OBESITY, ADIPOSITY, PHYSICAL FITNESS AND ACTIVITY LEVELS IN CREE CHILDREN

Carmina Ng [1], Dru Marshall [1], Noreen D. Willows [2]

[1]Faculty of Physical Education and Recreation, University of Alberta, Edmonton, Canada
[2]Faculty of Agriculture, Forestry and Home Economics, University of Alberta, Edmonton, Canada

Received 13 February 2006; Accepted 1 August 2006

ABSTRACT

Objectives. To describe the levels of obesity, adiposity measures, physical activity and fitness in Cree children aged 9-12 years.
Study Design. Cross-sectional survey.
Methods. The study took place in northern Quebec, Canada. Height, body mass, waist circumference and five skinfold thicknesses were measured. Physical activity was assessed by having children wear a pedometer for two days. Children performed the 20-metre shuttle run test (SRT) to determine their physical fitness level.
Results. Of 82 participating children, 33% were overweight (but not obese) and 38% were obese according to an international reference. The mean sum of five skinfold measures exceeded the 95th percentile of Canadian children. Compared with the Third National Health and Nutrition Examination Survey, the majority of children exceeded the 85th percentile for waist circumference (62%) and at the suprailiac (80%), subscapular (72%), and triceps (54%) skinfold sites. 90% of children scored below the 20th percentile in the SRT compared with normative data from Quebec children. Based on pedometer scores, only 49% of children were sufficiently active.
Conclusions. There is a high prevalence of overweight and central adiposity in this population, with low physical activity and fitness levels. This profile may result in adverse health outcomes.
(Int J Circumpolar Health 2006;65(4): 322-330.)

Keywords: aboriginal, waist circumference, skinfold thickness, physical fitness, child, obesity

INTRODUCTION

Using BMI to assign weight status, the number of children who can be considered obese in Canada is increasing (1) and the prevalence of obesity is reported to be even higher in Aboriginal (First Nations, Inuit, Métis) children than in the general population. Childhood obesity is associated with increased health risks, such as cardiovascular diseases and type 2 diabetes (2). The issue of excess body mass and adiposity in young First Nations children is particularly relevant given their potentially increased risk for type 2 diabetes (3,4). The Canadian Community Health Survey, completed in 2004, reported that Aboriginal children living off-reserve had an obesity prevalence of 20%, which was two and one-half times the national average for children (5). The First Nations Regional Longitudinal Health Survey (RHS) 2002-2003 of First Nations reserves across Canada revealed that 28.8% and 26.4% of the children aged 9 to 11 years who participated were overweight and obese, respectively (6). Other studies of obesity in remote Aboriginal communities support these observations that obesity is highly prevalent in childhood. For example, a study of children in St. Theresa Point First Nation in Manitoba (4) found that 64% of girls and 60% of boys exceeded the 85th percentile of reference values for BMI, and 40% of girls and 34% of boys exceeded the 95th percentile. Obesity in these children was associated with high fasting glucose and insulin levels and, for girls, the prevalence of diabetes was highest among those above the 95th percentile for BMI. While it appears from the information above that there is a significant existing problem in the Aboriginal population, the Aboriginal population is generally under-studied, and many of the studies that have been conducted used self-report data and were not comprehensive in scope.

There are limitations to the data about obesity in Aboriginal children (7). Not all studies have used measured heights and body mass to estimate overweight prevalence, despite known bias in data that is not directly measured. Self-reported measures underestimate the prevalence of overweight and obesity (8), whereas parents tend to underestimate their children's height, thus inflating estimates of overweight prevalence (5). Furthermore, many studies have placed children into weight categories using an American reference (9), which provides higher prevalence estimates of obesity in young children than the international reference that is recommended for population comparisons (10). In addition to limited information on the prevalence of obesity as determined from measured heights and body mass, there is a lack of data on adiposity measures, such as waist circumference and skinfold thicknesses, as well as physical fitness and activity levels. This additional information might aid in the interpretation of obesity data and be applied to the development of interventions to prevent obesity in children.

We wanted to address some of the methodological and measurement shortcomings of many of the previous studies of obesity in children in Aboriginal communities. Specifically, the aim of this paper was to describe the levels of obesity, adiposity, physical activity and fitness in First Nations (Cree) children living in northern Quebec, using objective measures. The prevalence of overweight and obesity was derived from measured heights and body mass using the International Obesity Task Force's (IOTF) definitions (11) to assign body mass categories and to allow international comparisons. Waist circumferences and skinfold thickness measures compared with the Third National Health and Nutrition Examination Survey (NHANES III) (12) were used as a verification of adiposity in children. Fitness was assessed using Leger's shuttle run test (13), and physical activity was ascertained using pedometers. The use of direct measures is a major strength of this study. We hypothesized, based on existing literature, that Cree children would have a high prevalence of obesity and adiposity and low fitness and activity levels.

