

# ETHNICITY INFLUENCES BMI AS EVALUATED FROM REPORTED SERUM LIPID VALUES IN INUIT AND NON-INUIT: RAISED UPPER LIMIT OF BMI IN INUIT?

Paneeraq Noahsen, BA; Stig Andersen, MD, PhD

**Objective:** To identify thresholds of BMI at which similar levels of serum lipids occur in Inuit and in non-Inuit as the impact of obesity on metabolic risk factors differ in Inuit compared to other ethnic groups.

**Design:** Published comparative data among Inuit and non-Inuit whites on BMI and HDL-cholesterol and triglyceride were identified for analysis.

**Methods:** A literature search was done for BMI, lipids, Inuit and Greenland or Canada. Studies with data on triglycerides and HDL-cholesterol in Inuit and non-Inuit Caucasians were selected and data were retrieved.

**Main Outcome Measures:** Regression equations were computed for BMI and HDL-cholesterol and BMI and triglycerides. BMI for similar levels of lipids in Inuit and non-Inuit and ratios of Inuit/non-Inuit BMI's were calculated.

**Results:** At BMI 25 kg/m<sup>2</sup> HDL-cholesterol was 1.7/1.6 mM in Greenland Inuit/non-Inuit women and 1.7/1.5 mM in men in a major comparative study. HDL cholesterol decreased by 0.09 for each 1 kg/m<sup>2</sup> increase in BMI. Serum triglycerides were 1.0/1.1 mM for Greenland Inuit/non-Inuit women and 0.9/1.4 mM for men at BMI 25 kg/m<sup>2</sup>. Slopes were around 0.1. A comparative study in Canadian Inuit/non-Inuit gave similar results. The BMI levels required for similar HDL-cholesterol or triglycerides were around 27.5 kg/m<sup>2</sup>, and Inuit/non-Inuit BMI-ratios were around 1.1.

**Conclusion:** The same degree of dyslipidaemia was seen when Inuit had a 10% higher BMI compared to non-Inuit. This may support the establishment of Inuit-specific BMI cut-offs for the purposes of health screening and population health surveillance. (*Ethn Dis.* 2013;23[1]:77–82)

**Key Words:** BMI, Ethnicity, Inuit Eskimo, Triglycerides, HDL-cholesterol, Overweight, Obesity

## INTRODUCTION

The prevalence of overweight and obesity has risen sharply worldwide over the past decades<sup>1</sup> and a similar increase has been reported among Inuit in Alaska, Canada and Greenland.<sup>2,3</sup> This development is of concern as higher levels of body fat are associated with an increased risk of adverse health consequences. Thus, obesity has been shown to associate with dyslipidemia and increase the risk of glucose intolerance, type-2 diabetes, hypertension, and cardiovascular disease.<sup>4</sup>

Prediction of the disease risk can be done from measures of adiposity as documented in Western populations.<sup>5–7</sup> The anthropometric measures and indices proposed include body mass index (BMI), waist circumference (WC) and waist hip ratio (WHR), which are known predictors of metabolic syndrome and vascular health.<sup>5,7,8</sup> Yet, they are all indirect measures of adiposity, a fact that may explain some of their ineffectiveness in identifying metabolic risk, and researchers still dispute which measure of body fat is the more appropriate. A recent study of Canadian Inuit compared anthropometric measures with percent body fat measured by bioelectrical impedance.<sup>9</sup> The latter should be interpreted with caution as it needs to be validated in Inuit but this preliminary report finds a higher agreement between body fat and BMI than between body fat and WC or WHR.<sup>9</sup> This may suggest the use of BMI as an appropriate measure of overweight in Inuit.

