *Department of Anthropology, Northwestern University, USA*

3) *Department of Anthropology, University of North Carolina-Chapel Hill, USA*

4) *Institute of Molecular Genetics, Russian Academy of Sciences, Russia*

5) *Institute of Health, Academy of Sciences of the Republic of Sakha/Yakutia, Russia*

Abstract Once considered a disease of affluence and confined to industrialized nations, obesity is currently emerging as a major health concern in nearly every country in the world. Available data suggest that the prevalence rate of obesity has reached unprecedented levels in most developing countries, and is increasing at a rate that far outpaces that of developed nations. This increase in obesity has also been documented among North American circumpolar populations and is associated with lifestyle changes related to economic development. While obesity has not been well studied among indigenous Siberians, recent anthropological studies indicate that obesity and its associated comorbidities are important health problems.

The present study examines recent adult body composition data from four indigenous Siberian populations (Evenki, Ket, Buriat, and Yakut) with two main objectives: 1) to determine the prevalence of overweight and obesity among these groups, and 2) to assess the influence of lifestyle and socioeconomic factors on the development of excess body fat. The results of this study indicate that obesity has emerged as an important health issue among indigenous Siberians, and especially for women, whose obesity rates are considerably higher than those of men (12% vs. 7%). The present study investigated the association between lifestyle and body composition among the Yakut, and documented substantial sex differences in lifestyle correlates of obesity. Yakut men with higher incomes and who owned more luxury consumer goods were more likely to have excess body fat while, among Yakut women, affluence was not strongly associated with overweight and obesity. *J Physiol Anthropol* 25(1): 75–84, 2006 <http://www.jstage.jst.go.jp/browse/jpa2>

[DOI: 10.2114/jpa2.25.75]

Keywords: obesity, body composition, economic development, circumpolar, Russia

Introduction

The World Health Organization (WHO, 2000) recently recognized obesity as a global epidemic, reflecting the widespread distribution of the condition, its status as a disease with metabolic and endocrine abnormalities, and its well-established association with a variety of negative health outcomes. According to the WHO (2000, 2002), at least one billion adults are considered overweight, and 300 million are obese worldwide. Most developed nations have seen a dramatic increase in body fatness and a rising prevalence rate of obesity over the past few decades. In the United States, for example, the prevalence of obesity among adults has increased over the last 25 years from 13% to 31% and, overall, 65% of the population is now classified as either overweight or obese (Flegal et al., 2002). In much of Europe, obesity has also increased rapidly in recent decades; the current prevalence rate varies by location from 10 to 20% in men and 15 to 25% in women, with annual growth rates of approximately 25% (Seidell and Rissanen, 1998; Popkin, 2003).

Once considered a disease of affluence and confined to industrialized nations, obesity is emerging as a major health concern in nearly every country in the world; in many nations, obesity was virtually absent only a generation ago (Popkin and Doak, 1998; WHO, 2000; Martorell, 2002). It is, however, impossible to fully describe global patterns and trends in obesity since nationally representative data are unavailable in most developing countries, and many estimates of obesity are based on small population samples (WHO, 2000).

Available data suggest that the prevalence rate of obesity has reached unprecedented levels in most developing countries; in much of Asia, North Africa, and Latin America, obesity is continuing to increase at a rate that far outpaces that of developed nations (Popkin, 2003; WHO/FAO, 2003). In much of the developing world, the prevalence of obesity has increased twofold to threefold within the last decade. The most

rapid increases are currently occurring in countries experiencing rapid economic development, including parts of Latin America and Asia (Seidell and Rissanen, 1998; Visscher and Seidell, 2001). China, for example, with its population of well over one billion, has shown a rapid increase in overweight and obesity in less than a decade; the incidence of overweight or obesity increased by 100% in men and 50% in women between 1989 and 1997 (Popkin, 2002).

Despite the emergence of obesity in developing nations, many still focus public health policies on undernutrition and are not geared for the prevention of obesity (WHO/FAO, 2003). In fact, many developing nations have what has been called a “double burden of disease,” with the coexistence of obesity and undernutrition (e.g., protein-energy malnutrition); this problem is especially serious in Asia, Latin America, and sub-Saharan Africa (Popkin and Doak, 1998; WHO, 2000; WHO/FAO, 2003).

A recent secular increase in adiposity and an elevated prevalence of overweight and obesity have been documented in circumpolar populations in North America and are associated with lifestyle changes related to economic modernization. The most extensive studies of this phenomenon were conducted with the Igloodik Inuit from the Northwest Territories of Canada (e.g., Shephard and Rode, 1996). When initially examined in the late 1960s, the Inuit had fairly low levels of obesity. Over the following two decades, the population transitioned away from a traditional hunting-based subsistence economy and experienced massive lifestyle change (Shephard and Rode, 1996). Coincident with these lifestyle changes, body fatness increased, aerobic capacity and muscular strength declined, and the population experienced a rise in chronic disease mortality. Other circumpolar populations from North America have shown similar increases in adiposity and rates of obesity with economic development (e.g., Kuhnlein et al., 2004).

Overweight and obesity has been less well studied among native Siberians. This stems, in part, from the fact that nationally representative Russian health data have not been disaggregated by ethnicity. However, some recent anthropological studies (e.g., Rode and Shephard, 1995; Leonard et al., 2002; Sorensen, 2003) have presented body composition data for indigenous Siberians and indicate that obesity and its associated comorbidities are important health problems among the native population of Russia.

In the current study, we investigate body composition among indigenous Siberians with a focus on two main issues. First, we analyze data on body composition among four indigenous Siberian populations (Evenki, Ket, Buriat, and Yakut) and examine prevalence of overweight and obesity. Second, we assess the influence of lifestyle factors on the development of excess body fat among the Yakut using extensive information on socioeconomic variables, participation in subsistence activities, diet, and material style of life.

