BODY MASS INDEX MAY OVERESTIMATE THE PREVALENCE OF OVERWEIGHT AND OBESITY AMONG THE INUIT

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ABSTRACT

Body mass index (BMI) is a widely used body weight classification system but has known limitations, and may need to be adjusted for sitting height in order to be useful as an indicator of health risks in special populations. Data confirm that Inuit and Far East Asians have shorter legs and relatively higher sitting heights compared with all other populations. Using standing height alone to calculate the BMI may overestimate the number of individuals that are overweight and obese, and at risk for type 2 diabetes mellitus and cardiovascular disease among the Inuit. Measuring sitting height allows for the calculation of a sitting height-to-standing height ratio (SH/S) which can be used to correct the observed BMI. Incorporating sitting height measurements into health research could help formulate Inuit-specific screening guidelines. (Int J Circumpolar Health 2005;64(2):163-169.)

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INTRODUCTION

Body mass index (BMI) has become a widely used tool for identifying overweight and obese individuals (1,2). BMI is an index of weight to height (kg/m²), and while it is not a direct measure of body fat, or lean tissue, it is the most commonly used indicator of health risks associated with overweight (type 2 diabetes mellitus, insulin resistance and cardiovascular disease) and underweight (osteoporosis, infertility) (2). According to Canadian guidelines for body weight classification in adults, a BMI between 25 and 29.9 places individuals at increased risk of developing health problems compared with those in the normal range of 18.5 – 24.9 (2). As the BMI increases from 30 to 40, or above, the risk of developing health problems changes from high to extremely high (2,3).

Despite its usefulness as a body weight classification system, BMI has several limitations (2), and may not be an equally good indicator of risk in individuals, or populations, who have very long, or short legs relative to torso
length (4). BMI will tend to underestimate obesity among those with long legs and overestimate obesity among those with short legs relative to torso length. Empirically, the limitations of BMI have been demonstrated in research studies. For example, BMI underestimated obesity among the tallest, and overestimated obesity among the shortest men and women in a subset of normal, healthy adults from the NHANES III survey (5). Differences in leg lengths are reported to increase (5,6), or decrease BMI values by as much as five, or even ten units (kg/m²) (7). Other groups, or individuals, for whom the BMI may have certain limitations include young adults who have not reached full growth, adults who are very muscular, over 65 years of age, or belong to certain ethnic, or racial groups (2). To circumvent some of these difficulties, alternate anthropometric measurements have been suggested. Among them is a standardized BMI, which makes use of a sitting height measurement to correct the observed BMI by applying a correction factor based on a linear regression model (1,7).

The purpose of the current review paper is to explore the evidence for the extent to which sitting height may be a useful additional anthropometric indicator to include in research and whether it could help refine screening guidelines for Inuit adult populations.

**Sitting Height Methodology**

To measure sitting height, an anthropometer is placed against a wall or the edge of a sitting tool (box, chair or table), and the individual sits on this sitting tool as tall and as straight as possible, either with the forearms and hands extended forward, horizontally, and with the palms facing each other (8) (Figure 1), or with the hands resting on the thighs (9). Sitting height is then measured as the distance from the highest point on the head to the base of the sitting surface. No gold standard for sitting height measurements exists, but recommendations suggest that the back of the knees be in close contact with the edge of the sitting tool (9), or in contact with the edge (10), that the thighs and lower legs be at a 90 degree angle (9), and that the feet be supported by an adjustable shelf, although eliminating the latter has given results that are in close agreement (9).

Another option is to measure sitting height using a standard chair, or box, and then to subtract the height of the chair, or box, from the distance measured from the highest point on the individual’s head to the floor (9). The sitting height measurement could also be taken with an anthropometer placed directly on the chair, or box. In both cases, sitting height may not be as accurate since the chair may not be a completely flat surface, the individuals’ knees may not be in close contact with the edge of the chair, and thighs and lower legs may not necessarily be at a 90 degree angle. Using a combination of standing height and sitting height, leg length can be calculated by subtracting the sitting height from the standing height (9).