Norgan calculated that a difference in sitting height/height ratio of 0.01 associated with a difference in BMI of 0.9 kg/m<sup>2</sup>.<sup>10</sup> A higher sitting-height/height ratio in Inuit compared to non-Inuit thus indicates a relatively higher

BMI<sup>11–13</sup> that may suggest the need for a higher BMI in Inuit for the same risk of disease.<sup>12,14,15</sup> Interestingly, the impact of obesity on metabolic indicators such as plasma lipids is lower in Inuit than in other populations.<sup>13</sup> This led us to evaluate available data for a difference in the association between BMI and serum lipids between Inuit and non-Inuit Whites, as it is crucial to identify accurate anthropometric markers of cardiovascular and metabolic risk among Inuit.

## METHODS

### Study Selection

We searched PubMed and Scopus for literature that included data on BMI, triglycerides and HDL-cholesterol in Greenland and Canadian Inuit and non-Inuit. In the first search, we used the search terms *BMI* and *lipids* and *Inuit* and *Greenland*. Of the seven articles found, two were relevant to our scope.<sup>2,14</sup> In the second search, we used the search terms *BMI* and *lipids* and *Inuit* and *Canada*. This provided three articles

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From the Arctic Health Research Centre, Aalborg University Hospital, Denmark

Address correspondence to Paneeraq Noahsen; Arctic Health Research Centre; Hobrovej 42D-1; 9000 Aalborg; Denmark; 99321960; 99326108 (fax); paneerak@yahoo.dk

and we identified one relevant to our scope in one of the article's reference list.<sup>15</sup> The selected literature was concordant with the study selection criteria, except for one article that lacked data on non-Inuit for comparison. We thus conducted another search using the search terms *BMI, Denmark, lipids, and obesity*. This search gave 67 responses, of which one included data useful for comparison with an Inuit study.<sup>3</sup> We also searched the reference lists of the articles found by the search engines. Thus, we acquired four articles applicable for our evaluation.<sup>3,5,14,15</sup>

### Sample

The study by Jørgensen et al<sup>14</sup> was a comparative study that included 1,108 Inuit (485/623 men/women) in the capital, a coastal town and four villages in West Greenland and 6,784 (3302/3482 men/women) Caucasian White Danes from the Copenhagen area. All inhabitants in the town and villages were invited while a random sample of the population was included from the capital Nuuk in Greenland and in Copenhagen. Study participants were aged 30 years or older and the mean age was comparable, being 47.3 years in Greenland and 46.0 years in Denmark. Inuit was defined by at least one Inuit parent reported by the participant. Height and weight were measured in undergarments. Serum lipids were measured in two laboratories by the same enzymatic calorimetric techniques with cross calibration.<sup>14</sup>

The study by Young<sup>15</sup> reported values for 387 Inuit (199/235 men/women). They invited a random sample of 20% of the population of the Keewatin region in Northwest Territories, Canada, and excluded 47 individuals who did not report full or part Inuit ancestry. The same methods were used in the Manitoba portion of the Canadian Heart Health Survey of southern non-Native American population from which data were used for comparison. Data are provided for age

groups <35 years, 35–49 and 50+ years but mean age is not reported. Height and weight were measured with the participant in undergarments and a hospital gown and serum HDL and triglyceride levels in Inuit and southern Canadians were measured at the National Lipid Reference Laboratory at the University of Toronto and used references traceable to the US National Cholesterol Reference Network.

The study by Deutch et al<sup>3</sup> was part of the Arctic Monitoring and Assessment Program (AMAP). It reported BMI in 406, serum HDL in 157, and serum triglycerides in 396 of the 413 Inuit men and women participants, aged 18 thru 49 years. Inuit were recruited by random selection from the districts of Ittoqqortoormiit and Tasilaq in East Greenland (192 men and women), and Qaanaaq, Uummanaq and Sisimiut in West Greenland (221 men and women). Inuit descent was defined as having more than two Greenlandic grandparents. Height and weight were measured with participants in undergarments. Triglycerides were measured at a laboratory in Canada and HDL cholesterol was measured at the University Hospital in Aarhus. The laboratory methods are not reported.

