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Original Research Article

Do Physical Activity and Sedentary Behavior Relate to Cardio-Metabolic Risk Factor Clustering in Indigenous Siberian Adults?

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Objectives: To investigate whether having multiple risk factors for cardio-metabolic disease is associated with objectively measured physical activity or sedentary behavior within a sample of Yakut (Sakha) of Siberia.

Methods: This cross sectional study involved 63 Yakut adults (32 men) who were measured for cardio-metabolic risk factors. Free living physical activity and sedentary behavior were calculated from waist accelerometry. Correlations and *t*-tests were used to assess the relationship between moderate-vigorous physical activity (MVPA), sedentary behavior (SB), and individual risk factors and clustering of risk factors.

Results: These Yakut were physically active, with 54.4% spending at least 30 min in MVPA, with men being more active than women and women having less favorable cardio-metabolic profiles. These Yakut spent about 7.5 h in SB a day. SB was not related to cardio-metabolic risk factors. MVPA was significantly and negatively related to waist circumference and risk factor clustering in men and the total sample. MVPA was not related to women's risk factors.

Conclusions: Objectively measured physical activity was related to lower risk of cardio-metabolic risk factor clustering within this sample of Yakut men, but not women. SB was not related to cardio-metabolic indicators. Physical activity may contribute to a reduction in clustering of metabolic risk factors within indigenous circumpolar populations. Am. J. Hum. Biol. 27:149–156, 2015.

INTRODUCTION

Much of the world is undergoing major epidemiological, demographic, nutrition, and economic transitions that have widespread effects throughout the population (Popkin, 1993), with an increase in noncommunicable diseases (Misra and Khurana, 2008; Popkin, 1993). Part of the proliferation in noncommunicable diseases includes a rise in the clustering of multiple metabolic risk factors within an individual, which may (Moller and Kaufman, 2005) or may not (Grundy et al., 2005) have a single underlying cause. When three or more cardio-metabolic risk factors cluster together in an individual, it is referred to as the Metabolic Syndrome (MetS) (Grundy et al., 2005). Clustering of two or more cardio-metabolic risk factors (Chateau-Degat et al., 2008, 2009; Das et al. 2012; Katulanda et al., 2012; Liu et al., 2006) is a major health concern in transitioning populations. The concern includes indigenous circumpolar populations, who appear to be buffered, being at lower than expected risk of some of the negative health consequences of transition (Chateau-Degat et al., 2008, 2011; Jorgensen et al., 2003; Snodgrass, 2013). Even such buffered populations experience the lifestyle changes associated with an increased risk of noncommunicable diseases, primarily due to changes in diet and behavior.

As populations transition, lifestyles become more mechanized, leading to decreased levels of physical activity and increased sedentary behavior (SB) (Biddle et al., 2004; Katzmarzyk et al., 1994; Leonard et al., 2005; Ng and Popkin, 2012; Popkin, 1993; Snodgrass, 2012). Physical activity leads to improvements in the cardio-metabolic profile (Ertek and Cicero, 2012) and reduces the potential of clustering of risk factors (Baceviciene et al., 2013; Das et al., 2012; Janseen and Ross, 2012). SB, which can also be considered physical inactivity or very low physical activity, leads to worsening of the cardio-metabolic profile (Healy et al., 2011; Saunders et al., 2012) and increases the chances of risk factor clustering (Edwardson et al., 2012). Declining physical activity linked with transition (Ng and Popkin, 2012; Popkin, 2002) may be a concern for indigenous circumpolar populations but relatively little research has investigated this relationship (Smith et al., 2006). Even less is known about SB within indigenous circumpolar populations. One issue with the current body of literature for both physical activity and SB is that they rely heavily on self-report, which tends to over-report physical activity (Celis-Morales et al., 2012; Dahl-Petersen et al., 2013a; Prince et al., 2008).

