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Body fat distribution in Alaskan Eskimos of the Bering Straits region: the Alaskan Siberia Project

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OBJECTIVE: To describe the body fat content and distribution of adult Alaska Natives of the Bering Straits Region.
DESIGN: Cross-sectional screening in the spring of 1994.
SUBJECTS: 454 non-pregnant native residents from four rural Alaskan villages.
MEASUREMENTS: Height, weight, waist, hip and thigh circumference, bioelectrical impedance, sagittal abdominal diameter, and triceps, biceps, suprailiac, subscapular and thigh skinfolds.
RESULTS: Mean height, weight and subscapular-to-triceps ratio were higher in men than women. The women had larger waist, hip and thigh circumferences, higher body fatness, as well as larger skinfolds than the men. There were no demonstrable differences between men and women in measures of body fat distribution. The proportions of women and men with high waist-to-hip ratio ($\geq$0.8 for women, $\geq$0.9 for men) for low ($<$25 kg/m^2), medium (25–30 kg/m^2) and high ($>$30 kg/m^2) body mass index (BMI) groups were compared with a Canadian study of all races.[1] In the lowest BMI subgroup ($<$25 kg/m^2) a much higher proportion of Eskimo women exhibited a high waist-to-hip ratio (91%) than Eskimo men (42%) or Canadian women (29%) or men (51%). In the highest BMI subgroup ($>$30 kg/m^2) Eskimo women were similar in proportion of high waist-to-hip ratio (99%) compared to Eskimo men (100%), but still demonstrated a much greater proportion of subjects with high waist-to-hip ratio than either Canadian men (90%) or women (76%).
CONCLUSIONS: The large abdominal fat depots found in Eskimo women were similar to men, and may indicate that future increases in diabetes mellitus and other metabolic alterations can be anticipated.
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Keywords: body fat distribution; body composition; Eskimos; anthropometry; Alaska; obesity

Introduction

Obesity is a prominent risk factor associated with many chronic diseases including coronary heart disease, diabetes mellitus and hypertension.[2−6] These complications are related not only to the level of body fatness, but also to body fat distribution. It is well established that central fat, located in and around the viscera, may have a particularly detrimental effect on glucose and lipoprotein metabolism.[7] Through these or other mechanisms, body fat distribution has a unique effect on several chronic diseases, regardless of the overall level of body fatness.

The body fat content and distribution of modern Alaska Natives have not been characterized, although other populations have been studied extensively. Inconsistencies in fat patterning have been demonstrated between the different genders[8−10] and ethnic groups,[11] and between different levels of body fatness in other research.[7] Certain patterns of body fat distribution have been associated with risk of cardiovascular disease,[12−15] diabetes[16,17] and other metabolic abnormalities.[2,5,11,17−21] These relationships are relevant for Alaska Natives in whom chronic metabolic conditions including heart disease,[22] diabetes mellitus[23,24] and hypertension[25] are evident.

The objective of this study was to describe the current body fat content and distribution of adult Alaska Natives of the Bering Straits Region. The relationships of several measures of body fatness and body fat distribution were also explored.

Methods

The Alaska Siberia Project (ASP 1994) was a cross-sectional survey of four villages in the Bering Straits Region of northwestern Alaska conducted in April–May 1994. Village councils were consulted about the proposed study, as was the Board of the Norton Sound

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Health Corporation, which provides health care to Native residents of the region. Enthusiastic support by village councils led to the selection of four villages of approximately the same size (abvout 550 individuals). These villages were selected to represent the three major ethnic groups in the area: Inupiat, Central Yupik and Siberian Yupik.

The data are presented for the three groups of Eskimo subjects that were represented by this project. Alaska's indigenous people, numbering 85 698 in the 1990 census, can be divided into three main population groups: Eskimo, Indian and Aleut. These groups are further subdivided by geographic region of inhabitance, as well as by characteristics of linguistics and culture. Among the Eskimo, the Inipiaq (Inupiat) Eskimos inhabit the northern and northwestern coastal regions, the Yupik Eskimos live in the southwestern regions (Central Yupik), and the St Lawrence Island Eskimos (Siberian Yupik) inhabit St Lawrence Island, which is in the Bering Strait between the coasts of Alaska and Siberia. The Athabaskan Indians reside in the interior of the state, and the coastal Indians (Tlingit, Haida and Tsimshian) inhabit southeastern coastal Alaska. The Aleuts include residents of the Aleutian Islands, the Pribilof Islands, and the western tip of the Alaska Peninsula, the Kodiak area, and the coastal regions of south central Alaska.

