Original Research Article

Seasonal and Socioeconomic Influences on Thyroid Function Among the Yakut (Sakha) of Eastern Siberia

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Objectives: Previous research has shown that the extreme cold and short day lengths of polar winters promote increased production and uptake of thyroid hormones, resulting in marked declines in free triiodothyronine (fT3). However, this "polar T3 syndrome" has been documented almost exclusively on small samples of male sojourners and little is known about seasonal changes in thyroid function among indigenous circumpolar groups. The present study addresses this gap by examining seasonal changes in thyroid hormone levels among the indigenous Yakut (Sakha) of northeastern Siberia.

Methods: Anthropometric dimensions and thyroid measures (fT3, free thyroxine [fT4], thyroid-stimulating hormone [TSH]) were obtained on two occasions (July/August, 2009 and January 2011) on a sample of 134 Yakut adults (51 men, 83 women) from the village of Berdygestiakh, Sakha Republic/Yakutia, Russia.

Results: Yakut men and women both displayed significant declines in fT3 and fT4, and significant increases in TSH from summer to winter despite showing only modest seasonal changes in body mass and composition. Among men, gains in fat-free mass (FFM) were associated with larger reductions in fT3 and greater increases in TSH. Men living more traditional lifeways showed larger winter declines in fT4 and greater increases in TSH.

Conclusions: The Yakut exhibited significant winter declines in fT3 levels similar to other circumpolar groups studied. However, the magnitude of seasonal change was greater in the Yakut, perhaps reflecting their distinctive metabolic physiology. Lifestyle factors play a mediating role in thyroid responses, such that men with more traditional lifeways had more exaggerated seasonal changes. Am. J. Hum. Biol. 25:814–820, 2013.

Circumpolar populations are exposed to marked seasonality in environmental conditions that strongly shape their metabolism (Snodgrass et al., 2007). Elevated basal metabolic rates (BMRs) are a central adaptation to cold temperature stress and alter health patterns among indigenous subarctic groups (Leonard et al., 2002, 2005; Snodgrass et al., 2005, 2008). Increased rates of production and clearance of thyroid hormones appear to be one mechanism responsible for high BMRs among circumpolar populations (Leonard et al., 1999).

Previous research has shown substantial seasonal changes in thyroid hormone activity among residents and sojourners to high latitudes. In a series of studies among sojourners to Antarctica, Reed et al. (1986, 1990a,b) identified a constellation of physiological changes in response to severe cold exposure and reduced photoperiod. This cluster of responses, known as the "polar T3 syndrome," is associated with increased rates of production and clearance of triiodothyronine (T3), the active form of thyroid hormone, and thyroxine (T4), generally leading to reduced circulating levels of free (i.e., unbound and biologically active) T3 and T4 (fT3 and fT4) (Harford et al., 1993; Reed et al., 1990a,b). Research conducted in northern Europe, however, documents greater variability in seasonal changes in thyroid function, demonstrating both winter increases and decreases in fT3 and fT4 (Hassi et al., 2001; Maes et al., 1997; Plasqui et al., 2003).

Overall, the available evidence does not provide a consistent picture of how extreme seasonality shapes thyroid function. Additional research is required to evaluate the prevalence of winter reductions in serum fT3 and fT4 levels due to elevated rates of hormone clearance that exceed rates of production, as predicted by the "polar T3 syndrome" (Reed et al., 1990b). Previous work on this topic is limited by small sample sizes of sojourners or recent migrants to severe climates, often including only men. As such, we still know relatively little about seasonality in thyroid function among populations native to Arctic and subarctic climes. Additionally, previous work documents interactions between biological adaptation to cold stress and negative health outcomes, such as elevated blood pressure and high rates of autoimmune thyroid disorders in women (Cepon et al., 2011; Snodgrass et al., 2008). Finally, interactions between biological adaptation and health may be altered by changing lifestyle contexts.

