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Lifestyle Incongruity, Stress and Immune Function in Indigenous Siberians: The Health Impacts of Rapid Social and Economic Change

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ABSTRACT The purpose of this study was to investigate the impact of economic and cultural change on immune function and psychosocial stress in an indigenous Siberian population. We examined Epstein-Barr virus antibodies (EBV), an indirect biomarker of cell-mediated immune function, in venous whole blood samples collected from 143 Yakut (Sakha) herders (45 men and 98 women) in six communities using a cross-sectional study design. We modeled economic change through the analysis of lifestyle incongruity (LI), calculated as the disparity between socioeconomic status and material lifestyle, computed with two orthogonal scales: market and subsistence lifestyle. EBV antibody level was significantly negatively associated with both a market and a subsistence lifestyle, indicating higher cell-mediated immune function associated with higher material lifestyle scores. In contrast, LI was significantly positively associated with EBV antibodies indicating lower immune function, and suggesting higher psychosocial stress, among individuals with economic status in excess of material lifestyle. Individuals with lower incongruity scores (i.e., economic status at parity with material resources, or with material resources in excess of economic status) had significantly lower EBV antibodies. The findings suggest significant health impacts of changes in material well-being and shifting status and prestige markers on health during the transition to a market economy in Siberia. The findings also suggest that relative, as opposed to absolute, level of economic status or material wealth is more strongly related to stress in the Siberian context. Am J Phys Anthropol 138:62–69, 2009.

A number of studies on stress and health in acculturating populations have focused on the health consequences of economic growth and culture change. This work has emphasized the role of adjustment to changing cultural norms, behaviors and lifestyles in contexts of economic modernization and transition (Chin-Hong and McGarvey, 1996; Bindon et al., 1997; Dressler and Bindon, 1997; Hanna, 1998; McDade, 2001; McDade, 2002). Several studies on cultural change, stress, and immune function have documented declines in cell-mediated immunity, suggesting increased stress associated with rapid culture change (McDade et al., 2000b; McDade, 2001; McDade, 2002).

Markers of immune function provide a useful window onto the study of psychosocial stress, as a key pathway through which stress influences health status is through suppression of immune function, diminishing the body's ability to fight infection. A growing body of literature has documented the links between immunosuppression and a range of life stressors (e.g., bereavement, academic exams, marital strain and divorce, and social isolation). This work has consistently found that chronic psychosocial stress leads to increased cytokine production, inflammation, and diminished cell-mediated immune function (Herbert and Cohen, 1993; Glaser and Kiecolt-Glaser, 1994; McEwen, 1998; McEwen and Seeman, 1999; Segerstrom and Miller, 2004; Glaser and Kiecolt-Glaser, 2005; Glaser et al., 2005).

Multiple studies have demonstrated that antibodies to Epstein-Barr virus are a valid indirect marker of psychosocial stress (Cacioppo et al., 2002). Previous work has found elevated EBV antibodies in association with chronic psychosocial stress in Samoan adolescents (McDade, 2001), in U.S. adolescents exposed to life strain and traumatic life events (McDade et al., 2000a), in adults in a poor quality marriage (Kiecolt-Glaser et al., 1987), and in medical students taking exams (Glaser et al., 1993).

This study contributes to this body of work by investigating linkages between economic status, material wealth, residence location, and a marker of immune function (antibodies to Epstein-Barr virus). We develop

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an ethnographically informed measure of material lifestyle (wealth) and economic status grounded in the concept of cultural models (Dressler, 1995; Dressler and Bindon, 2000) that is locally specific and considers heterogeneous subsistence lifeways in a cattle and horse-herding circumpolar population.