The protocol for data collection was tested in a pilot study among residents of one Siberian Yupik village which took place in September 1992.[25,26] In 1994 the participation was low in this village due to many men being away hunting, and the fact that the second screening was perceived as unnecessary by residents who had previously participated. The data from this and one other Siberian Yupik village were combined due to the relatively poor participation in this village, and the fact that the two villages are very close geographically, are of the same ethnic group, and share food and other resources.

All village residents present who were 25 y of age and older (expect pregnant women) were invited to participate by the principal investigator, SOEE, during a personal interview. In analysis, eligible subjects were limited to individuals who were at least one-quarter Eskimo, which was determined by the ethnicity of the participant's grandparents as reported in the screening clinic interview by the participant. Also, if absent at the time of the screening a resident of the village was considered eligible if he/she had been absent from the village (by report of family members) for less than 6 months. Separate lists of the name, birth date and gender of all adult residents were provided by the Center for Disease Control (CDC) and by the local health board, which were compared, and from which information on participation could be derived. All methods for the project were approved by the institutional human subjects review boards of the Alaska Native Medical Center, the Public Health Service, the University of Alaska, and the Johns Hopkins University.

On the first day of the screening, subjects were visited at home for a dietary interview (data not presented). After an overnight fast, participants attended a diabetes and cardiovascular disease screening clinic, which included anthropometric measurements. Physical measurements included standing (height, weight, waist and hip circumferences, and skinfolds) and supine measurements (bioelectrical impedance analysis, sagittal abdominal diameter, and thigh circumference). The subjects undressed to underwear with one set of long underwear permitted. Men took off undershirts. A trained data collector conducted the series of measurements assisted by a recorder.

Weight was measured with one standard lever balance with an attached extendible arm for height measurement. For the height measurement, the subject stood flat-footed with the heels touching the back edge of the scale, the subject's head was positioned, and the T bar (ruler arm) was lowered to the top of the subject's head. In two villages the arm did not arrive with the balance, precluding its use in measuring height. A tape measure was secured to the wall next to the balance. The subjects' feet were flat with heels touching the wall, and a ruler was used in place of the arm.

Waist circumference was measured at the level of the umbilicus with the subject standing for both men and women. Hip circumference was measured at the point of the greatest circumference over the buttocks with the tape horizontal (parallel to floor) touching the skin, but not indenting the skin. The measurer took the waist and hip circumference measurement twice. If the two values differed by greater than 2 cm, then it was repeated for a third measurement.

The following skinfolds measurements were taken using Holtain calipers with the subject standing, with arms relaxed at the subject's sides. The non-dominant arm was used for measurement of triceps and biceps. All skinfolds measurements were repeated, removing the caliper and releasing the skinfolds between measurements. Skinfolds were measured twice with an additional measurement if the first two differed by more than 5 mm.

Before measurement of triceps and biceps, the site was marked. The length of the arm was measured from the tip of the acromial process of the scapula (bony portion of the shoulder) to the olecranon process of the ulna (elbow) with the subject's arm bent at approximately 90°. The midpoint on the skin was marked on the inside (medial) and outside (lateral) aspects of the arms (two marks). The double fold of skin was measured at the lateral midpoint for the triceps and at the medial midpoint for the biceps.

The measurer marked the site for the suprailiac skinfolds just above the iliac crest on the mid-axillary line. A diagonal double fold of skin and fat was measured 1 cm posterior to the marked site, following the normal cleavage line of the skin. For measurement of subscapular skinfolds, the inner angle of the scapula (shoulder blade) was located by palpation. The site just below the angle was marked. A diagonal (45°) fold of skin and fat was measured about 1 cm up and medial to the marked site.

For the thigh skinfolds, the measurer marked the bony tip of the hip bone. A measurement was made from this site to the tip of the patella (knee cap), noting the midpoint between the landmarks. The skin and fat thickness was measured vertically at the front of the thigh at the midpoint.