The study by Suadcani et al<sup>5</sup> included 2,982 men from Copenhagen. The mean age was 63 years, range 53–75. This area is dominated by ethnic Caucasians.<sup>16</sup> Height and weight were measured but further details are not reported. Serum HDL and triglycerides were measured using enzymatic assays (Boehringer-Mannheim Biochemica, Mannheim, Germany).<sup>5</sup>

### Analysis

Data from Jørgensen<sup>14</sup> and Young<sup>15</sup> were used to compute regression equations of HDL and triglycerides with BMI as explanatory variable. Mean values and standard deviations were used to calculate 90% and 95% prevalence intervals. From these, we computed

regression equations that were used to calculate the value of HDL and triglycerides at BMI 25 kg/m<sup>2</sup> for non-Inuit. These values for serum lipids were used to calculate a corresponding BMI for Inuit. The two different BMI values were used to compute an Inuit/ non-Inuit BMI ratio. Subsequently, these ratios were compared to ratios calculated similarly from the data by Deutch et al<sup>3</sup> and by Suadcani et al.<sup>5</sup>

## RESULTS

The data used for calculations are shown in Table 1. At BMI 25 kg/m<sup>2</sup> mean HDL cholesterol was 1.7 mM in Inuit and 1.6 mM in non-Inuit women while it was 1.7 mM and 1.5 mM respectively in men.<sup>14</sup> The slope for HDL cholesterol was  $-.08$  to  $-.10$  in Jørgensen's study,<sup>14</sup> and  $-0.06$  and  $-0.08$  in Young's research.<sup>15</sup> It was around  $-0.03$  in the studies included for comparison as found in Table 2. Thus, HDL cholesterol decreased by between 0.10 and 0.03 mM for each 1 kg/m<sup>2</sup> increase in BMI. Similarly, at BMI 25 kg/m<sup>2</sup> serum triglycerides was 1.0 mM for Inuit and 1.1 mM for non-Inuit women, while it was 0.9 mM and 1.4 mM for men.<sup>14</sup> Slopes were around 0.1<sup>14</sup> and 0.15<sup>15</sup> (range 0.07–0.28) suggesting an increase in triglycerides of 0.10 to 0.15 mM with an increment in BMI of 1 kg/m<sup>2</sup>.

The HDL cholesterol value corresponding to non-Inuit BMI set at 25 kg/m<sup>2</sup> was used to calculate an Inuit BMI at that particular HDL cholesterol level. Similar calculations were performed for triglycerides. Table 3 gives the calculated Inuit BMI values corresponding to a non-Inuit BMI of 25 kg/m<sup>2</sup> and the percentage the Inuit BMI was higher than non-Inuit BMI. All Inuit BMI were above the non-Inuit BMI, the lowest being 26.5 kg/m<sup>2</sup><sup>14</sup> and 26.4 kg/m<sup>2</sup><sup>15</sup> with similar values in the studies included for comparison. Also, ratios of Inuit/non-Inuit BMI with similar levels

**Table 1. Data on BMI, HDL and triglycerides available in the studies selected**

		Inuit					Non-Inuit				
		HDL (mM)		Triglycerides (mM)			HDL (mM)		Triglycerides (mM)		
		BMI	Mean	SD	Mean	SD	BMI	Mean	SD	Mean	SD
Jørgensen et al <sup>a</sup>	Men	26.6; 4.4	1.6	0.5	1.1	0.6	26.8; 4.0	1.3	0.4	1.6	0.4
	Women	26.8; 5.4	1.6	0.44	1.1	0.4	25.9; 5.1	1.55	0.4	1.2	0.4
Young <sup>b</sup>	Men	26	1.40		0.88		26	1.25		1.28	
		28	1.39		0.94		28	1.10		1.9	
		30	1.18		1.32		30	1.01		2.42	
	Women	26	1.66		0.95		26	1.45		1.15	
		28	1.45		1.2		28	1.30		1.45	
		30	1.33		1.4		30	1.21		1.86	
Deutch et al <sup>c</sup>		<20	1.55	0.44	1.18	0.54					
		25–30	1.35	0.56	1.59	1.20					
		>30	1.23	0.39	2.01	0.94					
Suadicani et al <sup>d</sup>	Men						<20	1.55	0.42	1.42	2.51
							20–25	1.44	0.36	1.28	0.61
							>25–27.5	1.33	0.32	1.55	0.82
							>27.5–29.9	1.27	0.34	1.91	1.29
							>30	1.17	0.28	2.14	1.47

<sup>a</sup> Data from reference 14, table 1. BMI given as mean; SD.