Finally, a sitting height table equipped with a sliding anthropometer adjustable for thigh length and an adjustable foot support may be used (Figure 1). Unfortunately, sitting height tables can be expensive, distributors are limited, and not all models are portable, which is a disadvantage for fieldwork. Whichever tool is used, a sitting height to standing height ratio (SH/S) can be used to correct the observed
BMI from the population under study to obtain a standardized BMI (1).

**Inuit specific context**

The emergence of obesity and chronic diseases, such as type 2 diabetes mellitus (DM), among Aboriginal populations in the Circumpolar North has become an area of public health concern (11-13). The prevalence of obesity among the Inuit, as measured by BMI, is now comparable to, and in some cases greater than, that of the general Canadian population (14) and the North American population (15). The prevalences of obesity and central fat patterning were noted to be particularly high among women (15).

In the early 1980s, a sample of Siberian Yupik Eskimo women was compared with a white and black reference population from the U.S. Health Examination Survey. Yupik women were shorter, with shorter leg lengths, but had sitting heights, body weights and tricep skinfold thicknesses similar to those of the reference population (16). Furthermore, BMI values and SH/S ratios among the Yupik were higher compared with the reference population, particularly for males (16). Other anthropological data also showed that Inuit leg lengths were shorter (17) and that the SH/S ratio for men (0.541) and women (0.540) were higher compared with the average Canadian ratios (18). Inuit of Greenland were also found to have a higher sitting height ratio than their Danish counterparts. When height for age among the Inuit of Greenland was compared to that of Europeans, the Inuit were found to be shorter, although their weight for height was higher (19).

SH/S ratios have been established for some populations, and to date, they are the highest among Far East Asians (0.55 in Japanese, 0.54 in Chinese and Koreans, and slightly less in Thai and Vietnamese) (20) and the Inuit (0.54) (18), compared with Europeans whose average ratio is 0.52 (1). However, it is important to discuss that, among Asian Indians, the health risks at any given level of obesity are higher compared to those among Caucasians (21-23). Plausible explanations for these differences in risk for any given BMI are that Asian populations have higher percentages of body fat, and lower levels of lean body mass for every level of BMI compared to Caucasians (21-23). These observations have led to the lowering of BMI cut-off points for Asian populations for identifying at-risk individuals (24).
However, when Canadian Inuit were compared with a white Canadian population, high BMI (kg/m²) was associated with fewer metabolic consequences than among the Canadian population (25). At each level of BMI, the Inuit had lower mean triglyceride and higher mean HDL-cholesterol values compared with a white Canadian population, and a high BMI had little effect on glucose and insulin levels (15), suggesting that BMI does not have the same degree of health-related implications among the Inuit. When making cross-cultural comparisons, underlying differences in the SH/S ratio could contribute to differences in the BMI’s predictive value for chronic disease risk factors. However, one cannot rule out potential metabolic differences due to genetics, dietary factors, or other factors associated with recent and ongoing acculturation (15). We note, for example, that similar contradictions in type 2 diabetes mellitus risk factors were observed between Greenlandic Inuit and a Danish comparison group across categories of waist circumference (26), suggesting that a standardized BMI alone would likely not fully account for differences observed in risk factors between Inuit and other populations. Future research is needed to clarify the interplay of anthropometric and other determinants of health risks among the Inuit.

The Usefulness of Sitting Height Measurements

Using a population’s SH/S ratio to standardize the observed BMI would most likely better represent the Inuit’s risk for chronic disease and prevalence of chronic energy deficiency. Among selected African groups and Australian Aborigines who have low SH/S ratios (i.e. proportionately longer legs), BMI alone would likely lead to an underestimation of overweight and obesity and an overestimation of the prevalence of chronic energy deficiency (1). For example, among Australian Aborigines, the long legs relative to torso length underestimated their observed BMI values by approximately 2 kg/m² (27). The data illustrate that uniform BMI cut-off values are not valid across all populations, and that body proportions may have to be accounted for when BMI is used to assess nutritional status (27) and risk of chronic disease.

The SH/S ratio can also be influenced by secular trends in anthropometric indices within populations (28). Sitting height measurements have been used to track secular changes in body proportions. Among a population from Southeast England, secular changes were related to a greater increase in lower- rather than upper-body growth (29). Also, researchers in Holland concluded that the secular trend of increased standing height was due to increased leg length (30). Among the Inuit of Greenland, a secular trend in height was also due to an increase in leg length observed among boys and girls between 1964 and 1997 (19). On the other hand, among Amerindian adults, no secular changes were observed in leg length (28).