A hard, non-metal surface covered with a blanket was used for all supine measurements with a pillow placed at the head. The subjects reclined on the surface with their right side facing the measurer. The same mid-thigh mark used for thigh skinfolds was used in the thigh circumference.[27] With legs straight and feet relaxed and rotated outward approximately 60°, the tape measure was drawn around the thigh at the mid-thigh mark. The measurement was recorded to the nearest centimeter.

The technique for measurement of sagittal abdominal diameter was performed as described by Williamson using the Holtain–Kahn Abdominal Caliper, referred to as the 'abdometer'.[27] The flat fixed arm of the abdometer was slipped beneath the back at the mid-abdomen, which is approximately at the L4–L5 level. The movable arm was brought down to touch the surface of the abdomen without compression of the skin. The diameter was measured twice to the nearest 0.1 cm with removal of the caliper between measurements. The process was repeated a third time if the first two measurements differed by more than 1.0 cm. Due to hardware unavailability, sagittal abdominal diameter was not measured in the Inupiat village.

For measurement of bioelectrical impedance analysis (BIA) the subject was positioned according to the directions by RJL Systems, Inc. Electrodes were attached to the skin using stick-on plastic tabs, with emitting and detecting electrodes on the right hand and right foot of the subject, according to RJL anatomical landmarks. After the values were stabilized the measurer recorded the resistance and reactance as they were read from the screen.

Body mass index (BMI) was calculate by dividing the weight of the subject (kg) by the height squared (m^2; Quetelet's index). Percentage body fat was calculated from resistance and reactance readings using manufacturer's equations, as published with the Strong Heart Study data.[28] The results of these calculations will be referred to as 'percentage body fat (BIA)' in this text. Percentage body fat was also calculated from four skinfold measurements according to the regression equations developed by Durnin and Womersley,[29] and will be referred to as 'percentage body fat (DW)' in this text.

The circumference, skinfold and diameter are represented by the mean of the two most similar measurements. Waist-to-hip ratio (WHR) was calculated as waist circumference divided by hip circumference. Waist-to-thigh ratio was calculated as waist circumference divided by thigh circumference. Sagittal abdominal diameter (SAD)-to-thigh ratio was calculated as sagittal abdominal diameter divided by thigh circumference. Subscapular-to-triceps ratio was calculated as the subscapular skinfolds divided by the triceps skinfolds.

All statistical calculations were performed by use of SAS (SAS Institute, Cary, NC.) Ethnic group and gender differences were assessed via analysis of covariance (Ancova) tests with age entered first as a continuous variable, followed by either gender or ethnic group entered as independent variables.

The distribution of each variable was assessed. The ability of each variable to conform to a normal distribution was evaluated by visual examination of histograms. To improve the conformity to a normal distribution, transformations were used. The square root transformation was used for triceps skinfolds, and WHR. The log transformation was used for biceps skinfolds, subscapular skinfolds and thigh skinfolds.

All interaction terms were explored. A multiple comparisons test, Tukey's HSD, was used to make conservative estimates of differences between villages. For statistically significant differences according to this test the P-value was noted ≤ 0.05.

The proportion of participants in high/low WHR groups was determined after adjustment for age group and for BMI group. Categorical data analyses were used to determine differences in these proportion for all subjects between 35 and 74 y between ASP and Reeder's Canadian study[29] for each gender, and between genders for each study.

Results

The participation of eligible subjects with ASP 1994 has been described.[24] Of the 497 eligible men and 402 eligible women, 214 men (43%) and 240 women (60%) participated in the screening clinic. The percentage of eligible residents that participated was 69% among the Central Yupik, 55% among the Inupiat, and 44% among the Siberian Yupik people. Participation was higher for the older age groups with 66% of those ≥ 45 y and 41% of those < 45 y participating. The participation in the group of subjects 75 y and older was high (74%), but included only 31 individuals. As compared to the screening clinic alone, a higher proportion, 51% of men and 66% of women, participated in the overall study, which included a dietary interview the previous day (data not shown). Overall, 89% of the participants reported that all four grandparents were Eskimo, and only one was less than half Eskimo based on self-reported grandparent ancestry.

Crude means for each variable are shown between genders in Table 1 with comparisons after adjustment for age. Mean height, weight and subscapular-to-triceps ratio were higher in men than women. The women had larger waist, hip and thigh circumferences as well as larger skinfolds than the men. Women also had higher total body fatness as measured by BMI, percentage body fat (BIA) and percentage body fat (DW). There were no statistically significant differences between men and women in sagittal abdominal diameter, WHR, waist-to-thigh ratio, and SAD-to-thigh ratio.