The post-socialist transition in Siberia represents a case of rapid economic contraction. Following the collapse of the collective farm system during 1991–1994, subsequent economic crises and hyperinflation, many households in Siberia engaged in small-scale herding of horses and cattle, hunting, fishing, and gathering in the Boreal forest (Sorensen, 2003). In Yakutia, the collapse of the Soviet Union had profound impacts on health status: During the early-mid 1990s, life expectancy declined 6 years for men and 4 years for women (Goskomstat, 2000; Borisov and Tikhonov, 2001). These changes have been accompanied by increased mortality from accidents, injuries and suicides and cardiovascular disease. Our data from ethnographic interviews have shown increased perceptions of stress, vulnerability and economic uncertainty during this period.

Research on health in post-Soviet Siberia has examined lifestyle change, diet and risk for cardiovascular disease (Sorensen et al., 2005), adiposity, blood pressure and inflammation (Sorensen et al., 2006), physical activity and energetics (Snodgrass, 2004; Leonard et al., 2005), risk for obesity (Snodgrass et al., 2006), high blood pressure (Snodgrass et al., 2008), and growth and nutritional status (Leonard et al., 2002).

Prior work in urban regions of Russia and elsewhere in the former Soviet Union has explored the dramatic decline in life expectancy and examined specific regional and population patterns of mortality and morbidity (Bobadilla et al., 1997; Shkolnikov et al., 1998; Cornia and Paniccia, 2000). A number of factors have been proposed to explain these health effects, including increased alcohol consumption (Leon et al., 1997; Shkolnikov et al., 1997; Notzon et al., 1998), rapid impoverishment and material deprivation (Cornia and Paniccia, 1995; Bobak and Marmot, 1996; Bobak et al., 1998), unhealthy behaviors and lifestyles (Bobak and Marmot, 1996; Carlson, 2000), and the deterioration of the health care system (Field, 1995; Tulchinsky and Varavikova, 1996). Chronic psychosocial stress has been suggested as a key mechanism linking these broader sociopolitical and economic changes with health and biology (Eberstadt, 1994; Shapiro, 1995; Leon et al., 1997), yet few studies to date have directly measured stress (Kristenson et al., 2005), and more work is needed on changing socioeconomic conditions and household and individual subsistence practices in the post-Soviet context (Bobak et al., 2000; Pikhart et al., 2003).

Modeling interactions between economic status and material wealth: lifestyle incongruity

Lifestyle incongruity (LI) emphasizes the disparity between material lifestyle, measured as the ownership of consumer goods and luxury items, and socioeconomic status (SES), as a source of stress in populations exposed to modernizing influences (Dressler, 1995; McDade, 2001). In a group experiencing rapid economic and cultural change, such as the Yakut, this approach captures the psychosocial impact of the disparity between SES, a measure accumulated over the life course, and current wealth as measured by material lifestyle. The interpretive framework for the model is grounded in Weberian concepts of social class and status (Weber, 1978), and was developed to capture the health effects of shifting markers of social status and prestige among rapidly acculturating groups. Dressler proposes that under conditions of culture change, traditional status and prestige markers are supplanted by novel ones such as consumer and luxury goods. Pursuit of these items may lead to a lifestyle that is inconsistent with household economic resources, potentially leading to increased stress. Thus LI captures the ways individuals advertise their status and social position in ways that may diverge from the economic resources they possess. This approach has been applied in prior studies to investigate effects of LI on blood pressure (Chin-Hong and McGarvey, 1996; Bindon et al., 1997; Dressler, 1999), and stress and immune function (McDade, 2001).