The indigenous Siberian Yakut (Sakha) are an ideal population to study the relationship between physical activity and disease outcomes within the context of nutrition transition (Crate, 2006; Snodgrass et al., 2010; Sorensen et al., 2009) as they have a distinct transition trajectory compared to other indigenous circumpolar populations. In the 1930s, during the Soviet era, the Yakut were forced to abandon their traditional, family-based herding practices and collectivize into communal farms. During this era, education was widely available and

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regular deliveries of food and medicine were provided to even the most isolated, rural areas. The fall of the Soviet Union removed these buffers, driving the Yakut to reorganize their economic strategies. Currently the Yakut employ a mix of traditional and market based economic strategies, and the two strategies are not mutually exclusive (Crate, 2006; Snodgrass et al., 2010; Sorensen et al., 2009). Within a population as heterogeneous as the Yakut, it is likely that the influences on physical activity are different from other populations that employ a more homogeneous economic strategy.

The aim of this article is to determine if a day of objectively measured physical activity and SB associates with the clustering of cardio-metabolic risk factors within indigenous circumpolar adults with mixed-market economy. We hypothesize that moderate-to-vigorous physical activity (MVPA) will significantly relate to lower cardiometabolic risk factor clustering while sedentary behavior (SB) will significantly relate to increased clustering within Yakut adults.

METHODS

Data collection

Recruitment and ethics. Data collection occurred over 2 weeks during July and August of 2009 in the Gorny Regional Medical Center in Berdygestiakh, Sakha Republic/Yakutia, Russia (62°N, 127°E; pop. 4,900). These data are a subsample of participants with objectively measured physical activity data ($n = 89$) from a larger study on health within the Yakut ($n = 281$). Yakut adults ($\geq$18 years old) were recruited via advertisements in the local media and word of mouth for a study on health. The Office for Protection of Human Subjects at the University of Oregon approved the study protocol. All participants gave informed consent.

Anthropometry. Height, weight, waist circumference, and skinfolds (biceps, triceps, subscapular, and supra-illiac) measurements were taken using standard methods (Lohman et al., 1988).

Interview. Participants were interviewed in Russian on basic demographic and socioeconomic information including age, date of birth, education, and income. For more details, see Cepon et al. (2011).

Biomarkers. Fasting whole blood was collected via venipuncture by a trained nurse. A portion of venous blood was used to immediately measure serum glucose and serum lipid levels (total cholesterol, triglycerides, high density lipoproteins (HDL), low density lipoproteins (LDL)) using a CardioChek PA analyzer and PTS Panels (Polymer Technology Systems, Indianapolis, IN).

Blood pressure was taken twice on seated, fasting participants by a physician using a manual sphygmomanometer. The mean was calculated and used in all further analyses.

Accelerometry. Participants were given a triaxial, hip accelerometer (Actigraph GT3X; Pensacola, FL) to wear for 48 h in order to objectively monitor their physical activity. Participants were told that they needed to remove the accelerometer while bathing and that they were able to remove it at night for sleeping and wear the monitor on their right hip.

Participant feedback. The participants were given immediate feedback on their cardiovascular/metabolic health by trained medical personnel based upon their anthropometry, blood pressure, blood lipids, and fasting glucose. Potential lifestyle changes (e.g., simple dietary changes) were also suggested.

Data cleaning

Accelerometer data. Microsoft Excel was used for the accelerometer data cleaning. To reduce the impact of reactivity (Motl et al., 2012) and incomplete days of data (Ward et al., 2005), only the second day was analyzed. A full day was defined as at least 10 h (600 min) of wear time. Nonwear time was defined as sleep time and also 60 or more consecutive minutes of 0 counts in any axis, with allowances of up to 2 min of counts below 100 (Ward et al., 2005).

US cut points derived from the National Health and Nutrition Examination Survey were used for defining physical activity intensity. Moderate-to-vigorous physical activity (MVPA) was defined as counts per minute greater than 1951 on the vertical axis; sedentary behavior (SB) was defined as counts per minute below 100 on the vertical axis (Freedson et al., 1998). Individuals who spent at least 30 min in MVPA were classified as meeting international physical activity recommendations (Garber et al., 2011).