Comparisons of variable means after adjustment for age are presented for each ethnic group in Tables 2 and 3 for women and men, respectively. Mean height for men and women were largest in Inupiat subjects, smaller in Siberian Yupik participants, and again smaller still in Central Yupik participants. All of

Table 1 Physical measurements for Eskimo men and women of the Bering Straits Region, ASP 1994

	Female			*Male*			
Measurement	*n*	*Mean*	*s.e.*	*n*	*Mean*	*s.e.*	*Statistical significance*
Height (m)	239	153.9	6.2	211	165.8	6.2	*
Weight (kg)	240	65.4	14.5	212	72.1	14.3	*
Circumferences							
Waist (cm)	238	93.8	14.9	211	90.7	13.3	*
Hip (cm)	238	100.6	10.8	210	96	8.1	*
Thigh (cm)	238	52.4	6.6	212	50.6	5.6	*
SAD (cm)	181	20.7	3.5	162	20.6	3.3	ns
Skinfolds							
Triceps (mm)	232	20.2	8.2	209	10.4	5.3	*
Biceps (mm)	235	10.7	6.5	210	5.3	3.3	*
Subscapular (mm)	230	18.9	9.5	206	12	5.7	*
Suprailiac (mm)	230	21.4	10.9	205	16.2	8.2	*
Thigh (mm)	232	21.6	8.8	207	11	4.8	*
Ratios							
Waist-to-hip ratio	237	0.93	0.07	210	0.94	0.09	ns
Waist-to-thigh ratio	236	1.80	0.24	211	1.80	0.25	ns
SAD-to-thigh ratio	181	0.39	0.05	162	0.40	0.05	ns
Subscapular-to-triceps ratio	227	0.93	0.26	205	1.21	0.29	*
Body fatness							
BMI (kg/m^2)	239	27.5	5.5	211	26.2	4.9	*
Percentage body fat (BIA)	239	32.6	8.8	211	18.7	7.1	*
Percentage body fat (DW)	218	31.6	7.2	203	17.9	6.6	*

Crude data are presented; however, differences are after adjustment for age. Significant differences(*) between genders according to Ancova and Tukey's HSD ≤ 0.05). SAD = sagittal abdominal diameter.

Table 2 Physical measurements for Eskimo women of the Bering Straits Region (ASP, 1994) by ethnic group

	Central Yupik			*Inupiat*			*Siberian Yupik*		
Measurement	*n*	*Mean*	*s.e.*	*n*	*Mean*	*s.e.*	*n*	*Mean*	*s.e.*
Height (m)[a,b,c]	54	151.1	6.3	59	157.1	5.7	126	153.6	5.7
Weight (kg)[a,b]	54	62	13.8	59	70.9	14.2	127	64.4	14.4
Circumference									
Waist (cm)[b]	54	94.4	15.1	58	98.2	14.0	126	91.4	14.9
Hip (cm)[a,b]	54	98.0	9.3	58	105.7	10.4	126	99.4	10.9
Thigh (cm)[b]	54	52.7	6.7	57	50.2	5.1	127	53.3	7.0
SAD (cm)	54	21	3.4	0			127	20.5	3.5
Skinfolds									
Triceps (mm)[b]	51	20.4	9.1	58	22.8	7.5	123	18.8	7.8
Biceps (mm)	54	11.4	7.2	59	9.9	4.3	122	10.9	7.1
Subscapular (mm)[c]	50	21.7	10.1	56	19.6	8.2	124	17.4	9.5
Suprailiac (mm)[b,c]	50	26.8	8.6	57	28.9	7.9	123	15.8	9.7
Thigh (mm)	53	23.2	8.6	56	22.3	7.4	123	20.5	9.3
Ratios									
Waist-to-hip ratio[a,c]	54	0.96	0.08	58	0.93	0.06	125	0.92	0.07
Waist-to-thigh ratio[a,b,c]	54	1.80	0.22	56	1.97	0.22	126	1.97	0.22
SAD-to-thigh ratio[c]	54	0.40	0.05	0			127	0.39	0.06
Subscapular-to-triceps ratio[a,c]	49	1.07	0.30	55	0.88	0.24	123	0.90	0.24
Body fatness									
BMI (kg/m^2)	54	27.1	5.5	59	28.7	5.5	126	27.1	5.5
Percentage body fat (BIA)[b,c]	47	33.8	6.5	53	34.4	5.1	118	29.6	7.7
Percentage body fat (DW)[a,b]	54	31.5	8.9	59	36.2	7.8	126	31.4	8.9