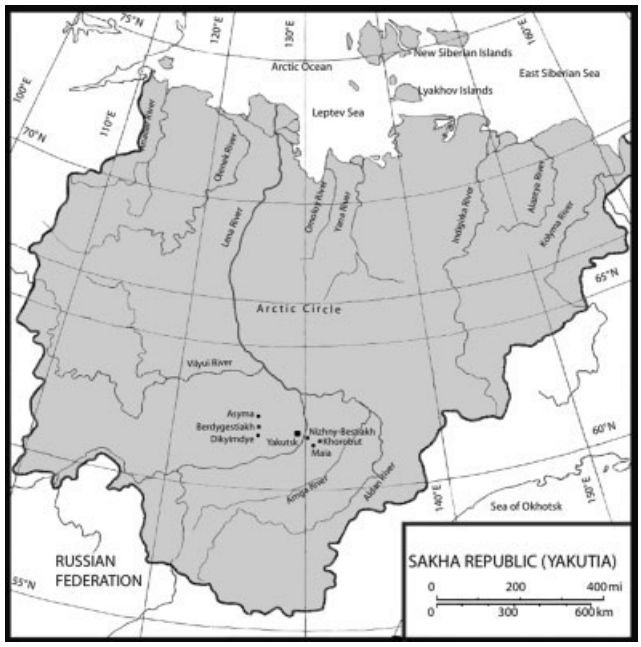

Fig. 1. Map of Yakutia.

METHODS

Study population

This study 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 Yakutia (Sakha) (Sorensen et al., 2005). EBV antibody concentrations were studied in 143 adults aged 18–79 recruited from three villages (pop. $\leq$ 1,000) and three towns (pop. $>$ 1,000) in two rural districts. The study districts were rural, with economies based on milk production and cattle and horse husbandry. All healthy men and nonpregnant, nonlactating women in selected households were eligible to participate.

The Sakha (Yakut) are a population of nearly 400,000 residing in the Sakha (Yakutia) Autonomous Republic in northeast Siberia from 56°–73° N and 107°–172° E (see Fig. 1). The Republic of Yakutia covers 3,103,200 km^2, nearly one fifth of the territory of the Russian Federation, with a population density of one person per

0.9 km^2. The total population in 2000 was 994,600, with majority ethnic Russians (~600,000) (Goskomstat, 2000). The Republic is rich in natural resources, including diamonds, gold, oil, natural gas, tin, and silver (Khazanov, 1995). In 2003, diamond mining generated more than 1.7 billion US dollars, and accounted for ~ 25% of world diamond production (Ministry of International Affairs, 2005).

Traditionally, the Yakut possess complex and heterogeneous subsistence cultures depending upon the regional ecological conditions (Tokarev and Gurvich, 1956). The three ethnographically defined groups of Yakut based subsistence patterns and clan origins include: North Reindeer herders, Viliui Cattle-breeders, and Central Sakha (Kangalas). The Central Yakut practice cattle and horse breeding and reside primarily in the Lena River valley, its tributaries, and surrounding regions.

Linguistically, Yakut is most closely related to Turkic language groups of the Central Asian Steppe, while elements of their material culture and subsistence behavior display characteristics common to Buriat and Mongolian populations of the Baikal region (Tokarev and Gurvich, 1956). The Yakut language shows affinities to Altai and Tuva languages of Central Asia, and Dolgan (Ruhlen, 1988). In the 12–13th centuries AD, the Yakut were displaced from their territory in the Transbaikal region by expanding Buryat populations. During this time the Yakut migrated north, and settled in the Lena and Viluyiuy River valleys and retained their horse and cattle herding lifestyle as opposed to the nomadic reindeer herding lifestyle of the Evenki and Yukaghir groups they displaced.

Protocol

Overnight fasting blood samples were collected by venipuncture. Blood spots were collected by applying five drops of whole blood extracted from 5 ml K2 EDTA vacutainers to standardized filter paper (Schleicher and Schuell, Keene, NH). The blood spots were then allowed to dry and were frozen prior to transport to the United States for analysis. Venous blood was separated in the field by centrifugation and frozen for transport to the United States for analysis of C-reactive protein (CRP).

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, 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, 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 the body mass index (BMI, kg/m^2).

Dietary intake

Dietary intake was assessed using the Harvard Food Frequency questionnaire (FFQ), a semi-quantitative food frequency instrument consisting of 131 food items (Rimm et al., 1992). The FFQ has been validated in multiple studies as a precise and accurate measure of long-term, usual intake of selected macro and micronutrients, including protein, fats, carbohydrates and total calories (Rimm et al., 1992; Willett, 1998). Nutrient scores were calculated by multiplying the frequency of consumption of specific food items by the nutrient context of the usual portion size consumed. Nutrient values were computed using the US Department of Agriculture database (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).