Participants were informed that they could remove the accelerometer at night; only 29 of the 89 participants did so. Within those who removed the accelerometer at night, sleep time was defined as the duration of 0 counts. Sleep disruption was common within the participants who kept the accelerometer on throughout the night, detectable even though waist accelerometers are not designed to detect sleep (Sadeh, 2011). A bout of sleep disruption was defined as at least two minutes of 100 counts per minute or more within 60 min of zero counts during the nighttime hours. This cut-off was used as the cut-off for physical activity and indicated that the participant was being physically active, most likely walking in the house. Almost half of the participants who did not remove the accelerometer at night had at least five bouts of disrupted sleep (Wilson et al., 2014), making identifying sleep time in these participants impossible. Participants were not asked to keep sleep diaries. Therefore, we imposed sleep times on all participants who did not remove their monitors. Sleep time was determined by imposing the mean wake and asleep time (rounded to the nearest 15 min) for the participants who removed their accelerometers at night and had at least 10 h of wear time, removing outliers whose data started after 12 pm ($n = 1$) or ended before 8 pm ($n = 2$). The sleep time imposed on the participants who did not remove their accelerometers at night was defined as the nighttime hours between 10:45 pm and 8:00 am and was not analyzed for MVPA or SB.

Anthropometry. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared.

Metabolic syndrome classification. Cardio-metabolic risk factors were defined using ATP III modified criteria for

TABLE 1. Anthropometry and accelerometry of Yakut men and women, mean (SD)

	Men	Women	Total
N (%)	32 (50.79)	31 (49.21)	63 (100)
Age	51.13 (13.26)	51.52 (13.04)	51.32 (13.04)
		Anthropometry	
Height (cm)	168.68 (7.23)[b]	154.44 (6.92)[b]	161.68 (10.04)
Weight (kg)	71.69 (16.49)[b]	62.17 (10.80)[b]	67.01 (14.67)
Body mass index (kg/m^2)	25.16 (5.33)	26.08 (4.32)	25.61 (4.84)
Waist circumference (cm)	87.71 (13.05)	85.86 (10.23)	86.80 (43.59)
		Metabolic risk factors	
Glucose (mmol/L)	4.97 (1.04)	4.74 (1.14)	4.86 (1.09)
Triglycerides (mmol/L)	0.93 (0.56)	0.87 (0.42)	0.90 (0.49)
High density lipoproteins (mmol/L)	1.30 (0.49)[a]	1.55 (0.35)[a]	1.42 (0.44)
Low density lipoproteins (mmol/L)	2.80 (0.65)	3.01 (0.62)	2.90 (0.63)
Total cholesterol (mmol/L)	4.52 (0.93)[a]	4.96 (0.71)[a]	4.74 (0.85)
Systolic blood pressure (mm/Hg)	121.90 (25.89)	127.73 (22.72)	124.77 (24.36)
Diastolic blood pressure (mm/Hg)	72.68 (11.68)	78.85 (14.19)	75.71 (13.24)
		Accelerometry	
Moderate-to-vigorous physical activity (min)	59.59 (52.07)[a]	35.52 (39.69)[a]	47.75 (47.59)
Sedentary behavior (min)	432.09 (159.84)	467.86 (124.31)	451.03 (142.19)

[a]Significant difference between the sexes using an independent *t*-test, $P < 0.05$.
[b]Significant difference between the sexes using an independent *t*-test, $P < 0.01$.

MetS (Grundy et al., 2005). Individuals were then classified as having at least 1, 2, or 3 risk factors for indicators of MetS. A relatively low proportion of participants had at least three risk factors for MetS (the clinical definition) and therefore further analyzes used "risk of MetS" defined as two or more risk factors.

Data analysis

The final sample size was 63 (32 men). Accelerometers were given to 89 participants of the 281 participants of the larger study, which was the most possible given the number of accelerometers and short data collection period. Of those given accelerometers, 21 were removed for incomplete accelerometry data (Wilson et al., 2014). Of the 68 participants with complete accelerometry data, an additional five women were excluded for missing blood pressure measures.

Variables were checked for normality using the Kolmogorov-Smirnov test and skewness and kurtosis *z*-statistics. Non-normal cardio-metabolic indicators (Glucose, triglycerides, HDL, SBP, number of cardio-metabolic risk factors) and accelerometry variables (MVPA) were transformed; the square root of MVPA and the base 10 logarithm of HDL were used for all statistical comparisons. All other cardio-metabolic indicators were non-normally distributed, regardless of transformation. Clustering of cardio-metabolic indicators was defined as having two or more clinical indicators. Diagnosed MetS was defined as three or more clinical indicators.