The purpose of this study is to examine seasonal variation in thyroid hormone levels among an indigenous population of Siberia, the Yakut (Sakha). We predict that the Yakut will show evidence of the polar T3 responses—having

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reduced levels of fT3 and fT4 during the winter. Further, we expect that these responses will be modified by lifestyle factors such that individuals with greater subsistence activity participation will show more pronounced seasonal variation in thyroid hormone levels.

METHODS

Study population

The Sakha Republic (Yakutia), located in northeastern Siberia, is an autonomous state within the Russian Federation. The majority of the population of the Sakha Republic is ethnically Yakut, an indigenous population of around 400,000 individuals (Sorensen, 2003). The Sakha Republic spans 3,103,200 km^2, and the territory consists of boreal forest (*taiga*) and Arctic tundra. The winter months are characterized by an annual "anti-cyclone" consisting of extreme temperature inversions, persistent fog, and lack of wind. Temperatures ranged between $-20^{\circ}C$ ($-4^{\circ}F$) and $-50^{\circ}C$ ($-58^{\circ}F$) during the winter data collection period. The summer is typically dry with sudden bouts of torrential rainfall, and temperatures ranged from $10^{\circ}C$ ($50^{\circ}F$) to $32^{\circ}C$ ($90^{\circ}F$) during the data collection period (Crate, 2006).

Previous work among communities responding to extreme seasonal environmental stressors, both in rural Siberia and elsewhere, has highlighted the utility of contextualizing biological adaptations within a framework of ongoing social, political and economic change (Leonard, 1989; Snodgrass, et al., 2007; Thomas, 1989). Beginning in the 1930s, the Soviet government forcibly organized Yakut families into herding and farming collectives in order to end "backward" nomadism and promote "civilization" (Forsyth, 1992). Lifestyle changes during the Soviet era were particularly dramatic for women since the organization of herding collectives stripped women of their livestock and hay-cutting responsibilities and relocated women to villages in order to focus on raising children and conducting wage labor (Snodgrass, 2004). During this time, the Soviet government made promises of technological modernization, but few came to fruition. At the end of the Soviet era, less than 1% of homes in Siberia had running water or central heat (Sorensen, 2003).

At present, Yakut villagers now face a variety of challenges and opportunities related to defining new subsistence lifeways (Crate, 2006). The social, political, and economic changes associated with the collapse of the Soviet Union has resulted in the emergence of a heterogeneity of lifestyles among indigenous Siberians, both within communities and within families (Snodgrass, 2004; Sorensen et al., 2005). Currently, the majority of Yakut who live in rural villages depend on a mixed cash economy that consists of a combination of traditional subsistence practices, such as hunting, fishing, foraging and raising cattle, and cash inputs (Crate, 2006; Snodgrass et al., 2005; Sorensen, 2003). These lifestyle changes have resulted in shifts in diet and activity patterns that have contributed to rising rates of obesity and other chronic health problems, particularly among women (Snodgrass et al., 2006, 2008, 2010; Sorensen et al., 2005).

Participants

Data were collected from participants of the rural community of Berdygestiakh ($62^{\circ}N$; $127^{\circ}W$; population 4,900), in the Gorny *ulus* of the Sakha Republic (Yakutia) (Cepon et al., 2011; Snodgrass et al., 2005). The sample includes 51 men and 83 women who were measured on two occasions: July/August of 2009 (summer) and January of 2011 (winter). The subjects ranged in age from 18 to 81 years at the time of the first measurement. All data were collected at the Gorny Regional Medical Center in Berdygestiakh. Participants were recruited on a voluntary basis based on word of mouth and advertising of the study in the community. Conditions in this remote part of Siberia prevent the recruitment of a truly random sample. Therefore, the study sample may be biased toward individuals who are open to health and physiological research and have the resources and time available to visit the health clinic. All participants were healthy at the time of measurement (with no known acute or chronic conditions), and pregnant or lactating women were excluded. The study protocol was approved by the Institutional Review Board of the University of Oregon.