Laboratory analyses

Epstein-Barr virus antibodies and immune function. Epstein-Barr virus is a ubiquitous herpes virus, with more than 90% of adults infected worldwide (Henle et al., 1969). In developing countries infection most often occurs in early childhood and resolves without symptoms, while in wealthy societies and higher SES groups primary infection often occurs in adolescence, commonly resulting in infectious mononucleosis (Macsween and Crawford, 2003). Following initial exposure, the virus is carried as a lifelong infection, with the virus maintained in a latent state by cell-mediated immune processes (Macsween and Crawford, 2003; Thorley-Lawson and Gross, 2004). Stress-induced upregulation of the hypothalamic-pituitary-adrenal axis and increased production of glucocorticoids (e.g., cortisol) and catecholamines (e.g., epinephrine) inhibit immune function, resulting in diminished cell-mediated immunity. Suppressed cell-mediated immune function leads to reactivation and opportunistic replication of latent EBV, which in turn results in increased product of anti-EBV antibodies. EBV antibody concentration therefore provides an indirect measure of an aspect of cell-mediated immune function (Glaser and Kiecolt-Glaser, 1994; Glaser et al., 1994; Glaser and Kiecolt-Glaser, 2005; Glaser et al., 2005).

Epstein-Barr virus antibody titers were analyzed using an enzyme-linked immunosorbent assay (ELISA) previously validated for use with dried blood spot samples (McDade et al., 2000a). The assay is specific for IgG antibodies to the p17 epitope of EBV, an immunodominant epitope of the viral capsid antigen complex (Diasorin Corp., Stillwater, MN, Product no. 7590). We identified prior exposure to EBV using a cutoff value of 20 ELISA units (McDade et al., 2000a). Based on this criterion nine subjects were determined to be seronegative for EBV and were excluded from further analysis.

Potential confounders. Immune function is altered under conditions of current infection or poor nutritional status. We evaluated nutritional status based on dietary energy, protein and fat intake, and on the body mass index (BMI, kg/m^2) and triceps skinfold. Current infection was assessed through analysis of CRP, a biomarker of infection and inflammation. CRP is part of the systemic response to injury or infection representing the body's initial response, and is a highly sensitive marker of systemic inflammation, infection, and tissue injury (Libby and Ridker, 1999; Mortensen, 2001; Sorensen et al., 2006).

Plasma CRP concentrations were determined using an immunoturbidimetric assay (Roche Diagnostics, India-

TABLE 1. Material lifestyle scales

Market lifestyle	Item total correlation	Frequency (%) or Median
Car	0.341	52 (36%)
Television	0.273	141 (98%)
Stereo	0.488	93 (65%)
Washing machine	0.339	111 (77%)
Video player	0.496	80 (56%)
Video camera	0.514	16 (11%)
Camera	0.503	77 (53%)
Barn	0.535	52 (36%)
Chickens	0.202	4 (59% own at least one chicken)
House	0.313	118 (82%)
Alpha (standardized)	0.738	
Subsistence (herding) lifestyle	**Item total correlation**	**Frequency (%) or Median**
Car	0.283	56 (44%)
Bath house	0.291	64 (44%)
motorcycle	0.406	70 (49%)
Cellar	0.481	45 (60%)
Cows	0.74	2 (64% own at least one cow)
Horses	0.598	1 (44% own at least one horse)
Pigs	0.529	1 (40% own at least one pig)
Chickens	0.402	5 (49% own at least one chicken)
Tractor	0.641	28 (19%)
Alpha (standardized)	0.794	

napolis, IN) at the Clinical Chemistry Laboratory at Children's Hospital at Harvard Medical School (cf. Sorensen et al., 2006). We used a cutoff of 10 mg/L to indicate current infection. One participant with a CRP value of 143.7 mg/L was excluded from further analysis based on this criterion.