Sex differences in MVPA, SB, individual cardio-metabolic indicators, clustering of cardio-metabolic indicators and diagnosed MetS were assessed using independent *t*-tests. Chi square assessed sex differences in clustering of cardio-metabolic indicators and meeting international recommendations for MVPA (≥30 min/day). Chi square also assessed whether meeting international MVPA recommendations was related to clustering of cardio-metabolic indicators. To assess the relationship between individual cardio-metabolic indicators and physical activity, indicators were correlated with $MVPA_{sqrt}$ and SB using Pearson's (HDL_{log}, DBP, WC) or Spearman's correlation (Glucose, triglycerides, SBP, number of cardio-metabolic risk factors). Independent *t*-tests were also used to compare $MVPA_{sqrt}$ and SB with risk of MetS.

RESULTS

This sample of Yakut had similar numbers of men and women (Table 1). The men were significantly taller and heavier than the women but there were no sex differences in BMI or WC. The only sex differences in cardio-metabolic risk factors were found in HDL and total cholesterol, with women having higher levels of both.

Of the participants who met the requirements for wear time, the mean wear time was 14.5 hours or 871 min (SD 81). This was an active sample with the mean time spent in MVPA being 48 min. 54.4% of the total sample spent at least 30 min in MVPA during the day of monitoring, meeting international physical activity recommendations (Garber et al., 2011). Men were significantly more active than women and were also significantly more likely than women to spend 30 min during the day in MVPA (68.8% versus 41.7%) (($x^2(1) = 5.010$, $P = 0.025$). Only five individuals (four men) spent any time in vigorous physical activity (>5,725 counts per minute), with 4 min being the longest time spent in vigorous physical activity during the day of measurement.

These Yakut participants spent just under a third of the day in SB (excluding sleep) and no sex differences in time spent in SB were found during the day of monitoring. The variation in time spent in SB was large.

The most common cardio-metabolic risk factors within this sample were low HDL, hypertension and abdominal obesity (Fig. 1). When assessed continuously, HDL was significantly higher in women, yet statistically equivalent proportions of men and women had HDL levels below the clinical cut-off. Hypertension and abdominal obesity were significantly more common in women compared to men. More women (41.9%) than men (21.9%) had at least two cardio-metabolic risk factors, but this difference did not reach statistical significance ($x^2(1) = 2.924$, $P = 0.086$). More women ($n = 4$) than men ($n = 2$) met the diagnostic criteria for MetS (at least three risk factors), but the expected count assumption was violated so a chi square test could not be computed.

Within the combined sample of men and women, 32% ($n = 20$) had clustering of cardio-metabolic risk factors (at least two cardio-metabolic risk factors). Abdominal obesity was the most common individual risk factor in the sample, and also was the most likely to cluster with other risk factors (Table 2). Abdominal obesity and hypertension co-occurred in 45% of the participants with clustering while abdominal obesity with reduced HDL occurred in 30% of participants with clustering. Abdominal obesity and elevated glucose co-occurred in 25% of participants with clustering. Hypertension and reduced HDL also co-occurred in 25% of participants with clustering. Within the six participants who had three or more cardio-metabolic risk factors: two had elevated glucose, hypertension and abdominal obesity; one had triglycerides, HDL and abdominal obesity cluster; one had triglycerides, HDL, abdominal obesity and hypertension cluster; one had elevated glucose, reduced HDL, hypertension, and abdominal obesity; and one had reduced HDL, hypertension, and abdominal obesity.