Materials and Methods

Study populations

Our understanding of the emergence of overweight and obesity among indigenous Siberians is complicated by transformations in the lifeways of indigenous Siberians experienced during the Soviet era, as well as by recent political, economic, and social changes following the collapse of the Soviet Union. The application of a centrally planned socialist system during the Soviet period introduced native Siberians to profound social and cultural transformations; these included forced relocation and sedentization into large, permanent villages, forced abandonment of traditional cultural practices, and a shift to a wage and welfare economy (Forsyth, 1992; Slezkine, 1994). At the end of the Soviet period, however, many of the promises of modernization were unfulfilled; much of rural Siberia remained isolated from urban centers, and most homes had poor heating, limited electricity, and no running water (Slezkine, 1994; Pika, 1999).

As a result of the collapse of the Soviet Union in 1991, many rural Siberians were forced to return to traditional subsistence practices to meet needs no longer met by the government (Fondahl, 1997; Jordan and Jordan-Bychkov, 2001; Leonard et al., 2002). In the years since, a heterogeneity of lifestyles has emerged among indigenous Siberians; this diversity exists within individual communities and even within families. Some individuals continue to rely on subsistence activities, while others now earn government or private sector wages and are minimally involved in subsistence activities; most, however, combine elements of the traditional and market economies. The following section provides a brief background on each of the four indigenous populations examined in this study.

The Evenki are a Tungusic-speaking population of reindeer herders from the northern Siberian boreal forest (Forsyth, 1992). At the time of Soviet collectivization, the Evenki were highly nomadic and occupied an enormous geographic area that stretched across northern Siberia. They subsisted by herding reindeer and fishing, and additionally hunted and trapped for commercial purposes (i.e., to trade furs for manufactured goods) (Forsyth, 1992). At the last major census (1989), the total Evenki population numbered approximately 30,000 (Fondahl, 1997). Additional information on the study population, as well as on the Evenki in general, can be found in Leonard and coworkers (1994, 1996, 2002) and references therein.

The Ket are a central Siberian population whose lifeways were traditionally structured around fishing. They are extremely small in number, and in the 1989 census numbered less than 1200 (Fondahl, 1997). The Ket are apparently a remnant of a considerably larger population, which was centered in the Yenisey Valley at the time of initial Russian contact, but which was subsequently decimated by epidemics of infectious disease (Forsyth, 1992). The Ket language is unique and, based on available evidence, appears unrelated to

any known language. Today, most Ket survive primarily by subsistence fishing, which they supplement by hunting and trapping.

The Buriat are descendants of Mongol populations that settled in the meadow-steppe region around Lake Baikal at the boundary of the northern forest (Forsyth, 1992). The Buriat language belongs to the Mongolic language family. At the time of initial Russian contact, the Buriat population was relatively large and increased substantially during the Russian and Soviet periods; at the last census, the Buriat population numbered over 400,000 (Fondahl, 1997; Forsyth, 1992). Today, most rural Buriat subsist off the products of cattle, which are fed through locally cultivated crops; in addition, local agricultural products and market foods are part of the diet (Humphrey and Sneath, 1999).

The Yakut (Sakha), members of the Turkic language family, number nearly 400,000 and are concentrated in northeastern Siberia (Forsyth, 1992; Balzer and Vinokurova, 1996; Jordan and Jordan-Bychkov, 2001). The Yakut traditionally practiced a complex and locally variable subsistence strategy that was largely dependent upon regional ecological conditions (Tokarev and Gurvich, 1964). In remote parts of the boreal forest, Yakut subsisted by hunting and fishing, while in the Lena River Valley the primary subsistence activity was transhumant pastoralism (primarily horse and cattle). Today, most rural Yakut populations rely on a mixture of subsistence activities (e.g., horse and cattle herding, fishing, gathering, hunting, and horticulture), government wages and pensions, private-sector salaries, and profits from “cottage” industries (Crate, 2001; Jordan and Jordan-Bychkov, 2001).

Participants

Evenki data were collected in the Tunguska region of central Siberia (63°N, 97°E) (Fig. 1) during research in 1991, 1992, and 1995. All measurements were taken on individuals living

in Baykit (pop. 6000), Poligus (pop. 500), Surinda (pop. 600), and in local reindeer herding brigades. Three hundred twenty-two adults (148 males and 174 females), who ranged in age from 18 to 81 years old, participated in the study.

Ket data were obtained in the Tunguska region of central Siberia during 1991 and 1992 (Fig. 1). Measurements were collected on individuals living in Sulamai (pop. 1100), a permanent fishing village located along the Stony Tunguska River in the Evenki Autonomous Territory (63°N, 97°E). Anthropometric data were available for 33 Ket adults (19 females, 14 males), who ranged in age from 19 to 63 years old.

Buriat data were collected in 1998 in the southern Siberian village of Gakhani (pop. 1000), located approximately 200 km northeast of Irkutsk in the western Lake Baikal region (53°N, 104°E) (Fig. 1). Data were available for 131 Buriat adults (80 females, 51 males), who ranged in age from 18 to 74 years old.

Yakut data were obtained from individuals living in the Sakha Republic of northeastern Siberia (62°N, 130°E) during research in 2001 and 2003 (Fig. 1). Measurements were collected in the communities of Asyma (pop. 800), Berdygestiakh (pop. 4900), Dikyimdye (pop. 600), Khorobut (pop. 800), Maia (pop. 6000), and Nizhny-Bestiakh (pop. 4000) (Safronov, 2000). Data were available for 414 Yakut adults (264 females, 150 males), who ranged in age from 18 to 88 years old.