Socioeconomic status and material lifestyle scales

Material wealth was measured with an index of 17 items. The item list was determined based on key informant interviews and was intended to capture a range of possessions related to a successful subsistence lifeway as well as possession of market items and luxury material goods (Table 1). Analysis of the index was conducted using the consensus analysis routine in ANTHROPAC v4.9 (Analytic Technologies, Natick, MA). A material lifestyle score was computed by dividing the sum of the items by the number of items in each dimension. The score for each individual ranges from 0 to 1 and is a measure of how closely an individual's possession of items agrees with the underlying cultural model of which items are important "in order to live successfully."

Two orthogonal dimensions of material lifestyle were identified using principal components analysis (Table 1). In constructing the scales, it became clear that a two dimension solution provided a better fit to the data than a single, summary lifestyle dimension. This approach was supported by ethnographic observations and interviews, and by analyses using principal components analysis and item response theory analysis (Bond and Fox, 2001). The first dimension was interpreted as a "market" lifestyle characterized by ownership 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 possession of subsistence-related items including cows, horses, pigs, and 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). The two dimensions have a moderate degree of internal consistency, as measured by Cronbach's alpha (Cronbach, 1951; Nunnaly, 1978).

SES was calculated at the individual level as the sum of monthly income (coded as a categorical variable with three levels based upon tertiles of the distribution), education level (three levels: grade school, high school, technical training or college degree), and employment status (three levels: no employment; manual labor (e.g., tractorist, mechanic, equipment operator, etc.); technical/professional (schoolteacher, nurse, administrator, etc.).

LI was computed by subtracting SES from material lifestyle, with separate incongruity variables calculated for market and subsistence lifestyle scales. Following McDade (2001) and Dressler (1995), each scale was first standardized to a mean of 50 and a standard deviation of 10. The incongruity variable provides a measure of the disparity between socioeconomic resources and material lifestyle. For each lifestyle dimension (e.g., subsistence and market lifestyle), negative (i.e., lower) incongruity values indicate SES in excess of material style of life, and higher (positive) values indicate material style of life in excess of SES.

A summary social status (SS) variable was constructed by summing standardized material lifestyle and SES variables (Dressler, 1995; McDade, 2001). A separate variable was created for each lifestyle dimension. This variable is not correlated with LI and provides a summary variable that controls for the direct associations of lifestyle and SES with EBV antibodies, and allows the incongruity variables to represent the independent contribution of the difference between lifestyle and SES.

Statistical analyses were conducted using the SAS System (SAS Institute, Cary, NC). Bivariate associations were examined using Pearson correlation coefficients and *t*-tests. The relationship between LI and EBV was examined using linear models. To control for the 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. Model 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 upon the mixed models, as they provide slightly more conservative significance tests.

Age, sex, protein intake, BMI and residence location (e.g., rural village *vs*. urbanized town) were included as covariates and subsistence and market LI were included in the models, with log transformed EBV as the dependent variable. Separate models were estimated for LI for each lifestyle dimension.

TABLE 2. Sample characteristics

	Urban women (n = 62)	Rural women (n = 36)	Urban men (n = 33)	Rural men (n = 12)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age	41.27 (14.4)*	48.14 (14.9)	48.73 (13.0)	47.50 (11.5)
BMI (kg/m^2)	23.78 (4.7)*	26.19 (5.5)	24.93 (4.9)	25.85 (4.5)
Percent body fat	34.68 (5.8)*	37.24 (5.9)	23.27 (6.2)	24.33 (7.3)
Socioeconomic status	4.37 (1.3)	4.00 (1.3)	3.43 (1.5)	3.35 (1.1)
Market lifestyle	0.83 (0.1)	0.8 (0.2)	0.78 (0.2)	0.87 (0.2)
Subsistence lifestyle	0.63 (0.1)**	0.72 (0.2)	0.60 (0.2)**	0.78 (0.1)
Epstein-Barr Virus antibody[a]	4.25 (0.7)	4.49 (0.7)	4.43 (0.7)*	4.85 (0.5)
C-reactive protein (mg/L)	0.67 (1.4)	1.02 (1.2)	1.15 (1.5)	0.55 (1.2)
Dietary protein (g/d)	88.78 (38.3)	84.00 (28.1)	88.70 (34.7)	87.91 (30.0)