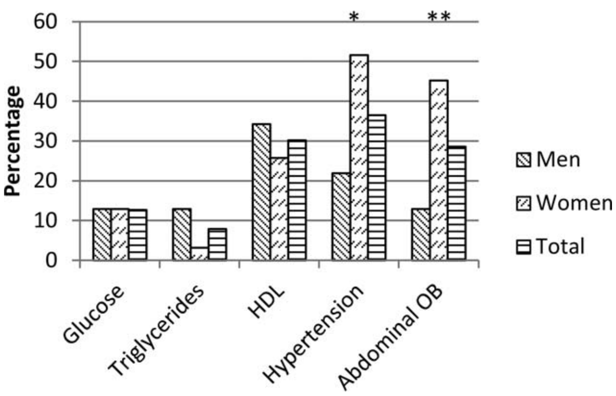

Fig. 1. Prevalence of risk factors for metabolic syndrome within an adult Yakut sample. Clinical values defined using modified ATP III criteria (Grundy et al., 2005). *Significant difference between the sexes found using Pearson chi square, $P < 0.05$. **Significant difference between the sexes found using Pearson chi square, $P < 0.01$.

MVPA was significantly and negatively correlated with number of cardio-metabolic risk factors and WC in men and the total sample (Table 3). Women had no significant correlations between number of cardio-metabolic risk factors and MVPA. SB positively and significantly correlated to triglycerides in the total sample (Table 4). Multiple linear regressions predicting every individual cardio-metabolic risk factor using MVPA and SB simultaneously found that neither were significant predictors of any risk factor (results not shown).

SB was not significantly related to clustering of cardio-metabolic risk factors ($t(61) = -0.797$, $P = 0.428$). MVPA was significantly related to clustering of cardio-metabolic risk factors ($t(60) = 3.091$, $P = 0.003$). Individuals without cardio-metabolic risk factor clustering spent significantly more time in MVPA [58 min (SD 53.1)] than individuals with two or more cardio-metabolic risk factors [25 min (SD 19.9)]. However, reaching the international recommendation for spending at least 30 min per day in MVPA did not impact risk for clustering of cardio-metabolic risk factors ($X^2(1) = 2.872$, $P = 0.090$).

DISCUSSION

The findings from this study provide some support for the hypothesis that MVPA was related to the clustering of cardio-metabolic risk factors within the Yakut but SB was not. These data are consistent with findings from physical activity interventions that have been found to improve the cardio-metabolic profile (Andersen et al., 2012) and reduce MetS (Kim et al., 2013). However, the weak

TABLE 2. Clustering of cardio-metabolic risk factors within Yakut adults[a,b]

	Elevated plasma glucose			Elevated triglycerides			Reduced high density lipoproteins			Hypertension		
	N	% cluster	% sample	*N*	% cluster	% sample	*N*	% cluster	% sample	*N*	% cluster	% sample
Elevated triglycerides	0	0	0									
Reduced HDL	3	15	4.7	3	15	4.7						
Hypertension	3	15	4.7	2	10	3.2	5	25	7.9			
Abdominal obesity	5	25	7.9	3	15	4.7	6	30	9.5	9	45	14.3

[a]Cardio-metabolic risk factors defined using modified ATP III criteria (Grundy et al., 2005).
[b]Six participants had more than two cardio-metabolic risk factors and are counted multiple times in this table.

TABLE 3. Correlations between the square root of moderate-to-vigorous physical activity and risk factors for cardio-metabolic disease within Yakut adults, mean (SD)

	Men		Women		Total	
	R	*P*	*R*	*P*	*R*	*P*
Glucose[b]	−0.022	0.905	−0.033	0.850	0.021	0.862
Triglycerides[b]	−0.251	0.166	−0.221	0.196	*−0.226*	*0.063*
HDL (log)[a]	0.212	0.245	0.033	0.849	0.024	0.849
Systolic blood pressure[b]	0.033	0.859	−0.286	0.119	−0.173	0.174
Diastolic blood pressure[a]	0.286	0.113	−0.276	0.138	−0.074	0.563
Waist circumference[a]	**−0.394**	**0.026**	−0.145	0.399	*−0.231*	*0.058*
Number of risk factors[b]	**−0.380**	**0.032**	−0.232	0.209	**−0.328**	**0.009**

[a]Pearson correlation used.
[b]Spearman's rank correlation used.