Anthropometry

Anthropometric dimensions were collected by one trained observer (L.A.T.) in each field season following procedures of Lohman et al. (1988). Stature was measured to the nearest 1.0 mm using a field stadiometer (Seca Corporation, Hanover, MD). Body weight was calculated to the nearest 0.1 kg using a Tanita digital bioelectrical impedance analysis (BIA) scale (Tanita Corporation, Tokyo, Japan). Percent body fat was measured using BIA. Body mass index (BMI) was calculated by dividing an individual's mass in kilograms by height in meters squared (kg/m^2).

Thyroid hormones

Whole blood samples were obtained by a trained nurse using venipuncture from subjects in a fasted state in the morning. Whole blood samples were immediately centrifuged and the plasma fraction was separated and stored at $-20^{\circ}C$ until laboratory analysis of thyroid hormones. Free T3, fT4, and TSH levels were determined using enzyme immunoassay with XEMA assay kits (Moscow, Russia). All laboratory analyses were conducted during the season in which they were collected in the Yakutsk Medical Center Department of Endocrinology (Yakutsk, Russia) under the supervision of Dr. Elizaveta Popova.

Lifestyle data

Each participant was given an extensive, standard questionnaire about socioeconomic status (SES) and lifestyle administered by a single interviewer. The survey asked about monthly income, occupation, and education level. In addition, to assess their material style of life, participants were asked about their ownership of 20 items: car, motorcycle, bicycle, television, stereo, VCR, video camera, camera, computer, telephone, washing machine, bath house, ice cellar, barn, tractor, house, cows, horses, pig and chickens. For each item, subjects were asked whether they owned it and, if so, how many they owned.

Other questions were asked about participation in various daily activities. Subjects were asked to estimate how many hours per day they spent watching television, and about their participation in various subsistence activities (i.e., tending animals, hay cutting, fishing, hunting, gathering, and farming). To assess the impact of lifestyle on

TABLE 1. Seasonal changes in anthropometric dimensions and thyroid hormone levels in Yakut men (n = 51) and women (n = 83)

Measure	Summer, mean ± SD	Winter, mean ± SD	t-statistic[a]	Interseason r[b]
Anthropometric		Men (n = 51)		
Weight (kg)	69.2 ± 12.1	69.5 ± 12.1	0.95	0.98***
BMI (kg/m^2)	25.1 ± 4.2	25.3 ± 4.3	1.57	0.97***
Percent body fat (%)[c]	23.6 ± 7.1	24.0 ± 8.0	0.71	0.87***
Fat mass (kg)	16.9 ± 7.6	17.3 ± 8.4	0.89	0.91***
Fat-free mass (kg)	52.3 ± 6.0	52.2 ± 6.0	0.19	0.93***
Thyroid				
TSH (mIU/l)	1.2 ± 0.8	1.4 ± 0.8	2.29*	0.76***
Free T4 (pmol/l)	16.0 ± 2.8	13.6 ± 2.1	6.65***	0.47***
Free T3 (pmol/l)	4.9 ± 1.7	3.7 ± 0.9	4.90***	0.34*
Anthropometric		Women (n = 83)		
Weight (kg)	62.0 ± 11.3	62.8 ± 11.5	2.52*	0.97***
BMI (kg/m^2)	25.9 ± 4.3	26.2 ± 4.3	2.45*	0.96***
Percent Body Fat (%)[c]	33.6 ± 7.4	34.4 ± 7.2	2.16*	0.91***
Fat mass (kg)	21.6 ± 8.1	22.3 ± 8.4	2.55*	0.95***
Fat-free mass (kg)	40.4 ± 3.8	40.5 ± 3.7	0.48	0.93***
Thyroid				
TSH (mIU/l)	1.5 ± 1.2	1.8 ± 1.6	2.07*	0.69***
Free T4 (pmol/l)	15.5 ± 3.5	13.7 ± 2.7	4.31***	0.58**
Free T3 (pmol/l)	4.7 ± 1.1	3.7 ± 1.5	6.90***	0.32**

[a]Paired t-tests: seasonal differences are significant at: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[b]Pair-wise correlations between summer and winter measures; significant at: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[c]Percent body fatness from bioelectrical impedance analysis (BIA).