All data were collected based on a series of cross-sectional studies. Participants were volunteers recruited from local communities, with the exception of the Yakut sample from 2001. That study, which included adults from randomly selected villages and households, was part of a regional health survey; additional information can be found in Sorensen (2003). The non-random nature of the data collected in the current study, as well as the extended temporal period covered, presents limitations to documenting overall population level prevalence of overweight and obesity. However, the current



Fig. 1 Map of the Russian Federation showing locations of the study populations and field research sites.

study provides the best estimate of the extent of overweight and obesity among indigenous Siberians.

Anthropometry

Anthropometric dimensions were recorded for all participants according to standard procedures (Lohman et al., 1988). Stature was recorded to the nearest 1.0 mm using a field stadiometer (Seca Corporation, Hanover, MD) or field anthropometer (GPM101; Seritex, East Rutherford, NJ), depending on field season. Body weight was measured to the nearest 0.1 kg using either a Tanita TBF-511 electronic scale or a Tanita BF-558 electronic scale (Tanita Corporation, Tokyo, Japan), depending on field season. Participants were weighed in light clothing and a correction of 0.5 kg was made to account for the weight of this clothing.

Body composition was assessed using two derived measures: body mass index (BMI) and percent body fat (BF). BMI was calculated by dividing mass by height in meters squared (kg/m^2). Standard BMI categories for adults (WHO, 2000) were used to classify individuals as normal or underweight (<25.0), overweight (25.0–29.9), or obese (30.0 and above). BF was calculated using the sum of four skinfolds (triceps, biceps, subscapular, and suprailiac) measured to the nearest 0.5 mm with Lange skinfold calipers (Beta Technology, Santa Cruz, CA); all skinfold measurements were taken without clothing. Skinfold measurements were repeated three times; the average of the measurements was used in all analyses. BF was calculated according to the sex- and age-specific equations of Durnin and Womersely (1974). Although these predictive equations were derived from lower latitude study populations, Rode and Shephard (1994) documented only minor differences (approximately 1 to 3%) in Inuit men when compared to hydrostatic weighing.

Lifestyle

Lifestyle correlates of excess body fat were assessed in a sub-sample of 149 Yakut individuals (60 males, 89 females) based on data collected in 2003. Each participant was administered an extensive survey of socioeconomic status (i.e., monthly income, occupation, and education) and lifestyle. Lifestyle questions were focused on participation in subsistence activities and ownership of various consumer goods (e.g., car, television, etc.) and livestock. Participants were queried about their involvement in subsistence activities (i.e., tending domesticated animals, hay cutting, fishing, hunting, gathering, and horticulture) and asked to estimate the number of days per year that they engaged in each activity. In addition, a self-reported estimate of the amount of food consumed (as a percent) (i.e., market foods [MF]) that was purchased from a store was recorded. In addition, participants reported the number of hours of television viewing that they engaged in per week. Finally, participants were queried about current smoking patterns and the variable was coded as “smoker” or “non-smoker,” irrespective of consumption pattern or duration of smoking pattern. Factor analysis was

used to explore the role and patterns of covariance of lifestyle variables with anthropometric dimensions (see below).

Statistical Analysis

Pearson’s correlations were used to assess the relationships between measures of body composition and lifestyle variables. Partial correlation was used to control for the effects of various parameters (i.e., age and smoking status) when considering correlations between body composition and lifestyle variables. Student’s *t*-tests were used to assess differences between males and females for anthropometric variables. One-way ANOVAs were used to assess the influence of age on body composition measures. Age and smoking status were examined in order to assess potential confounding effects on lifestyle.

Factor analysis (FA) was used for data reduction and to assess the relationship between lifestyle variables and body composition. FA was performed with sexes combined and with a total of 30 variables. FA was performed by means of principal components analysis using Promax non-orthogonal rotation with Kaiser normalization, and all factor scores were saved by means of the regression method. FA identified six factors with eigenvalues over 1.5; the factor analysis significantly differed from identity ($p < 0.001$) and KMO was acceptable at 0.632. Factor loading scores at or above 0.3 were considered acceptable and those at or above 0.5 were given special consideration.

Factor analysis identified six main factors based on socioeconomic and lifestyle data. Factor 1 has an eigenvalue of 3.9 and explains 13.0% of the observed variance. This factor is related to cattle herding lifestyle since it loads heavily on certain subsistence variables, such as cow ownership, animal tending, hay cutting participation, tractor ownership, and negatively with MF. Interestingly, this factor is positively associated with television viewing hours. Factor 2 has an eigenvalue of 2.8 and explains 9.2% of observed variance. This factor is defined by dispersed resource subsistence activities, as it loads on hunting and fishing participation, as well as hay cutting. Factor 3 has an eigenvalue of 1.9 and explains 6.5% of the variance. This factor is related to ownership of luxury consumer goods, since it is defined by videocamera, computer, and stereo ownership. Factor 4 has an eigenvalue of 1.7 and explains 5.6% of the variance. This factor is defined by horse-related subsistence activities and loads on horse ownership, animal tending, as well as car and tractor ownership. Factor 5 has an eigenvalue of 1.6 and explains 5.4% of the variance. This factor is related to affluence since it loads on income, as well as possession of a telephone, car, and camera. Interestingly, television hours load negatively on this factor. Finally, Factor 6 has an eigenvalue of 1.6 and explains 5.2% of the variation. This factor is related to high socioeconomic status, as it is associated with income, education, and ownership of certain luxury consumer goods (i.e., videoplayer and videocamera).

Comparisons were considered statistically significant at $p < 0.05$. All statistical analyses were performed using

SPSS 10.0.