TABLE 4. Correlations between sedentary behavior and risk factors for cardio-metabolic disease in Yakut adults

	Men		Women		Total	
	R	*P*	*R*	*P*	*R*	*P*
Glucose[b]	0.028	0.879	−0.216	0.207	−0.099	0.424
Triglycerides[b]	0.253	0.162	0.273	0.107	**0.261**	**0.031**
HDL (log)[a]	*−0.338*	*0.059*	0.234	0.169	−0.067	0.588
Systolic blood pressure[b]	−0.156	0.395	0.009	0.961	0.055	0.669
Diastolic blood pressure[a]	−0.105	0.569	0.015	0.938	−0.008	0.947
Waist circumference[a]	0.116	0.527	0.152	0.376	0.115	0.351
Number of risk factors[b]	0.074	0.688	0.193	0.298	0.138	0.282

[a]Pearson correlation used.
[b]Spearman's rank correlation used.

relationship between MVPA and cardio-metabolic risk factors suggest that physical activity is not the primary force buffering this indigenous circumpolar population from noncommunicable diseases. Yet definitive conclusions are not possible from these preliminary physical activity data. These findings within these Yakut are supported by a study of Inuit in Greenland, which found physical activity energy expenditure was significantly and inversely related to glucose, insulin, and diabetes (Dahl-Petersen et al., 2013b). However this relationship was attenuated after controlling for covariates (age, sex, day of the week, and waist circumference) (ibid). The current state of the evidence suggests that physical activity is beneficial for health (Yu et al., 2009; Wagner et al., 2012), yet within these indigenous Siberians it may not be as protective as has been found in other populations.

Cardio-metabolic risk factors

Cardio-metabolic risk factors within this sample of Yakut are similar to previous studies of Yakut (Snodgrass et al., 2010) and broadly comparable with other indigenous circumpolar populations. Abdominal obesity was found in 29% of this sample, and was much more common in women, which is consistent with findings from other indigenous circumpolar populations (Chateau-Degat et al., 2011; Young et al., 2007). It seems that several populations of indigenous circumpolar men and women have similar absolute values of waist circumferences (Chateau-Degat et al., 2011; Young et al., 2007) but the lower cut-off for abdominal obesity in women (88 cm versus 102 cm) results in much higher rates of abdominal obesity within women. However, rates of abdominal obesity are not universally high in indigenous circumpolar populations; a sample of Alaskan Eskimos reported abdominal obesity prevalence to be less than 10% (Howard et al., 2010). Hypertension within indigenous circumpolar populations ranges from 10% in a sample of Canadian Nunavik Inuit (Noel et al., 2012) to 61% in a sample of Canadian Inuit (Kellet et al., 2012). Therefore, while the finding that 37% of these Yakut have hypertension is high, it is still within the range of values found in similar populations (Chateau-Degat et al., 2010, Howard et al., 2010; Jolly et al., 2011; Young et al., 2007). Dyslipidemia as measured by triglycerides was 8% in this sample of Yakut and 30% of the Yakut had low HDL. Low HDL was much less common in a sample of Canadian Inuit (10% of men and 13% of women) (Chateau-Degat et al., 2010). Another sample of Canadian Nunavik Inuit had dyslipidemia rates of 29% (Noel et al., 2012). High fasting glucose was found in 13% of this sample of Yakut. This is higher than the 7–9% prevalence found in two samples of Canadian Inuit (Chateau-Degat et al., 2011; Noel et al., 2012) and higher on average than populations in Alaska and Greenland (Young et al., 2007) but is much lower than the 34% reported in another sample of Canadian Inuit (Kellet et al., 2012). Overall, indigenous circumpolar populations have similar rates of cardio-metabolic risk factors, but large variation is found between populations and studies.