[a] Log-ELISA units.
* $P < 05$; **$P < 01$. Statistically significant difference between rural and urban locations; independent samples t-test.

RESULTS

Descriptive statistics are presented in Table 2. Urban women were significantly younger (41 *vs*. 48 years P = 0.02) and were leaner, with significantly lower BMI (24 *vs*. 26, P = 0.02) and body fat (35% *vs*. 37% body fat, P = 0.02). SES was slightly higher in women and was higher in urban locations (P = 0.09), while market lifestyle scores were similar in rural and urban communities. Subsistence lifestyle scores were significantly higher in rural locations (P = 0.001).

EBV antibodies were significantly higher for rural men. EBV antibodies were positively correlated with age (r = 0.18, P = 0.022), but not with BMI, triceps skinfold, or with dietary energy, protein or fat intake. Epstein-Barr virus antibodies, CRP, and dietary protein intake were slightly higher in rural communities;

Material lifestyle scores were positively correlated with age, with protein intake, and with the triceps skinfold, but not BMI. Material lifestyle was associated with higher adiposity among younger, urban residents. This effect was strongest for younger women (ages 18–34) residing in urbanized towns, suggesting greater positive energy balance in these women (Sorensen et al., 2005). Subsistence lifestyle was positively associated with triceps skinfold (r = 0.25, P = 0.018) and percent body fat (r = 0.21, P = 0.048) but not BMI (r = −0.01, P = 0.989).

Material lifestyle and SES

Material lifestyle and SES were associated with EBV antibodies. We examined the relationship between EBV antibodies, material lifestyle and SES by fitting separate linear regression models for each lifestyle dimension, controlling for age, sex, dietary protein, BMI, and residence (not shown in table). In these models EBV antibodies were significantly negatively associated with both material lifestyle dimensions, and was marginally positively associated with socioeconomic status, indicating that higher market and subsistence lifestyle scores were associated with higher cell mediated immune function. In contrast, higher SES was associated with marginally lower cell-mediated immune function.

Lifestyle incongruity

The effect of LI upon EBV antibodies was evaluated by fitting a linear model with effects for age, dietary protein intake, BMI, residence location, and summary social status (Table 3). Higher LI was associated with significantly lower EBV, indicating higher cell-mediated immune function in individuals with material lifestyle in excess of socioeconomic status.

TABLE 3. Mixed model analysis of subsistence and market lifestyle incongruity

Parameter	Standardized coefficient	P value
Model		
Intercept	0.4355	0.0728
Age	−0.02502	0.8701
Sex	0.1201	0.3022
Location: rural	0.4233	0.0011
Dietary protein (g/day)	−0.1307	0.3182
BMI (kg/m^2)	−0.02871	0.8316
Economic status	−0.03415	0.7709
Subsistence lifestyle incongruity	−0.3492	0.0103
Intercept	0.2475	0.0587
Age	−0.2895	0.1036
Sex	0.1074	0.3352
Location: rural	0.3985	0.0011
Dietary protein (g/day)	−0.1299	0.2971
BMI (kg/m^2)	0.0461	0.7253
Economic status	−0.124	0.3302
Market lifestyle incongruity	−0.3336	0.002