Results

Descriptive statistics for age and anthropometric dimensions for the pooled sample of all four indigenous Siberian populations are presented in Table 1. Data were available for a total of 900 individuals, including 537 females and 363 males; participants ranged in age from 18 to 88, with a mean age of 37.7 (± 14.5) years. There were no significant differences in age between females and males (38.1 ± 14.5 vs. 37.4 ± 14.4 years; n.s.). Among females, 12.1% of individuals were classified as obese, 24.2% as overweight, and 63.7% as of normal body weight or underweight. Among males, 6.6% of individuals were classified as obese, 18.2% as overweight, and 75.2% as of normal body weight or underweight.

The relationship between age and body composition was investigated in the combined sample of indigenous Siberians. Among males, age was positively correlated with BMI ($r=0.323$; $p<0.001$) and BF ($r=0.460$; $p<0.001$), but not with body mass ($r=0.056$; $p=0.286$). Similar trends were observed among females; age was positively correlated with BMI ($r=0.277$; $p<0.001$) and BF ($r=0.450$; $p<0.001$), and was additionally correlated with body mass ($r=0.129$; $p=0.003$). Sex-specific age categories are presented in Table 2.

Descriptive statistics for age and anthropometric data for the sub-sample of Yakut individuals from the 2003 study are presented in Table 3. Participants ranged in age from 18 to 58 years old; there were no significant differences in age between females and males (32.5 ± 11.3 vs. 31.0 ± 11.0 years; n.s.). Among females, 15.7% of individuals were classified according to WHO (2000) categories as obese, 15.7% as overweight, and 68.5% as of normal body weight or underweight. Among males, 8.3% of individuals were classified as obese, 13.3% as overweight, and 78.3% as of normal body weight or underweight.

Among Yakut males, Factor 3 was positively associated with body mass ($r=0.281$; $p<0.05$), while Factor 4 was positively correlated with body mass ($r=0.273$; $p<0.05$) and BF ($r=0.283$; $p<0.05$). Factor 5 was positively associated with all

three of the body composition variables (body mass [$r=0.366$; $p<0.01$], BMI [$r=0.366$; $p<0.01$], and BF [$r=0.339$; $p=0.01$]). Factor 6 was positively associated with BMI ($r=0.273$; $p<0.05$). The other factors were not significantly associated with any of the body composition measures. Among Yakut males, monthly income was positively correlated with all of the body composition measures considered in this study (body mass [$r=0.477$; $p<0.001$], BMI [$r=0.509$; $p<0.001$], and BF [$r=0.444$; $p<0.001$]). MF was not significantly correlated with any of the measures of body composition.

Partial correlation was used to adjust for the potential

Table 2 Anthropometric characteristics of indigenous Siberian males and females (Evenki, Ket, Buriat, and Yakut) by age group^a

	Body Mass ^c kg	BMI ^{c,d}	Body Fat ^{b,c,d} %
<i>Males</i>			
18–29	60.6 (8.7)	21.8 (2.4) ^{f,g,h,i}	13.8 (5.1) ^{f,g,h,i}
30–39	63.8 (12.8)	24.0 (3.4) ^e	19.3 (5.1) ^e
40–49	65.1 (13.1)	24.4 (3.8) ^e	22.2 (7.1) ^e
50–59	61.2 (13.2)	23.9 (4.1) ^e	20.9 (8.7) ^e
60 and older	61.9 (14.2)	25.1 (5.3) ^e	23.6 (7.9) ^e
<i>Females</i>			
18–29	53.6 (10.7) ^{g,h}	22.4 (3.7) ^{f,g,h,i}	30.2 (6.3) ^{f,g,h,i}
30–39	57.3 (11.5)	24.3 (4.3) ^{e,h}	34.1 (5.1) ^{e,g,h}
40–49	59.8 (13.5) ^e	25.6 (5.2) ^e	37.8 (5.2) ^{e,f,h}
50–59	63.0 (15.4) ^{e,i}	27.6 (6.3) ^{e,f}	41.1 (5.8) ^{e,f,g,i}
60 and older	55.6 (14.3) ^h	25.3 (5.6) ^e	37.0 (6.4) ^{e,h}

^a All values are presented as means and standard deviations

^b Calculated according to skinfold measurements

^c Significant differences ($p<0.001$) by age group for females

^d Significant differences ($p\leq 0.001$) by age group for males

^e Significant difference ($p<0.05$) compared to 18 to 29 age group (one-way ANOVA; Scheffe's post-hoc test)

^f Significant difference ($p<0.05$) compared to 30 to 39 age group (one-way ANOVA; Scheffe's post-hoc test)

^g Significant difference ($p<0.05$) compared to 40 to 49 age group (one-way ANOVA; Scheffe's post-hoc test)

^h Significant difference ($p<0.05$) compared to 50 to 59 age group (one-way ANOVA; Scheffe's post-hoc test)

ⁱ Significant difference ($p<0.05$) compared to 60 and older age group (one-way ANOVA; Scheffe's post-hoc test)

Table 1 Descriptive statistics for age and anthropometric data for combined sample of four indigenous Siberian populations (Evenki, Ket, Buriat, and Yakut)^{a,b}

Measure	Females (n=537)	Males (n=363)
Age (years)	38.1 (14.5)	37.4 (14.4)
Height (cm)	152.9 (7.0)***	163.2 (8.4)
Weight (kg)	57.1 (12.8)***	62.5 (11.9)
Body Mass Index	24.4 (5.0)**	23.4 (3.7)
Sum of Skinfolks (mm)	82.0 (34.4)***	42.2 (23.5)
Body Fat (%)	34.7 (6.8)***	18.5 (7.2)
Fat-Free Mass (kg)	36.6 (5.4)***	50.3 (6.6)