MATERIAL AND METHODS

Study population

The Cree Nation of Mistissini is located 830 km north of Montreal, Quebec, Canada. Mistissini is the second largest Cree community of the James Bay Cree region of Quebec, with an approximate population of 3500, and is accessible by road. This community was selected for participation because of larger enrolment numbers of elementary school children.

Cree children regularly attending grades four to six (n = 112) in Mistissini were given information letters and consent forms to take home. For those children whose parents, or guardians, gave permission for their child to participate, the child's decision about participating was respected. Announcements were made through the local radio station informing community members of the general purposes of the study and researchers provided schoolteachers and each class with a demonstration of the procedures involved.

All research materials and procedures were pilot tested on a sample of children (n = 42) from the school in June 2004. Based on pilot testing, one physical activity questionnaire was removed from the test battery due to language difficulties. All other procedures were deemed appropriate. Data reported here were collected during October and November 2004. This study was approved by the Human Research Ethics Board of the Faculty of Agriculture, Forestry and Home Economics at the University of Alberta, and was supported by the Cree Board of Health and Social Services of James Bay, the school principal in Mistissini, and members of the 'Active Kids Project' Steering Committee in Mistissini.

Anthropometric variables

Children were measured for height, body mass and waist circumference without shoes and in minimal indoor clothing. Height was measured using a set square and a tape measure and recorded to the nearest centimeter. Body mass was measured using a portable scale (Health-O-Meter Professional Scale, Model HAP300-01, Boca Raton, FL, US) and recorded to the nearest pound. This was later converted to kilograms by dividing body mass in pounds by 2.2. Waist circumference was measured with a fiberglass tape measure at the level of the umbilicus, recorded to the nearest centimeter, and used as a measure of central adiposity.

Skinfold thicknesses were measured by a trained tester using a Harpenden skinfold caliper (Model HSK-BI, Baty International, West Sussex, UK) at five sites: triceps, biceps, subscapular, suprailiac and medial calf. Body sites were selected from the right side of the body and measurements were taken in accordance with standardized techniques (14) and recorded to the nearest 0.2 mm. Each skinfold was measured twice. If the first two measurements differed by greater than 0.4 mm, a third measurement was taken (15). The mean value of the closest two readings was recorded as the measured thickness. The sum of five skinfolds was used to indicate overall adiposity.

Body mass classification

BMI (BMI = body mass/height^2) was calculated to the nearest 0.01 kg/m^2. Students were classified into three body mass categories (i.e., normal, overweight and obese) based on the IOTF's age- and gender-specific definitions (11).

Physical fitness

Students completed the Leger 20-meter shuttle run test (SRT) (13) during physical education class. Students ran back and forth between two lines 20 meters apart in the school gymnasium at a progressively increasing pace, set by an audio-recorded beep, until they were no longer able to maintain the pace, or they voluntarily stopped running. The SRT score was equivalent to the time recorded when a student failed to reach within two strides of one of the end lines two consecutive times, or when they voluntarily stopped running. Maximal effort was encouraged by verbal prompting from researchers and classmates. Comparative normative data from Quebec schoolchildren were available for this test.

Physical activity level

Students wore a pedometer (Yamax SW-200 Digiwalker, Yamasa Corp., Tokyo, Japan) for two school days. In the pilot study, there was no significant difference in this population between two and three days of recording, so we decided to go with two days to increase children's compliance. Each morning during the first class, pedometers were placed on students. Pedometers were attached to the student's waistband, or belt, at a position directly in line with the patella. For students who experienced discomfort in wearing the pedometer at this position, researchers attached the pedometer to the student's back waistband, directly in line with the midline of the posterior surface of the knee. Each student was individually instructed on how the pedometer should be worn and attached. Students were provided with an information sheet about pedometers to take home, and were asked to demonstrate that they understood the instructions by removing and reattaching their pedometer. Researchers verified that the pedometer was positioned correctly by checking the step count after the student walked 20 steps. Once this verification was done, pedometers were sealed with a cable tie to prevent accidental resetting, and to discourage behaviour modification due to access to the pedometer's step count. Students were asked to not tamper with the seal. Researchers collected the pedometers each morning, recorded the pedometer score, then reset, resealed and reattached the pedometer to the student. Students were verbally asked to confirm that they had worn the pedometer the entire previous day (except during bathing or sleeping). A small prize (e.g., pencil, eraser, notepad) was given for each day the student returned the pedometer. Optimal age- and gender-specific standards for steps per day related to international BMI cut points for body mass status were used to determine whether children were sufficiently physically active (16). Boys who accumulated 15 000 steps per day or more, and girls who accumulated 12 000 steps per day or more, were considered to have met physical activity recommendations. During the time of data collection, weather was not particularly inclement and should not have affected physical activity patterns.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (version 13.0 for Windows, SPSS Inc., Chicago, IL, US). Means and standard deviations were computed for all numerical variables for each gender and body mass status group. T-tests were used to assess any differences in adiposity measures between genders. One-way analyses of variances (ANOVA) were carried out to assess differences among body mass groups. Tukey's procedure was used to evaluate possible contrasts if an overall F-value was significant ($p < 0.05$). The Bonferroni correction was used for multiple comparisons.