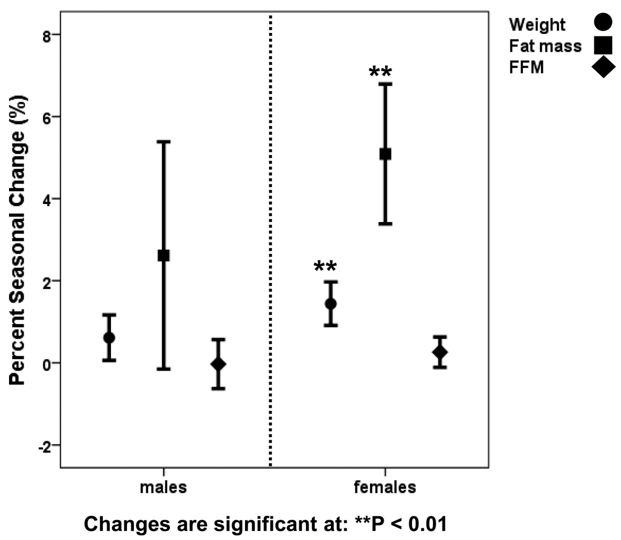

Fig. 1. Percent (%) seasonal changes in body weight and body composition among Yakut men and women. The pattern of change is similar in both sexes, with the largest percent winter increases being observed in fat mass. Yakut women show significant increases in body weight and fat mass during the winter. None of the seasonal changes are statistically significant in Yakut men.

diet, participants were asked to estimate the percentage of their food that came from the market/store.

A style of life (SOL) scale was created based on that of Bindon et al. (1997) to consider participation in subsistence activities, diet, and ownership of common consumer goods and livestock. Low SOL scores indicate more traditional ways of life (e.g., participation in more subsistence activities, less market food consumption, less formal education, and fewer consumer goods), whereas a high SOL suggests greater integration to the market. The individual components of the SOL score are presented and discussed in more detail in Cepon et al. (2011: 161).

Statistics

Statistical analyses were performed using SPSS 20.0. Paired t-tests were used to examine seasonal changes in thyroid hormone measures and body composition. Pair-wise correlations were used to examine relationships between seasonal change in thyroid hormones, body composition, and lifestyle measures. Comparisons and correlations were considered statistically significant at P value ≤ 0.05.

RESULTS

Seasonal changes in body composition and thyroid function

Table 1 presents descriptive statistics of seasonal changes in anthropometric and thyroid hormone measures for men and women. Both men and women exhibit significant increases in TSH levels and significant declines in fT3 and fT4 from summer to winter. Women show significant increases in weight, BMI, percent body fat and fat mass during the winter, whereas the changes in men are smaller and not statistically significant.

Figures 1 and 2 display the percent seasonal changes in body composition and thyroid hormone levels. In both sexes, seasonal changes in body mass are modest (<2%), with most of the winter increase presenting as fat mass (+3% in men, and +5% in women), while FFM remains stable. For the thyroid measures, TSH increases by ~17 to 18% in the winter, while fT4 levels decline by 12 to 16% and fT3 decline by 25 to 26%.

Summer and winter anthropometric dimensions are strongly correlated with one another. The correlations range from 0.87 (percent body fat) to 0.98 (weight) in Yakut men and from 0.91 (percent body fat) to 0.97 (weight) in women (P <0.001 for each pair-wise correlation). Thyroid measures are more variable across the