^a All values are presented as means and standard deviations

^b Differences between females and males are statistically significant at: ** $p<0.01$; *** $p<0.001$

Table 3 Descriptive statistics for age and anthropometric data for Yakut participants from the 2003 field season^{a,b}

Measure	Females (n=89)	Males (n=60)
Age (years)	32.5 (11.3)	31.0 (11.0)
Height (cm)	156.7 (5.6)***	169.8 (6.0)
Weight (kg)	60.8 (14.3)*	66.3 (12.8)
Body Mass Index	24.7 (5.4)*	23.0 (4.0)
Sum of Skinfolks (mm)	97.0 (36.9)***	51.3 (27.1)
Body Fat (%)	36.3 (6.5)***	19.8 (7.0)
Fat-Free Mass (kg)	38.0 (5.7)***	52.5 (6.3)

^a All values are presented as means and standard deviations

^b Differences between females and males are statistically significant at: * $p<0.05$; *** $p<0.001$

Table 4 Correlation matrix using partial correlation (adjusted for age and smoking status) for body composition and lifestyle variables in Yakut males (2003)^a

	Body Mass kg	BMI	Body Fat %
Factor 1 (cattle herding)	0.133	0.142	0.060
Factor 2 (dispersed resource subsistence)	0.148	0.091	-0.012
Factor 3 (consumer goods)	0.271*	0.239	0.148
Factor 4 (horse herding)	0.206	0.124	0.149
Factor 5 (economic)	0.340*	0.343*	0.290*
Factor 6 (economic)	0.189	0.214	0.084
Income	0.429**	0.423**	0.351**
Market Foods (MF)	-0.139	-0.129	-0.124

BMI: body mass index

^aCorrelations are statistically significant at: * $p < 0.05$; ** $p < 0.01$

confounding effects of age, given that age was positively correlated with all measures of body composition among males (body mass [$r = 0.298$; $p < 0.05$], BMI [$r = 0.424$; $p = 0.001$], and BF [$r = 0.465$; $p < 0.001$]). Smoking status was also included in multivariate models for males, given that smokers had lower BMI (22.2 ± 3.6 vs. 24.5 ± 4.4 ; $p < 0.05$) and BF (18.0 ± 6.1 vs. 23.5 ± 7.7 ; $p < 0.01$) than non-smokers. When adjusted for age and smoking status, Factors 1, 2, 4, and 6 were not significantly associated with any of the body composition measures (Table 4). However, Factor 3 was significantly associated with body mass ($p < 0.05$) and approached significance for BMI ($p = 0.09$) (Table 4). Further, Factor 5 was significantly associated with all body composition variables (body mass [$p = 0.01$], BMI [$p = 0.01$], and BF [$p < 0.05$]) (Table 4). After adjustment, all of the body composition variables remained significantly associated with income (body mass [$r = 0.429$; $p = 0.001$], BMI [$r = 0.423$; $p = 0.001$], and BF [$r = 0.351$; $p < 0.01$]) (Table 4). However, after adjustment, MF was not significantly correlated with any of the body composition measures (Table 4).

None of the lifestyle factors (i.e., Factors 1 to 6) were significantly associated with any of the body composition measures among Yakut females, with the exception of Factor 2 and BF ($r = 0.247$; $p < 0.05$). Income was significantly correlated with BF ($r = 0.226$; $p < 0.05$) but not with other body composition measures. MF was negatively correlated with BMI ($r = -0.210$; $p < 0.05$) but not with other body composition measures.

Partial correlation was used to adjust for the potential confounding effects of age among Yakut females, given that age was positively correlated with all measures of body composition (body mass [$r = 0.265$; $p < 0.05$], BMI [$r = 0.354$; $p = 0.001$], and BF [$r = 0.579$; $p < 0.001$]). Smoking status was not included in female multivariate models since smoking status was not associated with body composition measures among females. After adjustment for age, only Factor 3 was positively associated with body composition (BMI [$p < 0.05$], and it approached significance for body mass [$p = 0.08$] and BF

Table 5 Correlation matrix using partial correlation (adjusted for age) for body composition and lifestyle variables in Yakut females (2003)^a

	Body Mass kg	BMI	Body Fat %
Factor 1 (cattle herding)	0.133	0.185	0.123
Factor 2 (dispersed resource subsistence)	0.066	0.078	0.081
Factor 3 (consumer goods)	0.200	0.231*	0.206
Factor 4 (horse herding)	-0.047	-0.039	-0.063
Factor 5 (economic)	-0.174	-0.200	-0.211
Factor 6 (economic)	0.122	0.098	0.061
Income	0.024	0.015	-0.053
MF	-0.205	-0.272*	-0.159

BMI: body mass index; MF: market foods.

^aCorrelations are statistically significant at: * $p < 0.05$.

[$p = 0.07$]) (Table 5). Additionally, Factor 5 approached significance for BMI ($p = 0.08$) and BF ($p = 0.07$) (Table 5). In partial correlation models, income was not significantly correlated with any of the body composition variables (Table 5). However, after adjustment, MF was significantly associated with BMI ($p = 0.01$) and approached significance for body mass ($p = 0.06$) (Table 5).

Discussion

This study assessed the prevalence of obesity in a large sample of indigenous Siberian adults representing four ethnic populations (Evenki, Ket, Buriat, and Yakut). All measurements were taken since 1991 and, combined, they provide the best estimate of the magnitude of overweight and obesity among native Siberians in the post-Soviet period. In order to contextualize Siberian overweight and obesity, this study compared body composition data between the pooled sample and other populations at different levels of economic development, as well as among individual Siberian indigenous groups.