The single most common cardio-metabolic risk factor and the one most likely to cluster with other risk factors within this sample was abdominal obesity, which was significantly more common in women than men. Previous work has found that other indigenous circumpolar populations are apparently somewhat protected from the negative impacts of obesity, particularly abdominal obesity. A study of Canadian Inuit found that the indigenous circumpolar population had fewer cardio-metabolic risk factors at equivalent waist circumferences compared to individuals of European descent (Chateau-Degat et al., 2008) yet hypertension rates were 19% (Chateau-Degat et al., 2010). Within the same cohort of Canadian Inuit, the relationship between waist circumference and glucose was significantly weaker within Canadian Inuit than the Cree, another First Nation population (Chateau-Degat et al., 2011). It is difficult to determine with these limited, cross sectional data whether the Yakut are similarly protected. While elevated glucose was not the most common cardio-metabolic risk factor within this sample, it did cluster with abdominal obesity in five out of the eight participants with elevated glucose and the 19 participants with abdominal obesity. From these preliminary data, it is possible that the Yakut are not as buffered from the metabolic influences of abdominal obesity as other indigenous circumpolar populations. Future research will consider the universality of the apparent buffering of the metabolic impacts of abdominal obesity across indigenous circumpolar populations.

These data suggest that the prevalence of MetS within the Yakut is similar to other indigenous circumpolar populations (5–19%) (Boyer et al., 2007; Chateau-Degat et al., 2008; Jorgensen et al., 2004; Liu et al., 2006). Diagnosed MetS (three or more risk factors) was present in 10% of this sample of Yakut, and although the numbers were too small to perform statistical analyses, twice as many women (13%) had diagnosed MetS as men (6%). Prevalence of diagnosed MetS within these Yakut are very similar to a previous study performed in 2007 of a different sample of Yakut living in a rural village (population < 2,500) (Snodgrass et al., 2010). It remains to be determined how much of the heterogeneity in rates of MetS between indigenous circumpolar populations is due to various classifications being used versus true health differences (Jorgensen et al., 2004). It appears as though the Yakut are similar to other indigenous circumpolar populations in their rates of MetS.

Physical activity and sedentary behavior

On average, these Yakut were physically active, with 44% meeting international physical activity recommendations of 30 min a day in MVPA (Garber et al., 2011) over the 1 day of objective monitoring. This proportion of participants spending at least 30 min in MVPA is higher than most industrialized populations (Schuna et al., 2013). There were high levels of variation in both MVPA and SB, with MVPA being skewed by a few highly active individuals. While indigenous circumpolar populations are considered to be highly active, the majority of the recent data on the subject are from self-report measures (Dahl-Petersen et al., 2011; Hopping et al., 2010; Howard et al., 2010). In a recent study, duration of self-reported MVPA was found to be significantly over-estimated within Inuit of Greenland (Dahl-Petersen et al., 2013a), consistent with other populations (Celis-Morales et al., 2012; Ward et al., 2005). Yakut adults living in the same village as those in this study were found to be sedentary to moderately active using doubly labeled water (Snodgrass et al., 2006). Discrepancy between self-report and objective measure may be an explanation for the differences in activity levels found between this study of Yakut and other studies of indigenous circumpolar populations that report much higher levels of physical activity. Self-reports of MVPA are very high (4–9 h) (Dahl-Petersen et al., 2011, 2013; Hopping et al., 2010) while an objective measurement lowers the time spent in MVPA to 1.5 h (Dahl-Petersen et al., 2013a), which is still very high. It appears as though indigenous circumpolar populations are physically active, though it is likely that they are not as active as previously reported.

To the authors' knowledge, this is only the second study to objectively measure SB within an indigenous circumpolar population and found that on average the Yakut spend 7.5 h per day sedentary. This is less than half the time spent in SB than were found in the Inuit of Greenland (15.5 h, including sleep time) (Dahl-Petersen et al., 2013a). However if we assume that on average the Inuit of Greenland sleep for about 8 hours, then the Yakut spend a similar amount of time sedentary. Since research into sleep of indigenous circumpolar populations has yet to be published, this assumption requires further study. Another study on self-reported SB in the Inuit of Greenland found that a "modern," wage-based professional lifestyle was positively associated with an increase in self-reported SB, with the "professionals" spending two more hours per day in SB than hunters/fishermen (Dahl-Petersen et al., 2011). These Yakut are also less sedentary than populations in China (8.4 h) (Peters et al., 2010) and high income countries (8.4–16.7 h/day) (Healy et al., 2011; Koster et al., 2012; Scheers et al., 2013). The relatively low levels of SB found within these Yakut may potentially be an explanation for the lack of a relationship between SB and MetS. SB has been found to have half the magnitude of a relationship with the cardio-metabolic profile compared to MVPA (Jorgensen et al., 2004). Within the data for these Yakut, time in SB was consistently but not significantly higher among the group with clustering of cardio-metabolic risk factors. This that SB may contribute to cardio-metabolic functioning but this study was underpowered to detect the effect. Within populations in developed countries, SB has a relatively small influence of non-communicable disease risk and is not significant in every study (Chen et al., 2009).