<sup>b</sup> Data from reference 15, tables 2 and 3.

<sup>c</sup> Data from reference 3, table VI.

<sup>d</sup> Data from reference 5, table 1.

of HDL and triglycerides were around 1.1 (Table 3).

## DISCUSSION

HDL-cholesterol, triglycerides and BMI were included for both non-Inuit and Inuit in one study in Greenland<sup>14</sup> and one study in Canada.<sup>15</sup> The former was the more comprehensive study but

the findings in Canadian Inuit were comparable. Also, the results were similar to findings in a comparison of separate reports in non-Inuit<sup>5</sup> and in Greenland Inuit.<sup>3</sup> The upper limits for normal BMI were alike when using either HDL-cholesterol or triglycerides, and the same degree of dyslipidaemia was seen when BMI was approximately 10% higher in Inuit compared to non-Inuit for both genders.

The BMI cutoff points proposed by the WHO for classification of overweight and obesity were derived primarily by visual inspection of the curve relating BMI and mortality in predominantly Caucasian populations of European descent.<sup>17</sup> The current thresholds may therefore not necessarily be appropriate in all ethnic groups.<sup>18,19</sup> Indeed, cross-sectional studies on Canadians with different ethnic backgrounds showed that uniform cutoff points for obesity result in marked variation in the levels of metabolic abnormalities between different ethnic groups.<sup>19,20</sup>

Recently the WHO has proposed specific BMI cutoff values for Asian populations<sup>21</sup> as Asians have a higher prevalence of cardiovascular disease than Caucasians for a given BMI. This was further substantiated by findings that South Asian men had a lower lean body mass,<sup>22</sup> a higher percentage of body fat for a given BMI,<sup>23</sup> and a greater proportion of visceral adipose tissue for a given total body fat compared to Europeans.<sup>24</sup> Interestingly, not only total fat and visceral fat but also the distribution of subcutaneous fat differed

**Table 2. Regression equations for the association between BMI and HDL and triglycerides**

			BMI-HDL	BMI-Triglycerides
Jørgensen et al <sup>a</sup>	Men	Inuit	HDL = $-0.09\text{BMI} + 3.99$	TG = $0.14\text{BMI} - 2.49$
		non-Inuit	HDL = $-0.10\text{BMI} + 3.98$	TG = $0.10\text{BMI} - 1.08$
	Women	Inuit	HDL = $-0.08\text{BMI} + 3.78$	TG = $0.07\text{BMI} - 0.88$
		non-Inuit	HDL = $-0.08\text{BMI} + 3.58$	TG = $0.08\text{BMI} - 0.83$
Young <sup>b</sup>	Men	Inuit	HDL = $-0.06\text{BMI} + 2.86$	TG = $0.11\text{BMI} - 2.0$
		non-Inuit	HDL = $-0.06\text{BMI} + 2.80$	TG = $0.28\text{BMI} - 6.1$
	Women	Inuit	HDL = $-0.08\text{BMI} + 3.79$	TG = $0.11\text{BMI} - 2.0$
		non-Inuit	HDL = $-0.06\text{BMI} + 3.00$	TG = $0.18\text{BMI} - 3.5$
Deutch et al <sup>c</sup>	Both	Inuit	HDL = $-0.03\text{BMI} + 2.23$	TG = $0.08\text{BMI} - 0.69$
Suadicani et al <sup>d</sup>	Men	non-Inuit	HDL = $-0.03\text{BMI} + 2.01$	TG = $0.09\text{BMI} - 0.75$

<sup>a</sup> Data from reference 14, table 1. BMI given as mean; SD.