The results of this study indicate that obesity has emerged as an important health issue among indigenous Siberians (Table 6). This issue is especially critical for women, whose levels of obesity are nearly double those of men (12% vs. 7%). Age appears to be an important factor in the development of obesity, although there were important sex differences in the development of excess body fat with age.

When levels of overweight and obesity among indigenous Siberians are compared to Russians as a whole, important sex differences are visible. However, it is difficult to assess the recent shifts in overweight and obesity in Russia resulting from economic changes, since nationally representative data are not available for the final years of the Soviet period (Jahns et al., 2003). However, the World Health Organization's MONICA project does provide multi-year data on body composition for residents of Moscow and Novosibirsk from the mid-1980s through the mid-1990s (Silventoinen et al., 2004). The

Table 6 Overweight (BMI 25.0–29.9) and obesity (BMI≥30.0) among indigenous Siberians and selected circumpolar groups

Population	Year(s)	Sex	n	BMI	Overweight %	Obese %	Source
Evenki	1991, 1992, 1995	M	148	22.4	10	1	this study
		F	174	24.0	22	10	
Ket	1991, 1992	M	14	23.9	21	7	this study
		F	19	23.4	37	5	
Buriat	1998	M	51	23.4	22	8	this study
		F	80	25.1	29	15	
Yakut	2001, 2003	M	150	24.3	25	11	this study
		F	264	24.5	24	13	
Indigenous Siberians ^a	1991–2003	M	363	23.4	18	7	this study
		F	537	24.4	24	12	
Alaska Natives	1997–2000	M	644	—	—	27	Denny et al., 2003
		F	779	—	—	31	
Inuit (Canada)	1998, 1999	M	496	—	—	18	Kuhnlein et al., 2004
		F	464	—	—	30	
Inuit (Greenland)	1998–2001	M	575	—	—	16	Bjerregaard et al., 2002
		F	735	—	—	22	
Yukon (Canada)	1995	M	177	—	—	10	Kuhnlein et al., 2004
		F	198	—	—	17	

^a Combined Evenki, Ket, Buriat, and Yakut.

prevalence of obesity in middle-aged adults in both locations remained fairly stable during the late 1980s, and then rapidly declined in the early 1990s, with a decrease in prevalence in both cities of approximately 50%; this decline is unsurprising given the cataclysmic social and economic changes that occurred in Russia during this period. Data from the Russian Longitudinal Monitoring Survey (RLMS) between 1992 and 2000 document a slight increase in obesity from 7 to 10% in men and 19 to 22% in women, although the combined prevalence of overweight and obesity remained stable for both sexes during this period (Jahns et al., 2003). The most recent data on obesity in Russia come from the year 2000 phase of the nationally representative RLMS. These rates of obesity among Russian men (10%) were similar to Yakut men (11%) and slightly higher than Buriat men (8%); Evenki men had extremely low rates of obesity (1%) that were five times lower than among Russians as a whole. Russian women had rates of obesity (22%) approximately twice those of the indigenous populations examined in the current study (12%).

While obesity is an emerging health issue among indigenous Siberians, obesity among these populations is considerably lower than that of most North American circumpolar populations, as well as much of the developed world. Circumpolar populations in North America experienced a rapid secular increase in adiposity and an increased prevalence of obesity with recent lifestyle changes related to economic modernization. For example, as the Inuit transitioned away from a traditional hunting-based subsistence economy and experienced massive lifestyle change, prevalence of obesity rapidly increased from minimal levels to over 15% among men and over 20% among women (Bjerregaard et al., 2002; Kuhnlein et al., 2004; Shephard and Rode, 1996) (Table 6). Other North American groups, such as Alaska Natives, have an

even higher prevalence of obesity, with approximately 27% of men and 31% of women (Denny et al., 2003) (Table 6).

Although Yakut men had the highest prevalence of obesity (11%) of all Siberian men considered in this study, this level is substantially lower than most North American circumpolar groups, including Inuit (16–18%) and Alaska Natives (27%) (Table 6). Yakut men have similar obesity rates as those found among the Canadian Yukon (10%). Compared to men in developed nations, such as the US (28%; Flegal et al., 2002), Australia (19%; Cameron et al., 2003), and England (15%; WHO, 2000), Yakut men have very low obesity rates. However, obesity rates among Yakut men are substantially higher than men in many of the developing nations of Asia, sub-Saharan Africa, and Latin America, which generally are below 8% (Martorell, 2002; Popkin and Doak, 1998; Popkin, 2002, 2003; WHO, 2000). The rate of obesity among Buriat men (8%) was far lower than other circumpolar populations, and was generally similar to the level found in developing nations in Latin America and parts of Africa. Evenki men had some of the lowest rates of obesity (1%) in the world and, as such, are comparable to much of eastern and southeast Asia, as well as sub-Saharan Africa. The combined indigenous Siberian sample had a prevalence rate of obesity (7%) considerably lower than most North American circumpolar populations and certain developing nations.

Yakut women (13%) have a considerably lower prevalence of obesity than North American circumpolar populations, including Alaska Natives (31%), Yukon (17%), and Inuit (22–30%) (Table 6). These rates are far lower than those seen in the US (33%; Flegal et al., 2002) and Australia (22%; Cameron et al., 2003), but only slightly lower than values for women of other developed countries such as England (17%; WHO, 2000). Yakut women have rates that are lower than

those of many Middle East and North African populations, whose obesity rates typically range from 15 to 30% (Martorell, 2002; Popkin and Doak, 1998; Popkin 2002, 2003; WHO, 2000). Yakut women had obesity rates similar to parts of Latin America, but considerably higher than much of eastern and southeast Asia (<6%; Popkin 2002; WHO, 2000). Buriat women (15%), with slightly higher obesity rates compared to the Yakut, and Evenki women (10%), with slightly lower rates, follow a similar pattern as Yakut women. The combined sample of indigenous Siberian women had rates of obesity (12%) considerably lower than most high-latitude North American populations.