Crude data are presented; however, differences are after adjustment for age. Statistical significance is designated for ethnic group differences by Ancova and Tukey's HSD as follows: [a]Inupiat–Central Yupik; [b]Inupiat–Siberian Yupik; [c]Central Yupik–Siberian Yupik. SAD = sagittal abdominal diameter.

Table 3 Physical measurements for Eskimo men of the Bering Straits Region (ASP, 1994) by ethnic group

	Central Yupik			Inupiat			Siberian Yupik		
Measurement	*n*	*Mean*	*s.e.*	*n*	*Mean*	*s.e.*	*n*	*Mean*	*s.e.*
Height (m)[a]	50	164.0	7.6	50	167.7	5.1	111	165.7	5.8
Weight (kg)[a]	51	67.9	12.8	50	76.8	17.3	111	71.9	12.9
Circumference									
Waist (cm)[a]	51	88.7	12.9	49	94.3	15.4	111	90.0	12.2
Hip (cm)	51	95.3	7.5	48	96.9	10.6	111	95.9	7.1
Thigh (cm)[a,b]	51	52.0	4.7	50	45.8	5.3	111	52.2	4.9
SAD (cm)	51	20.2	3.4	0			111	20.8	3.3
Skinfolds									
Triceps (mm)[b]	49	10.0	3.8	50	12.2	6.6	110	9.9	5.0
Biceps (mm)[b,c]	51	5.6	3.2	49	6.7	4.1	110	4.6	2.8
Subscapular (mm)[b]	50	12.3	4.3	47	13.5	6.9	109	11.1	5.6
Suprailiac (mm)[b,c]	47	19.1	7.7	49	17.9	7.8	109	14.1	8.2
Thigh (mm)[b,c]	51	11.8	4.2	46	12.1	5.3	110	10.1	4.7
Ratios									
Waist-to-hip ratio[a]	51	0.93	0.07	48	0.97	0.14	111	0.94	0.07
Waist-to-thigh ratio[a,b]	51	1.71	0.17	49	2.07	0.29	111	1.73	0.16
SAD-to-thigh ratio	51	0.39	0.05	0			111	0.4	0.05
Subscapular-to-triceps ratio	49	1.27	0.28	47	1.21	0.3	109	1.18	0.29
Body fatness									
BMI (kg/m^2)[a]	50	25.2	4.4	50	27.4	6.4	111	26.2	4.2
Percentage body fat (BIA)[b,c]	47	19.4	5.1	47	20.0	6.0	109	16.4	7.0
Percentage body fat (DW)	50	17.4	6.2	50	19.8	9.5	111	18.9	6.2

Crude data are presented; however, differences are after adjustment for age. Statistical significance is designated for ethnic group differences by Ancova and Tukey's HSD as follows: [a]Inupiat–Central Yupik; [b]Inupiat–Siberian Yupik; [c]Central Yupik–Siberian Yupik. SAD = sagittal abdominal diameter.

these differences were statistically significant for women, but only the Inupiat—Central Yupik difference was significantly different for men.

Weight and trunk circumference means were larger, while thigh circumference was lower for Inupiat participants of both genders. Weight and hip circumference means for women were significantly larger for Inupiat than for both other ethnic groups. Average waist circumference was significantly larger for Inupiat women than for Siberian Yupik women, but otherwise was not significantly different between ethnic groups. Inupiat women also had significantly smaller mean thigh circumference than women of both other ethnic groups.

For men, mean weight and waist circumferences were significantly larger in Inupiat participants than in Central Yupik participants. Hip circumference was not significantly different between ethnic groups for men. Thigh circumference means for men were significantly smaller for Inupiat than for Siberian Yupik subjects.