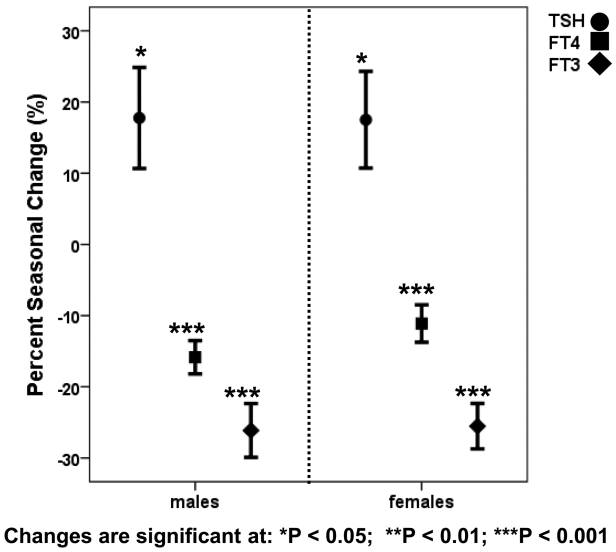

Fig. 2. Percent (%) seasonal changes in thyroid hormone measures (TSH, fT4, fT3) among Yakut men and women. During the winter, both sexes show significant increases in TSH levels (+17 to 18%), and significant declines in fT4 (−12 to −16%), and fT3 (−25 to 26%).

TABLE 2. Correlations[a] of seasonal changes in thyroid hormone levels with age and seasonal changes in anthropometric dimensions in Yakut men and women

Measure	ΔTSH	ΔFT4	ΔFT3
Men			
Age (yr)	0.01	0.05	0.06
ΔBMI (kg/m^2)	0.08	−0.19	−0.01
ΔPercent body fat (%)	0.24*	−0.13	0.30*
ΔFat-Free mass (kg)	0.38**	−0.02	−0.40**
Women:			
Age (yr)	0.18	−0.09	0.04
ΔBMI (kg/m^2)	0.05	0.16	−0.01
ΔPercent body fat (%)	−0.03	0.25*	−0.09
ΔFat-Free mass (kg)	0.07	−0.10	0.03

[a]Significance (one-tailed): *$P < 0.05$; **$P < 0.01$.

seasons. The correlations between summer and winter measures range from 0.34 (fT3) to 0.76 (TSH) in men, and from 0.32 (fT3) to 0.69 (TSH) in women ($P < 0.01$ for each pair-wise correlation).

Table 2 shows correlations between seasonal changes in body composition and thyroid function for Yakut men and women. Among men, changes in fT3 are positively associated with changes in percent body fat ($r = 0.30$; $P < 0.05$), and negatively associated with FFM ($r = -0.40$; $P < 0.01$). Seasonal changes in TSH are positively associated with FFM ($r = 0.38$; $P < 0.01$) and negatively associated with percent fatness ($r = -0.24$; $P < 0.05$). Among women, seasonal changes in fT4 are positively correlated with changes in percent body fat ($r = 0.25$; $P < 0.05$).

Socioeconomic and lifestyle influences on seasonal changes

Table 3 presents the descriptive statistics for selected socioeconomic and lifestyle factors based on data collected during the summer of 2009. Men and women of this sample have similar levels of income, use of store-bought food, and hours of TV watching per week. In contrast, men

TABLE 3. Selected socioeconomic measures in Yakut men and women

Measure	Males ($n = 46$), mean ± SD	Females ($n = 74$), mean ± SD	t-statistic[a]
Monthly Income (rubles)	29,711 ± 13,091	27,461 ± 13,812	0.89
Hay cutting (days)	14.2 ± 13.7	4.1 ± 10.8	4.48***
Percent Store food (%)	74.9 ± 19.5	79.1 ± 20.3	1.13
TV watching (hr/wk)	18.1 ± 9.8	17.2 ± 19.3	0.31
SOL score	10.6 ± 3.6	14.4 ± 2.7	6.51***

[a]Sex differences are significant at: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

TABLE 4. Correlations[a] of seasonal changes in thyroid hormone levels and anthropometric dimensions with socioeconomic measures in Yakut men and women

Measure	ΔTSH	ΔFT4	ΔFT3	ΔBMI	ΔPctFat	ΔFFM
Men						
Income	0.01	−0.18	−0.10	−0.16	−0.18	0.07
Hay cutting	−0.18	−0.24***	0.05	0.28*	0.23***	−0.07
%Store Food	0.24***	0.43**	−0.11	−0.15	−0.11	−0.03
TV hours	−0.29*	−0.02	0.11	−0.08	−0.01	−0.14
SOL	0.24***	0.25*	−0.07	−0.21***	−0.27*	0.16
Women						
Income	0.34**	−0.05	−0.02	−0.17***	−0.11	−0.07
Hay cutting	0.05	−0.05	−0.07	−0.11	−0.16	0.08
%Store Food	−0.13	−0.12	0.01	−0.02	−0.05	0.02
TV hours	0.01	−0.07	0.02	−0.05	−0.06	−0.01
SOL	0.16	−0.01	0.08	0.15	0.11	0.07