The Buriat and Evenki both show substantial sex differences in excess adiposity, with women far more likely to be obese. This is most extreme among the Evenki, where obesity among women is far more common than among men (10% vs. 1%). Among the Buriat, 15% of females were classified as obese, whereas considerably fewer males (8%) were obese. The sex differences in obesity in these indigenous Siberian groups may originate with occupational changes implemented during the Soviet period. Evenki subsistence traditionally centered on reindeer herding activities and generally involved a fairly fluid division of labor, with women responsible for many physically demanding tasks, including hide preparation and encampment movement (Leonard et al., 2002). Soviet collectivization asserted state control of the reindeer herds and restructured subsistence roles; men were given primary responsibility for reindeer herding activities and were structured into worker “brigades” (Forsyth, 1992). Participation in subsistence activities was curtailed for women, who instead focused on domestic responsibilities, including childcare and encampment maintenance. During collectivization, most Evenki populations were forced to settle into permanent villages, although men in herding brigades traveled extensively with reindeer herds. Evenki men were found to have a significantly higher total energy expenditure and level of physical activity than women, and this was true for each of the different residence locations (i.e., brigades, small villages, and urban centers) (Leonard et al., 2002). Additionally, these studies documented important differences in diet, with women having a greater positive energy balance than men.

In striking contrast to the situation described above, Yakut men have similar prevalence rates of obesity as Yakut women; 13% of women and 11% of men were classified as obese. An additional 24% of females and 25% of males were classified as overweight. This is surprising, given that, like other native Siberians, the Yakut experienced changes in labor and residence patterns during Soviet collectivization. During this period, men became primarily responsible for herding and hay cutting activities, although these had been family activities in the past (Seroshevski, 1993; Jordan and Bychkov-Jordan, 2001). Studies have documented that these occupational patterns have generally continued into the post-Soviet period, and recent evidence shows that women are less involved in subsistence activities outside the home than men (Crate, 2001).

The small sample of Ket makes comparisons problematic; however, similar rates of obesity were documented in males and females.

The present study investigated the association between lifestyle, measured with multiple variables (e.g., socioeconomic status, participation in subsistence activities, diet, and material style of life), and body composition among the Yakut. Substantial sex differences in the association of lifestyle and body composition were documented. Yakut men with higher incomes and who owned more luxury consumer goods were more likely to have excess body fat. Interestingly, consumption of market foods was not significantly associated with excess body fat among Yakut men. The influence of lifestyle on body composition was found to be considerably different and more complex among Yakut women. Women who owned certain luxury goods were more likely to have excess body fat, but income was not significantly associated with overweight and obesity. Women who consumed a greater proportion of store-bought food had less body fat, although this may reflect the relationship between market foods and components of socioeconomic status.

The pattern of sex differences in the Yakut in relation to income and body composition mirrors that seen among Russians in general. Recent nationally representative data from the RLMS document a close association between body fatness and income among Russian men, but not among women (Jahns et al., 2003). Russian men at higher levels of income were found to have greater excess body fat and a higher prevalence of obesity. No significant association was found between body fat and income among Russian females. It is unclear what specific factors mediate the relationship between income status and adiposity, or why there are distinct patterns by sex, but it does appear, based on these data, that diet plays an important role in the development of excess adiposity among men, given the close association between income and daily energy intake. The relationship between socioeconomic status and body composition among Yakut men, as well as in Russian men, is similar to that documented for developing nations and indigenous populations in developed nations (Stunkard, 1996). This pattern contrasts with that seen in developed nations, where the relationship is typically inverse. Further research is needed to fully understand the relationship between economic development, and specifically its associated lifestyle factors, and the development of excess body fat among indigenous Siberian populations.

Acknowledgments We thank Svetlana D. Petrova of the Academy of Sciences of the Sakha Republic (Yakutia) for her assistance with field research. We also thank the Minister of Health of the Sakha Republic (Yakutia), V.L. Alexandrov, for his support of this research. In addition, we would like to thank the following organizations for their generous financial support: Wenner-Gren Foundation, National Science Foundation, Natural Sciences and Engineering Research Council of Canada, National Geographic Society, The Leakey

Foundation, Sigma Xi, University of Guelph, University of Florida, and Northwestern University. Finally, we express our gratitude to all the individuals who participated in this study.