Skinfolds were smallest for Siberian Yupik participants compared with both other villages. For men, means of biceps, suprailiac and thigh skinfolds were significantly smaller for Inupiat men compared with both other Eskimo groups, while triceps and subscapular, skinfolds were significantly smaller for the Siberian Yupiks compared only with the Inupiat.

For women, the skinfolds measurements were also smallest for the Siberian Yupik subjects. Suprailiac skinfolds were significantly smaller for Siberian Yupik women than for both other ethnic groups. Triceps skinfolds were significantly smaller for Siberian Yupik women compared only with the Inupiat. Subscapular skinfolds means were also significantly smaller for Siberian Yupik compared with Central Yupik subjects.

Means of measurements of body fatness were highest for Inupiat participants, although statistical significance was not reached in all cases. For women, percentage body fat (BIA) was higher for the Inupiat subjects than for women of both other ethnic groups, but was not significantly different between Eskimo groups for men. Percentage body fat (DW) for both genders was significantly higher for Inupiat and Central Yupik participants compared with Siberian Yupik participants. BMI was not significantly different between ethnic groups for women, but for men was highest in the Inupiat, which was significantly higher compared with Central Yupik participants.

Measurements of upper *vs* lower body fat averaged highest for Central Yupik women and Inupiat men. For women, mean waist-to-hip ratio, SAD-to-thigh ratio, and subscapular-to-triceps ratio were highest for Central Yupik women, although waist-to-thigh ratio was highest for Inupiat women. For men, waist-to-hip ratio and waist-to-thigh ratio were highest for the Inupiat men. Neither subscapular-to-triceps ratio nor SAD-to-thigh ratio was significantly different between ethnic groups for men.

The proportion of subjects with high waist-to-hip ratio (defined as ≥ 0.8 for women and ≥ 0.9 for men) after adjustment for age was calculated for the ASP at different levels of BMI, and results were compared with the Canadian data reported by Reeder *et al*[1] (Table 4).

Table 4 Frequency and percentage participants with high WHR by age group and BMI status for Canadian[29] and Alaskan Eskimo (ASP, 1994)

	BMI (kg/m^2)	*Women* *WHR* ≥ *0.8*	*Men* *WHR* ≥ *0.9*
Canadian	≤25	282 (29)	340 (51)
	25–30	416 (58)	827 (78)
	≥30	363 (76)	426 (90)
ASP	<25	58 (91)	31 (42)
	25–30	48 (98)	50 (85)
	≥30	70 (99)	30 (100)

n = frequency, number of participants, % = percentage of subjects within the category (row percentage). The proportion of subjects with high WHR was significantly higher for Canadian men *vs* Canadian women (chi-square = 231.4, df = 1, $P \leq 0.0001$), lower for Eskimo men *vs* Eskimo women (chi-square = 52.0, d.f. = 1, $P \leq 0.0001$), and higher for Eskimo women *vs* Canadian women (chi-square = 131, d.f. = 1, $P \leq 0.0001$). All of these differences are across all levels of BMI.

At the lowest level of BMI (< 25 kg/m^2) 91% of ASP women had high WHR while fewer (29%) of Canadian women from the same age groups respectively had high WHR. At the highest BMI (> 30 kg/m^2) 99% of ASP women had high WHR, while much fewer (76%) Canadian women had high WHR. After adjustment for age group and across all levels of BMI, the Eskimo and Canadian studies were found to have significantly different proportions of high/low WHR women (chi-square = 129.7, d.f. = 1, $P \leq 0.0001$).

At the lowest level of BMI, 42% of ASP men had high WHR, while a similar proportion (51%) of Canadian men had high WHR. At the highest level of BMI (< 30 kg/m^2), 100% of ASP men had high WHR while 90% of Canadian men had WHR. These differences were not statistically significant across all levels of BMI, and after adjustment for age.

After adjustment for age and BMI status, Eskimo women had a significantly higher proportion of high WHR participants than Eskimo men (chi-square = 51.5, d.f. = 1, $P \leq 0.0001$). For the Canadian study, the proportion of men in the high WHR group was higher than for women across all levels of BMI, which was statistically significant after adjustment for age and BMI (chi-square = 231.36, d.f. = 1, $P \leq 0.0001$).