<sup>b</sup> Data from reference 15, tables 2 and 3.

<sup>c</sup> Data from reference 3, table VI.

<sup>d</sup> Data from reference 5, table 1.

**Table 3. Ratio of Inuit:non-Inuit BMI at equal levels of serum lipids, the Inuit BMI with similar lipid levels to non-Inuit at BMI 25, and the percentage higher BMI in Inuit**

			BMI-ratio <sup>a</sup>	BMI	
			Inuit/Non-Inuit	Inuit <sup>b</sup>	Higher in Inuit <sup>c</sup>
Jørgensen et al <sup>d</sup>	Men	HDL	1.12	27.62	10%
		Triglycerides	1.16	28.64	15%
	Women	HDL	1.05	26.54	6%
Triglycerides		1.08	27.18	9%	
Young <sup>e</sup>	Men	HDL	1.14	28.36	13%
		Triglycerides	1.12	26.36	5%
	Women	HDL	1.09	27.93	12%
		Triglycerides	1.11	27.27	9%

<sup>a</sup> Calculated with HDL set at 1.4 and TG set at 1.2 mmol/L.

<sup>b</sup> BMI value where Inuit have similar lipid levels as non-Inuit have at BMI 25 kg/m<sup>2</sup>.

<sup>c</sup> %-higher Inuit BMI when non-Inuit BMI is 25 kg/m<sup>2</sup>.

<sup>d</sup> Reference 14.

<sup>e</sup> Reference 15.

Note: The equations given in Table 2 were used

between South Asian and European men.<sup>25</sup> This has not been investigated in Inuit but it may be speculated to contribute to the paradox of high prevalence of central fat patterning and low prevalence of obesity-related cardiovascular disease risk factors among Inuit.<sup>9</sup> Furthermore, our knowledge about the relationship between adiposity and metabolic risk is limited to an increase in adiposity that is paralleled by a rise in diabetes, impaired glucose tolerance, ischemic heart disease and hypertension, and the question of causality remains to be settled.

A recent study showed a higher agreement between body fat and BMI than between body fat and WC or WHR in Canadian Inuit.<sup>9</sup> They measured percent body fat by bioelectrical impedance. This is an indirect measure of adiposity that is based on the assumption that the body is a cylindrical-shaped ionic conductor where extra- and intracellular non-adipose tissues act as resistors and capacitors. Thus, bioelectrical impedance may be influenced by differences in these compartments such as ethnicity<sup>26</sup> and tissue hydration<sup>27</sup> and caution should be taken as this is yet another indirect measure of adiposity. This may explain some of their ineffectiveness in identifying met-

abolic risk. Also, the potential persistence of metabolically active brown fat in adult Inuit<sup>28</sup> could influence this association and the hypothesis of metabolically healthy obese Inuit is premature. Hence, there is a need for directly measured data linking adiposity to anthropometric measures in Inuit

The different findings of the usefulness of BMI among various ethnic groups may be overcome by establishing ethno-specific BMI cutoff values.<sup>18</sup> Some have argued to maintain an unaltered threshold because of a substantial variation in calculated cut-off values in different Asian populations.<sup>21</sup> However, it is hypothesized that the evolutionary radiation of circumpolar groups occurred quite rapidly and produced relatively low morphologic divergence among Inuit,<sup>29</sup> a theory supported by observations such as the narrow range of sitting height ratios among Canadian Inuit. Thus, Inuit may have more uniform anthropometric measures.