RESULTS

Of the 112 students who were invited to participate, the parents or guardians of 105 students provided consent. One child declined to be weighed. We report the results for the 82 students who had complete data for all measures and tests (females n = 48; males n = 34) (participation rate 73%). Mean (± SD) age, height, body mass, BMI, waist circumference, skinfold thicknesses, SRT score and two-day pedometer step count average are presented by body mass status group and gender in Tables I and II, respectively. Boys and girls had statistical differences in height, medial calf skinfold and pedometer scores; however, only pedometer scores were statistically different after the Bonferroni correction was applied, with girls taking fewer steps than boys (Table II).

Adiposity and obesity measures

Using international reference standards, 24 (29%) of the 82 students had normal weight, 27 (33%) were overweight (but not obese) and 31 (38%) were obese. Fifty-one children (62%) had waist circumferences (i.e., central adiposity) that met, or exceeded, the 85th percentile of gender- and age-matched children from the NHANES III cohort (12). NHANES III reference data were available for the triceps, subscapular and suprailiac skin-

Table I. Adiposity measures, fitness and pedometer scores by body mass status (mean ± SD).

Variable	Normal (n = 24)	Overweight (n = 27)	Obese (n = 31)	F	p
Age (y)	10.6 ± 1.2	10.7 ± 1.0	10.8 ± 1.0	0.069	0.933
Height (m)	1.45 ± 0.08	1.48 ± 0.09	1.52 ± 0.08	4.799	0.011
Body mass (kg)	38.8 ± 6.3	49.8 ± 8.8	68.6 ± 12.8	63.777	0.000*
BMI (kg/m^2)	18.24 ± 1.57	22.58 ± 1.91	29.50 ± 3.6	41.399	0.000*
Waist (cm)	67.1 ± 6.2	80.1 ± 7.5	96.5 ± 9.1	34.228	0.000*
Triceps (mm)	14.3 ± 4.2	21.3 ± 4.4	30.0 ± 5.8	18.254	0.000*
Biceps (mm)	8.5 ± 2.8	13.0 ± 3.8	19.5 ± 5.2	13.777	0.000*
Medial Calf (mm)	13.6 ± 4.2	22.4 ± 6.6	34.0 ± 10.2	14.824	0.000*
Subscapular (mm)	13.5 ± 6.6	26.9 ± 7.6	42.4 ± 12.4	20.323	0.000*
Suprailiac (mm)	22.9 ± 10.4	38.8 ± 12.1	56.0 ± 14.1	17.065	0.000*
Sum of Skinfolds (mm)	72.8 ± 24.8	122.4 ± 27.0	181.9 ± 39.0	21.691	0.000*
Shuttle Run Score (min)	3.27 ± 1.33	2.29 ± 0.82	1.53 ± 0.78	21.006	0.000*
Pedometer Score (steps/day)	13525 ± 3915	13900 ± 4611	11970 ± 5391	1.357	0.263

* significant difference among all body mass status groups ($p \leq 0.001$)

Table II. Adiposity measures, fitness and pedometer scores by gender (mean ± SD).

Variable	Male (n = 34)	Female (n = 48)	p
Age (y)	10.1 ± .886	10.4 ± 1.067	0.123
Height (cm)	1.46 ± 0.09	1.51 ± 0.08	0.011
Body mass (kg)	110.0 ± 32.0	123.8 ± 36.3	0.072
BMI (kg/m^2)	23.14 ± 4.82	24.49 ± 5.69	0.249
Waist (cm)	81.6 ± 13.6	83.1 ± 15.1	0.651
Triceps (mm)	20.8 ± 8.2	23.8 ± 7.9	0.111
Biceps (mm)	13.3 ± 7.0	14.7 ± 5.4	0.325
Medial Calf (mm)	20.5 ± 9.9	26.8 ± 11.7	0.011
Subscapular (mm)	30.0 ± 15.5	28.0 ± 15.0	0.572
Suprailiac (mm)	41.5 ± 21.0	40.0 ± 16.4	0.726
Sum of Skinfolds (mm)	126.2 ± 58.4	133.4 ± 52.4	0.570
Shuttle Run Score (min)	2.59 ± 1.48	2.08 ± .92	0.085
Pedometer Score (steps/day)	15808 ± 5167	11115 ± 3322	0.000*

* significant difference between genders (p ≤ 0.001)

fold thicknesses. A high percentage of students exceeded the 85th percentile for triceps (54%), subscapular (72%) and suprailiac (80%) skinfolds, and 42 students (51%) exceeded the 85th percentile for all three skinfolds. There were no significant gender differences among adiposity measures.