We evaluated nonlinear effects of LI on EBV antibodies by creating dummy variables for LI. Figure 2 shows the effect of LI on EBV plotted at tertiles of the LI distribution, controlling for the other terms in the model (as noted in Table 3). The incongruity effect was significant for both market and subsistence LI, such that individuals with high SES and low material lifestyle had significantly higher EBV antibodies, thus lower immune function. The effect was linear for subsistence LI, indicating that the greater the magnitude of the difference between SES and material lifestyle (i.e., higher incongruity), the higher the EBV antibody level. The effect for market LI was nonlinear, suggesting a threshold effect. EBV antibodies in the lowest tertile of LI were significantly higher than those of the second and third tertiles of incongruity. Thus EBV was significantly higher for those at the highest level of SES who were at the same time at the lowest levels of market material lifestyle. In subjects with market lifestyle in excess of or at parity with SES there was no effect on EBV levels. These findings indicate varying stress and immune responses to different dimensions of lifestyle.

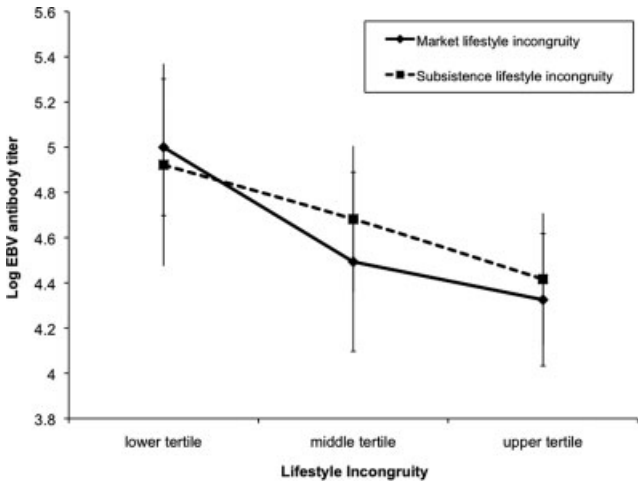

Fig. 2. Effect of lifestyle incongruity on Log EBV level, controlling for age, sex, BMI, residence location and socioeconomic status.

DISCUSSION

This study documents differences in immune function associated with economic status and material lifestyle in Yakutia. We attempted to capture the effects of economic change on stress and immune function through analysis of LI, calculated as the disparity between SES and material lifestyle, a measure of wealth. LI was significantly negatively associated with EBV antibodies, such that in individuals with lower or negative incongruity scores (i.e., SES in excess of material resources), EBV was higher, indicating lower cell-mediated immune function. In contrast, individuals with higher or positive incongruity scores (i.e., economic status at parity with material lifestyle, or with material lifestyle in excess of economic status) had significantly lower EBV antibodies. Higher incongruity, whether subsistence or market LI, was associated with significantly lower EBV antibodies for both men and women. In separate linear models, the partial effect of LI was similar for subsistence and LI. LI exerted a stronger effect on EBV antibodies than residence location, SES, age sex or BMI.

Why is LI stressful? In Yakutia, a lower incongruity score indicates a household with low material wealth, yet high socioeconomic status. Incongruity thus captures the interaction between SES, accumulated over the lifecourse, and current material possessions. One possibility is that LI captures stress associated with poverty and material deprivation. This is supported to some degree by the negative associations found between EBV antibodies and market and subsistence lifestyle, suggesting lower stress associated with higher material wealth. It is also possible that changes in social status and prestige following the breakup of the collective farms are associated with stress. Individuals with low LI possess higher levels of education and higher occupational status, and are likely to have had a high degree of economic security under the collective farm system. Yet these individuals currently possess fewer material resources for household subsistence including fewer livestock. Occupation is no guarantee of economic well-being, as many rural residents are employed by the government and wages are often in arrears for months at a time. Following the process of decollectivization, many occupations are no longer viable and there has been a shift towards household subsistence, particularly in smaller communities. In towns and cities, individuals pursue multiple places of employment simultaneously, yet in rural communities employment options are quite limited. Thus individuals with low LI may be experiencing stress despite higher levels of education and occupational status.