Our calculations support a higher BMI among Greenland Inuit compared to non-Inuit for similar lipid levels and favors the use of Inuit specific BMI cutoff points for overweight. This was proposed previously based on a different kind of data.<sup>30</sup> Height and weight were

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measured among 1,851 East Greenland Inuit between 1962 and 1964<sup>31,32</sup> who were fit<sup>33</sup> and without diabetes<sup>31</sup> or cardiovascular disease,<sup>34</sup> and upper limits of normal BMI were calculated to be set at 27.9 kg/m<sup>2</sup> for men and at 27.7 kg/m<sup>2</sup> for women.<sup>30</sup> These limits agree with our finding that Inuit BMI around 27.5 kg/m<sup>2</sup> corresponds to 25 kg/m<sup>2</sup> among non-Inuit. The authors advocated that the difference in BMI norms between Inuit and non-Inuit related to differences in body build.<sup>30</sup> Hence, Inuit-specific BMI cutoff values favor a more accurate prediction of metabolic risk. Still, this may cause difficulties in the comparison between populations and requires continuing evaluation as genetic admixture may decrease differences between Inuit and non-Inuit and cause subsequent underestimation of obesity rates.

Inuit have a larger torso and shorter limbs compared to non-Inuit<sup>9,11</sup> that gives Inuit a higher sitting-height/height-ratio (SH/H-ratio) compared to non-Inuit.<sup>11-13</sup> This influences BMI toward higher values<sup>10,35</sup> as the torso carries more weight per centimeter of height than do the limbs. Charbonneau-Roberts and colleagues found a sitting height/height ratio of 0.54 for Inuit and 0.52 for non-Inuit.<sup>12</sup> This difference corresponds to a 1.8 kg/m<sup>2</sup> higher BMI according to Norgan<sup>10</sup> and raises the upper limit of normal BMI to 26.8 kg/m<sup>2</sup>. This matches the results of our calculations.

Our study was restricted to an analysis of published data on serum lipids and BMI among non-Inuit and Inuit in comparative surveys. Data from one large study<sup>14</sup> was reported in detail and similar data from a smaller study provided similar results though calculations were hampered by BMI being reported in groups.<sup>15</sup> The similar findings in the two studies support the validity of our analysis. To further test the finding, we included additional data<sup>3,5</sup> in fewer Inuit with BMI reported in groups not matched for age or sex.<sup>3,5</sup> This decreases the precision of the findings as the difference in age may influence the results though dyslipidemia has similar effects between age groups.<sup>36</sup> Also, the preponderance of men in the non-Inuit comparison group could explain some of the smaller differences between Inuit and non-Inuit found in the comparison, as men tend to have slightly higher BMI than women. With these uncertainties the latter data should be interpreted with caution. Still, they conform to the calculations based on the studies by Jørgensen<sup>14</sup> and Young.<sup>15</sup>

Dietary differences between Inuit and non-Inuit may influence these findings.<sup>37</sup> The traditional Inuit diet provides a favorable n3/n6 fatty acids that lower triglycerides and may increase HDL in serum.<sup>3</sup> It may thus have a similar effect as BMI in our analysis. However, the effect of diet is limited<sup>37</sup> and the majority of participants in the major study were from the capital city<sup>14</sup> where the intake of traditional Inuit diet is limited.<sup>38,39</sup>

There is a relatively high homogeneity between Inuit in Greenland, Alaska and Canada and the comparisons in the two main studies were made with populations in Denmark and in southern Canada of mainly European descent. Still, some differences may be present that contributed to the differences in regression equations between the two studies used for comparisons.<sup>14,15</sup> Also, an influence of the time

span between the two main studies cannot be ruled out but a marked change in anthropometric measures is not expected within the 15 years.

Our evaluation was confined to an assessment of the associations between HDL-cholesterol and triglycerides in serum, and BMI. The results may be strengthened by similar evaluations of data on other risk factors. Still, this method cannot be used to settle ethno-specific BMI cut points. Whether the raised upper limit of BMI found in Greenland and Canadian Inuit is linked to different rates of diseases related to obesity remains to be determined in prospective studies with diseases as outcome variables; and our results point to the need for such studies.

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### AUTHOR CONTRIBUTIONS

*Design and concept of study:* Noahsen, Andersen

*Acquisition of data:* Noahsen

*Data analysis and interpretation:* Noahsen, Andersen

*Manuscript draft:* Noahsen, Andersen