[a]Significance (one-tailed): *$P < 0.05$; **$P < 0.01$; ***$P < 0.10$.

report significantly more time devoted to hay cutting (14.2 vs. 4.1 days/year; $P < 0.001$), a major subsistence task, and have significantly lower style of life (SOL) scores than women (10.6 vs. 14.4; $P < 0.001$).

Table 4 presents the pair-wise correlations of the lifestyle variables with seasonal changes in thyroid and body composition measures for men and women. Among men, changes in fT4 levels are positively correlated with consumption of store-bought foods ($r = 0.43$; $P < 0.01$) and SOL ($r = 0.25$; $P < 0.05$), and show an inverse trend with days of hay cutting ($r = -0.24$; $P = 0.058$). Changes in TSH levels are inversely related to hours of TV viewing ($r = -0.29$; $P < 0.05$) and show positive trends with consumption of store-bought food ($r = 0.24$; $P = 0.056$) and the SOL index ($r = 0.24$; $P = 0.052$). As for changes in body composition, changes in BMI are positively associated with days of hay cutting ($r = 0.28$; $P < 0.05$) and changes in percent fatness are inversely related to SOL ($r = -0.27$; $P < 0.05$).

Among women, changes in TSH levels are positively correlated with monthly income levels ($r = 0.34$; $P < 0.01$). None of the lifestyle variables are significantly correlated with the changes in body composition.

DISCUSSION

The present study examined seasonal changes in thyroid hormone function among an indigenous circumpolar population, the Yakut, and explored the influence of body composition and lifestyle factors on shaping these patterns of seasonal change. We found that both Yakut men and women experienced significant decreases in serum concentration of fT3 and fT4 and significant increases in TSH levels from summer to winter. These results are consistent with “polar T3 syndrome,” first described by Reed et al. (1986, 1990b).

While seasonal changes in thyroid measures are quite marked among the Yakut, changes in body mass and composition were relatively modest (Figs. 1 and 2). Yakut men showed small changes in weight and body composition that were not statistically significant. Yakut women showed significant increases in body weight during the winter, with most of the gain presenting as fat mass.

Among men, it appears that gains or preservation of lean mass may play an important role in regulating thyroid function. For example, changes in fT3 levels in men are inversely related to changes in FFM and positively correlated with body fatness. Changes in TSH levels are positively correlated with FFM. These findings suggest that greater lean mass is associated with higher uptake/clearance of fT3 during the winter among Yakut men. The patterns are less clear among Yakut women. None of the thyroid changes are associated with changes in FFM. In contrast, fT4 levels are positively correlated with change in percent fatness. The differences between men and women may highlight underlying differences in metabolic responses to seasonal change that are shaped by differences in body composition.