Discussion

Anthropometric measurements in this study distinguished the physical characteristics between the Eskimo men and women of the Bering Straits Region. The men in this study were taller and heavier than the women. Women, however, had more body fat with larger trunk and lower extremity girths, larger central and peripheral subcutaneous fat, and a larger proportion of peripheral *vs* central fat than men. Women were indistinguishable from men on the basis of upper/lower body fatness.

Some of the contrasts between the genders that were observed in this study have been found in other studies. As in this project, other studies have shown that women were shorter and weighed less,[28,30] had a higher percentage body fat[28] and had larger triceps and subscapular skinfolds[30] than their male counterparts. Gender differences in BMI among other research have been mixed. BMI was similar for men and women in the NHANES III cross sectional study of Americans,[31] higher for men than women for Canadians of all races of the Canadian Heart Health Survey[1] and, as in this study, higher for women than men for the Native American populations of the Strong Heart Study.[28]

Body fat distribution, which can be gender specific, was determined for this study via several different measurements. Each measurement examined the size of a fat depot in a different anatomic location. These fat depots may be described as toward the center of the body or located in the extremities (central *vs* peripheral). They also may be described as located around the waist and chest or around the hips and thighs (upper *vs* lower). More technically, fat can be located in subcutaneous compartments across much of the surface of the body, or in and around visceral organs (subcutaneous *vs* visceral). Some of the body fat distribution variables that were measured for this study reflect similar anatomic locations, while others measure a completely separate compartment.

Body fat depositions in central *vs* peripheral and upper *vs* lower body locations were examined by gender. Body fat distribution to central *vs* peripheral depots may differ by gender, as Hattori found in 18–23 y old Japanese men and women.[8] Women were found to have a higher proportion of body fat in subcutaneous depots compared to the proportion found in men.[8] This distribution follows the same patterns as for Alaska Native participants of this study in that women demonstrate a different depositon of peripheral fat than in men, women having a higher proportion in subcutaneous locations.

To our knowledge, no prior studies have documented similar WHR, waist-to-thigh ratio, or SAD-to-thigh ratio for men and women. In previous literature a consistent pattern of deposition of fat in upper *vs* lower trunk depots has been more characteristic for men than for women. Higher WHR in men than women has been observed in many ethically specific studies including those concerning Canadians,[1] Israelis,[32] Native Hawaiians,[33] Americans with heritage from Mexico and Europe,[34] Africans[35,36] and Native Americans.[28] Waist circumference and SAD, which may be even better predictors of cardiovascular outcomes,[37] are actually higher for women than for men in this study.

The similarity between genders in WHR for this study was due to the extremely high mean for women, as opposed to a low mean for men. ‘Extreme’ levels of

WHR have also been documented for southern Italian (ages 38 and 39 y, mean WHR = 0.82),[38] and Saudi Arabian (ages 20−48 y, mean WHR = 0.90)[39] women as compared to other European women. Eskimo women from this study had larger average waist circumferences than the Italian women, and similar average waist circumference compared with the Saudi Arabian women. In so far as WHR describes body habitus and risk for chronic disease, it is of considerable concern that the women studied in the ASP have a comparable or higher WHR when compared with populations having the highest reported average values in the world.

In other literature, upper body fat has been associated with many metabolic abnormalities. Waist-to-hip ratio has been associated with elevated triglycerides, low high-density lipoproteins[40−42] and elevated total cholesterol.[43] Cardiovascular disease has been associated with upper body fat distribution in women in some studies,[13,21,44,45] but not in others.[46,47] Body fat distribution has also been explored as a risk factor for type 2 diabetes.[18] An association has been demonstrated in women between WHR and diabetes status in women,[48] and specifically in obese women.[16,17] Association of WHR with serum glucose and serum insulin in pre-menopausal women[49] has also been observed. Kalkhoff, in a study of obese women, also found significantly higher serum glucose and insulin in the highest quartile of WHR compared with the lowest.[50]

Gender-based differences in WHR may account for the gender differences in incidence of heart disease.[44] Adjustment for WHR, therefore, may eliminate these differences in disease risk.[44] Women in this study may be at higher risk of heart disease, more similar to that of men, if the relationshipi with WHR holds true in this population.