Furthermore, sitting height has been used to measure growth velocity among children (19), and to assess scoliosis (31). Traditionally, weight for height measures are used to assess stunting in children’s growth patterns. However, its suitability should be questioned among children from various ethnic groups. Sitting height rather than arm span has also been shown to be a better choice for estimating pulmonary function in children with limb deformities (10).
In addition, sitting height measurements remain important in the design and layout of work stations among Navy personnel and other trades with limited spaces (8). Sitting height is a relatively simple measure and is feasible to determine in most situations. Inter-observer variations will, of course, always be present, as with standing height and other measurements, but they can be minimized by providing proper training.

Comparing BMI to the Predictive Value of Other Measures of Obesity

It is important to recognize that a normal range BMI does not dismiss health risks (21,32), just as a high BMI does not necessarily indicate a high health risk. BMI, in combination with other measures, is useful, because of its convenience and simplicity. Other commonly used measurements of obesity, such as bioelectrical impedance, skinfold thickness, waist circumference and waist-to-hip ratio, have been compared to BMI for their predictive value of risk factors for chronic diseases.

Bioelectrical impedance analysis (BIA) combines the impedance value with anthropomorphic data to provide body compartment measures (i.e. body fat %), but does not specify the location of body fat. It often replaces reference models, such as hydrodensitometry and dual energy x-ray absorptiometry (DEXA), because of its simplicity, speed, portability, affordability, non-invasiveness and, to some extent, acceptable results (33-37). While the epidemiological evidence strongly supports the association between upper-body obesity, in particular visceral obesity, and the development of obesity-related complications (38), the association between peripheral obesity and obesity-related complications is not as strong (39). Further, because the accuracy of BIA depends on the use of an appropriate prediction equation, it has been suggested that an equation be validated for each type of BIA analyzer and for each population (34). With measurements to differentiate ethnic-specific body builds, such as sitting height, or leg length, it may be possible to improve the prediction equation used to estimate body fat, making the results more population-specific (40).

Skinfold thickness is a tool used to measure subcutaneous fat and, again with the use of prediction equations, estimates total body fat (41). This method is inexpensive, relatively simple and very portable, but has several known limitations. For example, it requires a high degree of technical skill for consistent measurements of site locations, and there are considerable inter-observer variations in measurements (41). Further, the measurements do not always correlate well with body fat, especially among the obese (41–42) and older individuals (41), in whom the fat tends to reside well below the epidermis. Also, prediction equations have not been derived for all populations, restricting its use (41).

As for waist circumference, computed tomography demonstrated that waist circumference, or the abdominal sagittal diameter, were the preferred anthropometric correlates of the amount of abdominal visceral adipose tissue when compared to the waist-to-hip ratio (43). In a study by Clasey and colleagues, results from 76 Caucasian adults concluded that, in both men and women, waist circumference and abdominal sagittal diameter were the most predictive anthropometric measures.
of total abdominal fat ($r = 0.87$ to $0.93$) and abdominal visceral fat ($r = 0.84$ to $0.93$) and that the waist-to-hip ratio was the least predictive (44). Further, waist circumference values above about 100 cm, or abdominal sagittal diameters above 25 cm, were associated with disturbances in lipoprotein metabolism and plasma insulin-glucose homeostasis in both genders (43). Among Australian Aborigines, waist circumference was the best body size measurement in predicting diabetes (45). Waist circumference is a simple, convenient and reliable anthropometric index for determining the extent of abdominal obesity and the risk for related metabolic complications (43). The World Health Organization recommends that waist circumference be used within populations with a predisposition to central obesity and related risk for developing the metabolic syndrome, and that it be used to refine public health action levels in conjunction with BMI (24).

**CONCLUSION**

We recommend that sitting height be routinely incorporated into future cross-sectional and longitudinal health research evaluating the anthropometric determinants of health risks in populations with heterogeneous body proportions, or with body proportions that differ from those upon which standards are based. This will facilitate a better understanding of the interplay of risk factors related to diabetes and cardiovascular disease among the Inuit, and may help in the development of appropriate screening guidelines and prevention efforts.

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