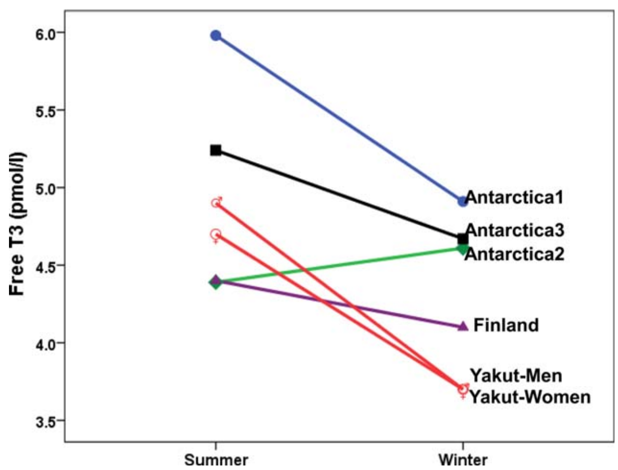

Fig. 3. Seasonal changes in fT3 levels among selected circumpolar groups. During the winter, fT3 levels decline in five of six samples. Yakut men and women show the largest percentage winter-time declines. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Analyses of socioeconomic data suggest that lifestyle factors may play a role in mediating seasonal thyroid responses, particularly among men. The correlational analyses suggest that that men pursuing a more traditional lifestyle experience greater reductions in fT4 and larger increases in TSH during the winter. Previous work among the Yakut also found that lifestyle factors are correlated with measures of thyroid hormone function. Cepon et al. (2011) found that the risk of autoimmune thyroid disorders was correlated with various indicators of market integration, which differed for men and women.

In comparison to samples of other circumpolar residents, the Yakut show relatively large seasonal changes in thyroid function, and have relatively low free thyroid hormone levels (both fT3 and fT4) during the winter (see Table 8). The substantially larger sample size of the present study compared to past circumpolar work strengthens our confidence in these results. The comparative data were restricted to studies that presented comparable thyroid measures to the present study (i.e., TSH, fT3, and/or fT4) for two seasons on the same individuals. The studies by Reed et al. (1986, 1990a, b) examined changes in thyroid function among male naval officers in Antarctica. Similarly, Levine et al. (1995) examined seasonality in fT4 levels in U.S. soldiers stationed in Alaska. The other three studies involved European populations in their home countries—including men in Northern Finland (Hassi et al., 2001), and both men and women from Belgium (Maes et al., 1997) and the Netherlands (Plasqui et al., 2003).

As shown in Figure 3, the most consistent pattern of seasonal thyroid changes observed across circumpolar groups is the reduction in fT3 levels during the winter. This is the key characteristic of the polar T3 syndrome described by Reed et al. (1990b), and appears to reflect increases in both the rate of T3 production and the rate of fT3 uptake into tissues in order to elevate metabolic rate as an adaptation to cold temperature stress. Yakut men and women show the largest percent reduction in fT3 levels during the winter, approximately 25%.

Additional evidence of the “polar T3 syndrome” is provided by Andersen et al. (2012). The authors measured serum thyroid hormones levels during the fall among Inuit groups of Greenland living in the capital, in a major town in a rural district, and in four settlements that lack modern housing facilities and roads. Individuals living in

TABLE 5. Comparative data on seasonal changes in TSH, FT4 and FT3 levels in circumpolar environments

			TSH (mIU/l)	Free T4 (pmol/l)			Free T3 (pmol/l)	
Location/reference	Sex	*n*	Summer	Winter	Summer	Winter	Summer	Winter
Antarctica1 (Reed et al., 1986)	M	17	2.17	2.02	32.18	29.60	5.98	4.91[a]
Antarctica2 (Reed et al., 1990a)	M	13	2.62	2.59	25.80	26.40	4.39	4.61
Antarctica3 (Reed et al., 1990b)	M	15	2.79	2.83	25.40	24.70	5.24	4.67[a]
Alaska (Levine et al., 1995)	M	19	–	–	13.90	17.76[a]	–	–
Belgium (Maes et al., 1997)	M	13	1.38	1.38	13.40	13.40	–	–
	F	13	2.11	2.15	15.10	15.00	–	–
Finland (Hassi et al., 2001)	M	20	1.70	2.10[a]	15.06	15.06	4.40	4.10[a]
Netherlands (Plasqui et al., 2003)	M	10	1.70	1.20	14.00	13.10[a]	–	–
	F	15	2.00	1.70	12.10	12.60	–	–
Yakutia (present study)	M	51	1.20	1.40[a]	16.00	13.60[a]	4.90	3.70[a]
	F	83	1.50	1.80[a]	15.50	13.70[a]	4.70	3.70[a]

[a]Significant seasonal changes.

the settlements had significantly lower serum fT3 levels than those living in the town and the city. Assuming that the settlement-dwellers and Inuit hunters are exposed to greater cold stress, these results provide further evidence that decreases in serum T3 levels among acclimatized populations are indicative of higher rates of T3 clearance and metabolic adaptation to low temperatures. Andersen et al. (2012) also compared thyroid hormone function among Inuit male hunters, Inuit men who did not hunt, and non-indigenous Greenlanders. These results exemplify the possible relationship between lifestyle and socioeconomic factors and thyroid hormone function. Men adopting a hunting lifestyle and residing in the settlement displayed a significantly different thyroid hormone profile than non-hunters and individuals living in the town and city.