The concern for Alaskan Eskimo women continues as comparisons were made with a sample of the general Canadian populatioin.[1] In the lower BMI subgroups Eskimo women are clearly more likely than Eskimo men, or Canadian men and women to have upper body obesity. In the high BMI subgroups Eskimo women are similar in proportion of higher WHR compared to Eskimo men, but still demonstrate a much greater proportion of subjects with high WHR than either Canadian men or women. This unusual finding is contrary to commonly found gender differences in body fat distribution, which demonstrate the typically male tendency toward upper body fat described by Vague as 'android'.[51]

Inherent differences between the Alaskan Eskimo and general Canadian populations may be indicated by these marked differences between the ASP and Canadian data. Variation in body fat distribution between other ethnic groups has been observed and reviewed.[11] Differences in body fat distribution have been documented between Mexican American and non-Hispanic White Americans,[39,52−54] between European ('white') and African Americans,[36,40,43] between European and Asian Americans,[10] between women of different European countries,[38,41] and between different ethinic groups within Mauritius,[55] the Pacific islands[56] and Israel.[32] These studies document differences in the association of body fat distribution measures with metabolic parameters, disease incidence, prevalence and mortality, or differences between intercorrelation of body fat composition measures. In other words, the risk associated with WHR for one population may not be transferable to other populations. Further, it may be inappropriate to apply cut-off levels for waist to hip ratios based on Caucasian populations to non-Caucasians.[36]

Ethnic differences were also examined for this study between the three ethnic groups within the ASP 1994. The full picture of body composition for each ethnic group is clearer for women than men, but is still evident in both genders. Compared with the other two ethnic groups, Inupiat subjects were tallest and carried more weight and body fat, although lower subcutaneous fat. Siberian Yupik subjects displayed the other extreme of having smaller weight and body fat and the smallest subcutaneous fat as compared to the other Eskimo groups. Central Yupik subjects displayed an unusual paradox of body fatness measurements. These subjects had smaller weight and hip circumference than the Inupiat and Siberian Yupik participants, but were not smaller statistically in body fat measurements than Inupiat participants. Also, along with Inupiat participants, Central Yupik subjects carried more subcutaneous fat than the Siberian Yupik participants. For women, Central Yupik subjects seemed to have relatively high upper to lower trunk fat, while Inupiat participants seemed to have the highest values for men.

Some portion of the observed differences between these small ethnically unique populations may be due to differences in the economic and lifestyle characteristics within each village or geographic location. Siberian Yupik subjects in this project reside in the only two Alaskan villages of Siberian Yupik heritage, while Inupiat and Central Yupik subjects were each represented by one village. The socioeconomic status, food availability, or other characteristics of these villages were not tested against the overall characteristics of these ethnic groups. It is difficult, therefore, to separate the lifestyle and dietary factors of the particular Inupiat and Central Yupik villages from the genetics and culture of the ethnic groups, as the representative nature of each village cannot be verified.

Menopausal status for women could confound any differences in comparison of body fat distribution among different ethnic groups within Alaska and between Alaskan Eskimo and Canadian studies. Menopausal status[9,57,58] and, more specifically, androgenicity in post-menopausal women[59] is associated with abdominal obesity. It is assumed that menopause occurs at a similar age across all ethnic groups within this study, and between Alaskan and the compared Canadian women, although this cannot be confirmed, and age adjustment should sufficiently eliminate differences in menopausal status between compared groups.

Study participation could certainly limit interpretation of these results. If under-represented subjects were mostly young men that were otherwise engaged in hunting or employment, one might expect their activity level (that is energy expenditure) to be higher than participants. Another interpretation might be that non-participating men included young men that hunted or were employed, who might have more native food sources or cash for buying groceries (that is energy intake). The relative probability of either of these scenarios is not known, but certainly either could limit extrapolation of these data to those under-represented groups. Further, the influence of possible response biases on the presented body fat distribution data cannot be predicted. Study participation for women was similar to that reported for the Strong Heart Study.[60]

In conclusion, this study documents a pattern of upper body fatness for Alaskan Eskimo women that is concerning. Neither the causes nor the implications of upper body fatness in Alaska Natives are clear. The acculturation process, however, continues to take the lifestyles and dietary habits further from the traditions of the past, and may be responsible in part for the observed body fat distribution of the participants in this study. Upper body fatness may be associated with alterations in glucose and lipid metabolism in this population, as has been found in others. If this speculation is true, increases in the incidence of chronic diseases can be anticipated. Follow-up studies in this population will be needed to document these possible changes.

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