Our findings are consistent with prior research on LI. McDade (2001) found lower cell-mediated immune function and increased stress associated with LI in a study of Samoan adolescents. Other work has found increased blood pressure associated with LI among Samoan adults (Chin-Hong and McGarvey, 1996; Dressler and Bindon, 1997). Chin-Hong and McGarvey found a positive association between LI and blood pressure for women, but a negative association for young men and urban men. It is interesting to note that in these studies, household material lifestyle in excess of economic status was associated with increased stress, which is the opposite effect to that found in our study.

In the context of the former Soviet Union, SES had a substantially different meaning than found in market economies, as chronic shortages and scarcity of goods in the centrally planned economy were mitigated not by SES as traditionally measured, but by the extent of one's social networks. The breakup of the Soviet Union and dismantling of the collective farm system altered the nature of these networks, such that families are oriented not toward status in the collective farm and party hierarchy, but toward the market and household subsistence. In this context, material wealth can be seen as a measure of proximate/current economic well-being, whereas SES reflects more of one's "traditional" social standing under the Soviet era conditions. Thus, the individuals with the lowest LI are those who had relatively privileged status in the collective system, but have lost economic standing with de-collectivization.

In contrast, individuals with higher incongruity scores (i.e., economic status at parity with material resources, or with material resources in excess of economic status) had significantly lower EBV antibodies. The findings also suggest that relative, as opposed to absolute, level of economic status or material wealth is powerfully related to stress in the Siberian context. The nonlinear effects of market LI on EBV, with significantly higher EBV in those with high SES in combination with low market lifestyle suggests a threshold effect, below which smaller differences between SES and lifestyle are not stressful.

The differences in the effects of market *versus* subsistence LI on EBV may partly reflect the items included in the two measures. The subsistence scale contains items with direct links with health and nutritional status, whereas the market lifestyle scale is comprised largely of 'prestige' items. This difference may contribute to the linear, 'dose-response' between subsistence incongruity and EBV, whereas market LI may require a larger disparity before biological consequences are observed.

Residence location is an important source of variation in health in Yakutia. In rural communities the transition from collective farm employment to traditional subsistence combined with inconsistent linkages with a cash economy and outside markets has had an impact. Rural residents report perceptions of economic insecurity and lack of control. Following the abrupt collapse of the collective farms after 1991, subsequent economic crises, and hyperinflation, many households were rapidly impoverished and returned to small-scale herding of

horses and cattle, and by hunting and fishing, and gathering in the boreal forest. The consistent provisioning of goods and services and state capital inputs gave way to economic contraction. In contrast, residents of larger towns and district administrative centers are increasingly integrated into regional and global markets and engaged in wage employment. These findings underscore the complex process of culture change in post-socialist Russia and indicate the importance of historical context on the biological and health consequences of lifestyle change. During the Soviet era, well-educated party and collective farm officials had the greatest status and the best lives, in part because they were less tied to traditional subsistence activities. With de-collectivization, it was these individuals who lost the most social standing, contributing to their low levels of LI. The impact of this loss of status would have been most acute in the isolated rural areas where options for wage/market employment were very limited.

Our study suggests increased psychosocial stress associated with a household herding lifeway, where households possess few livestock and must earn cash through various means, including gathering mushrooms and berries in the forest.

This study highlight the uneven impacts of global processes on local populations and the health effects of economic and cultural change. This research illustrates the dynamic and heterogeneous impact of culture change upon stress and immune function in Yakutia and complements previous work on the health impacts of modernization and culture change.

In this cross-sectional study, it was not possible to causally link EBV levels with LI. We were limited in our ability to examine age and sex specific patterns of LI and stress by the relatively small sample size. Further research is needed for the impacts of lifestyle and ecological factors on immune function and stress, in particular the mechanisms linking poverty and inequalities with health, as well the role of buffering and support, in societies experiencing rapid social and economic change.

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