Cross-cultural comparisons of seasonal change in free T4 provide only mixed support for adaptive seasonal decreases in serum T4 levels (see Table 5). As with the Yakut, Plasqui et al. (2003) reported significant winter declines in fT4 levels in the men of their Dutch sample, but not the women. Levine et al. (1995) reported significant increases in fT4 during the winter among U.S. soldiers stationed in Alaska. None of the other studies shown in Table 5 found significant seasonal changes in fT4 levels.

Evidence of seasonal change in serum TSH concentration is also mixed across groups studied in circumpolar environments. Besides the Yakut, the only other group to show significant seasonal change in TSH levels was the Finnish men studied by Hassi et al. (2001). As with the Yakut, the Finnish men had higher TSH levels during the winter. Indeed, of all the comparative groups considered here, the Finnish sample exhibits a seasonal pattern in thyroid function most similar to the Yakut—showing significant winter increases in TSH and declines in fT3 levels.

There are several limitations to this study. First, the winter and summer data were not collected within the same year, but rather 1.5 years apart. The time lapse in data collection and analysis may be an important source of error due to between-assay variation. Additionally, the modest seasonal differences in fat mass among women may be linked to gradual increases over time. Snodgrass et al. (2006) found that obesity has emerged as an important health issue among indigenous Siberians, particularly for women. Although our data suggest a positive correlation between change in fT4 and change in percent body fat among Yakut women, previous work suggests that fT4 levels are comparable between normal BMI and obese humans (Kozlowska et al., 2003; Reinehr 2010) and that short term fasting and overfeeding does not alter serum fT4 concentrations (Reinehr et al., 2006). Changes in fat mass were measured using a Tanita digital bioelectrical impedance analysis (BIA) scale. A limitation of this method is that the predictive equations produce greater error when the reference population from which they were derived is more homogenous than the sample population (Wilson et al., 1992). Currently the Tanita BIA equations and reference population information are unpublished.

Second, this study does not control for dietary iodine intake, which is an essential constituent of thyroid hormone. Previous work documents high fish and dairy consumption among the Yakut, which are two food groups known to be rich in iodine and are available yearlong (Crate, 2004; Haldimann et al., 2005; Sorensen et al., 2005). In addition, since our analysis required performing multiple correlations, our results are susceptible to type I error. Finally, this study does not directly examine rates of thyroid hormone uptake from the bloodstream into tissues; however, the cross-population pattern consisting of a drop in serum fT3 from summer to winter depicted in Figure 3 supports the interpretation that a decline in serum fT3 is reflective of higher tissue uptake as an adaptation to cold temperature stress.

CONCLUSIONS

In sum, this study has shown that the indigenous Yakut of northeastern Siberia experience marked seasonal changes in thyroid function. Consistent with previous work on circumpolar residents, the Yakut showed significant winter declines in fT3 levels. This polar T3 syndrome appears to result from the tissue-level uptake of T3 increasing at a faster rate than production or conversion. The marked declines in both fT3 and fT4 in Yakut men and women suggest an enhanced capacity to increase metabolic heat production during the severe winter cold. Our work also suggests that lifestyle factors help to mediate seasonal changes in thyroid function. Among men, those with more traditional lifestyle measures (e.g., less store-bought food, more time spent in subsistence tasks) showed exaggerated seasonal responses (declines in fT4, increases in TSH). Given the ongoing economic and lifestyle changes that are occurring in Siberia and in circumpolar regions around the world, additional research is needed to disentangle the pathways through which social and economic factors interact with underlying metabolic adaptations to shape variation in health status and disease risk.

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