References

- Balzer MM, Vinokurova UA (1996) Nationalism, interethnic relations and federalism: the case of the Sakha Republic (Yakutia). *Eur-Asia Stud* 48: 101–120
- Bjerregaard P, Jorgensen ME, Anderson S, Mulvad G, Borch-Johnsen K (2002) Decreasing overweight and central fat patterning with Westernization among the Inuit in Greenland and Inuit migrants. *Int J Obesity* 26: 1503–1510
- Cameron AJ, Welborn TA, Zimmet PZ, Dunstan DW, Owen N, Salmon J, Dalton M, Jolley D, Shaw JE (2003) Overweight and obesity in Australia: the 1999–2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Med J Aust* 178: 427–432
- Crate SA (2001) *Cows, Kin, and Capitalism: The Cultural Ecology of Viliui Sakha in the Post-Socialist Era.* (PhD thesis. Univ. North Carolina, Chapel Hill)
- Denny CH, Holtzman D, Cobb N (2003) Surveillance for health behaviors of American Indians and Alaska Natives: findings from the Behavioral Risk Factor Surveillance System, 1997–2000. *Morb Mortal Wkly Rep* 52: 1–13
- Flegal KM, Carroll MD, Ogden CL, Johnson CL (2002) Prevalence and trends in obesity among US adults, 1999–2000. *JAMA* 288: 1723–1727
- Fondahl G (1997) Siberia: assimilation and its discontents. In Bremmer I, Taras R eds. *New States, New Politics: Building the Post-Soviet Nations.* Cambridge University Press, Cambridge, 190–232
- Forsyth J (1992) *A History of the Peoples of Siberia: Russia's Asian colony 1581–1990.* Cambridge University Press, Cambridge
- Humphrey C, Sneath D (1999) *The End of Nomadism? Society, State and the Environment in Inner Asia.* Duke University Press, Durham
- Jahns L, Baturin A, Popkin BM (2003) Obesity, diet, and poverty: trends in the Russian transition to market economy. *Eur J Clin Nutr* 57: 1295–1302
- Jordan BB, Jordan-Bychkov TG (2001) *Siberian Village: Land and Life in the Sakha Republic.* University of Minnesota Press, Minneapolis
- Kuhnlein HV, Receveur O, Soueida R, Egeland GM (2004) Arctic indigenous peoples experience the nutrition transition with changing dietary patterns and obesity. *J Nutr* 124: 1447–1453
- Leonard WR, Galloway VA, Ivakine E, Osipova L, Kazakovtseva M (2002) Ecology, health and lifestyle change among the Evenki herders of Siberia. In Leonard WR, Crawford MH eds. *The Human Biology of Pastoral Populations.* Cambridge University Press, Cambridge, 206–235
- Leonard WR, Katzmarzyk PT, Comuzzie AG, Crawford MH, Sukernik RI (1994) Growth and nutritional status of the Evenki reindeer herders of Siberia. *Am J Hum Biol* 6: 339–350
- Leonard WR, Katzmarzyk PT, Crawford MH (1996) Energetics and population ecology of Siberian herders. *Am J Hum Biol* 8: 275–289
- Lohman TG, Roche AF, Martorell R (eds.) (1988) *Anthropometric Standardization Reference Manual.* Human Kinetics Books, Champaign
- Martorell R (2002) Obesity in the developing world. In Caballero B, Popkin BM eds. *The Nutrition Transition: Diet and Disease in the Developing World.* Academic Press, Amsterdam, 147–164
- Pika A (1999) *Neotraditionalism in the Russian North: Indigenous Peoples and the Legacy of Perestroika.* University of Washington Press, Seattle
- Popkin BM (2002) An overview of the nutrition transition and its health implications: the Bellagio meeting. *Public Health Nutr* 5: 93–103
- Popkin BM (2003) The nutrition transition in the developing world. *Devel Policy Rev* 21: 581–597
- Popkin BM, Doak CM (1998) The obesity epidemic is a worldwide phenomenon. *Nutr Rev* 56: 106–114
- Rode A, Shephard RJ (1994) Prediction of body fat content in an Inuit community. *Am J Hum Biol* 6: 249–254
- Rode A, Shephard RJ (1995) Modernization of lifestyle, body fat content and body fat distribution: a comparison of Igloodik Inuit and Volochanka nGanasan. *Int J Obesity* 19: 709–716
- Safronov FG (2000) *Encyclopedia of Yakutia.* Open Press, Moscow
- Seroshevski W (1993) *The Yakut.* 2nd ed., Imperial Russian Geographical Society, St. Petersburg
- Seidell JC, Rissanen AM (1998) Time trends in the worldwide prevalence of obesity. In Bray GA, Bouchard C, James WPT eds. *Handbook of Obesity.* Dekker, New York, 79–91
- Shephard RJ, Rode A (1996) *The Health Consequences of 'Modernization': Evidence from Circumpolar Peoples.* Cambridge University Press, Cambridge
- Silventoinen K, Sans S, Tolonen H, Monterde D, Kuulasmaa K, Kesteloot H, Tuomilehto J (2004) Trends in obesity and energy supply in the WHO MONICA Project. *Int J Obesity* 28: 710–718
- Slezkine Y (1994) *Arctic Mirrors: Russia and the Small Peoples of the North.* Cornell University Press, Ithaca
- Sorensen MV (2003) *Social and Biological Determinants of Cardiovascular Risk among Rural and Urban Yakut: The Impact of Socioeconomic Upheaval.* (PhD thesis. Northwestern University, Evanston)
- Stunkard AJ (1996) Socioeconomic status and obesity. In Chadwick DJ, Cardew G eds. *The origins and consequences of obesity.* Wiley, Chichester (England) 174–182
- Tokarev SA, Gurvich IS (1964) The Yakut. In Levin MG, Potapov LP eds. *The Peoples of Siberia.* University of Chicago Press, Chicago, 243–304

Visscher TLS, Seidell JC (2001) The public health impact of obesity. *Annu Rev Publ Health* 22: 355–375

World Health Organization (2000) Obesity: Preventing and Managing the Global Epidemic. World Health Organization, Geneva

World Health Organization (2002) Reducing Risks, Promoting Healthy Life. World Health Organization, Geneva

World Health Organization/Food and Agriculture Organization (2003) Diet, nutrition and the prevention of chronic

diseases. World Health Organization, Geneva

Received: April 29, 2005

Accepted: October 12, 2005

Correspondence to: J. Josh Snodgrass, Department of Anthropology, University of Oregon, Eugene, OR97403, USA

Phone: +1-541-346-4823

Fax: +1-541-346-0668

e-mail: jjosh@uoregon.edu