Gender differences

One of the most striking findings of this study is the marked gender differences in activity and cardio-metabolic risk within these Yakut. The Yakut women were significantly less active than the men, spending almost half the time, 25 fewer minutes, in MVPA during the single day of monitoring compared to men. These results are consistent with a previous study within Yakut of the same community (Snodgrass et al., 2006), other indigenous Siberian populations (Katzmarzyk et al., 1994; Leonard et al., 2002, 2005), and other indigenous circumpolar populations (Dahl-Petersen et al., 2013b). Women also tended (not significantly) to be at increased risk of clustering of cardio-metabolic risk factors though MVPA was not significantly related to risk factor clustering. The higher levels of physical activity within the men are likely due to the strong gender roles of the Yakut. The men do the majority of physically demanding tasks while the women do the majority of easily mechanized domestic chores and are often employed in sedentary occupations. It is possible that these strong gender roles are influencing health-related behaviors and disease risk.

Whatever the reasons behind the gender difference in MVPA, it is interesting that the relationship between MVPA and MetS is significant in men but not women. This may be a statistical power issue due to overall low sample size and short monitoring period. Also, it is possible that biological differences between men and women may influence the MetS and MVPA relationship. In particular, menopause may mediate the MVPA-MetS relationship in women (Carr, 2003; Lobo, 2008). At this time, physical activity interventions examining MetS have focused on men (Andersen et al., 2012; Kim et al., 2013) so the effectiveness of physical activity to reduce MetS risk in women remains to be determined. Another possible explanation for the gender difference is there may be a threshold for MVPA above which MetS risk is reduced and these Yakut women were not sufficiently active to reach the threshold. Yet a previous study in an urban Lithuanian population found a linear dose-response between physical activity and MetS rather than a threshold effect (Baceviciene et al., 2013). The state of the evidence is not sufficient to understand this relationship, particularly in transitioning populations.

STRENGTHS AND LIMITATIONS

One of this study's strengths is the study population, indigenous Siberians. Most of the research into indigenous circumpolar populations examines North American or European populations. The Soviet and post-Soviet period have given Siberia a distinct transitional path from other circumpolar populations. As such it allows for comparisons between related populations within a variety of circumstances. A limitation of the study is the relatively small sample size, which restricted the power of the analysis, reduced generalizability, and eliminated the ability to assess potential confounders (Cohen, 1992). One other strength is the use of objectively measured physical activity, which is less error prone than self-reported physical activity and requires a smaller sample size to detect differences (Prince et al., 2008; Ward et al., 2005). However the strength of objective measurement is somewhat mitigated by the short monitoring period. It is not possible to reliably extrapolate the findings of one day of accelerometry to habitual physical activity, the standard for relating physical activity to health outcomes. Only having one season of physical activity data further reduced generalizability because of the high seasonality of circumpolar populations. With the small sample size and short accelerometry monitoring period, these data do not represent all Yakut. Instead they are intended to increase information available about physical activity and health in indigenous circumpolar populations, an area that is currently not widely researched.

In conclusion, MVPA significantly related to a reduced clustering of cardio-metabolic indicators in these Yakut men but not women. Yet, SB did not have a significant relationship with cardio-metabolic risk factor clustering. Clustering of cardio-metabolic risk factors was common within this sample of indigenous Siberians. While active, these Yakut were not as active as previously reported in other indigenous circumpolar populations but may spend a similar amount of time sedentary. However, due to the short monitoring period for physical activity, these data are not sufficient to draw conclusions about the habitual physical activity levels within this sample. Physical activity and SB are two of the many behaviors that influence health and change with a transition to the globalized, market based economy. Yet many behaviors and aspects of culture also shift during this transition and the details of the complex web of relationships is still largely unclear.

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