Physical activity and fitness level

In general, children exhibited very low physical fitness based on SRT scores (group mean = 2.29 ± 1.20 stages completed, range 0.30 to 7.25). Obese children achieved significantly lower fitness scores on the SRT compared with overweight, or normal-weight children (Table I). Using comparative normative data of age- and gender-matched Quebec children (13), 67% of normal-weight (n = 16), 96% of overweight (n = 26), and 100% of obese children (n = 31) had fitness scores that were below the 20th percentile.

Forty children (49%) met pedometer recommendations (12,000 steps per day for girls, and 15,000 steps per day for boys). Mean pedometer step counts did not differ significantly among body mass groups.

DISCUSSION

While it appears that there is a significant problem of obesity in Aboriginal children in Canada, many studies of Aboriginal populations have used self-, or parent-reported data and were not comprehensive in scope. Using measured heights and body mass, we found that 71% of this sample of Cree children aged 9 to 12 years in northern Quebec were overweight, or obese. The prevalence of obesity in this study population is about four times that of the general Canadian population of children (38% vs. 9-10%, respectively) (17), but is more similar to reported rates of obesity for children living in several First Nations communities (6). Based on our analyses, high BMI in Cree children can be attributed to excess subcutaneous fat mass. The mean of the sum of the five skinfold measures for this sample exceeded the 95th percentile of gender- and age-matched Canadian children from the 1980s (18). In addition to indicating excessive adiposity, the results of this study suggest that this sample of Cree children exhibits high levels of truncal obesity, an indicator of increased health risk (19-21). Compared with a sample of age-matched Mohawk children living in Kahnawake, Quebec, mean subscapular skinfold thicknesses were more than two times higher for the Cree children of this study, while triceps skinfold thicknesses were approximately 30 to 50% higher (22). This pattern of having comparable skinfold thicknesses in the extremities, but substantially higher skinfolds in the truncal region, was also observed when comparing the results with a sample of gender- and age-matched urban Ojibwe and Dakota/Lakota children from Minnesota (23). The Cree children of this study had similar triceps and biceps skinfold thicknesses as the Native American children, but truncal skinfold thicknesses at the subscapular and suprailiac sites averaged approximately 10 mm higher. In addition, all skinfold and waist measures in Cree children were higher when compared with a sample of 7- to 11-year-old Native American children from Arizona (24). Central fat patterning, assessed by skinfold thickness or waist circumference measures, has been observed as a correlate of various disease risk factors, including elevated serum indicators of diabetes risk (25-27), blood pressure (23) and lipid levels (28).

Half of the children met physical activity recommendations according to pedometer step counts (16). At the same time, this population demonstrated extremely low physical fitness. Ninety percent of the students, many of whom were overweight or obese, scored at or below the 20th percentile of reference data from the early 1980s from a sample of gender- and age-matched Quebec children (13). It may be that children are active, but not at a sufficient intensity to cause a fitness or health benefit. Since pedometers do not measure intensity of activity, the potential mediating influence of activity intensity will need to be explored in future studies. These results were similar to results from Sandy Lake First Nation in northern Ontario, which revealed that the risk of overweight was significantly higher in children with fitness scores in the first quartile (i.e., low fitness levels), compared with those children in the third and fourth quartiles (29). However, as the present study was cross-sectional, the causal relationship between fitness and body mass status is not known. Diet is another obvious mediating variable in the development of obesity, but was beyond the scope of this report. Further work is required to determine causative factors of the high obesity rates seen in Aboriginal populations.

One strength of this study is that measured, rather than reported, heights and body mass were obtained from children, eliminating body mass classification based on biased reporting. In addition, high adiposity was confirmed in children using measures other than BMI. Since BMI does not account for differences in body composition, skinfold thicknesses at five sites and waist circumference were measured. While these measures of central fat patterning can be superior indicators of health risk than BMI alone in Aboriginal populations (20, 21), this study was able to describe both overall and central fat patterning through BMI, waist circumference and multiple skinfold measures, in recognition that overall obesity without excessive central obesity can also be predictive of adverse health outcomes (30).

Another strength of this study was that physical fitness and activity levels were included and were empirically derived from a maximal fitness test and pedometer counts, respectively, rather than submaximal testing or questionnaires. At the same time, the limitations of the tests used need to be acknowledged. The SRT ends voluntarily, or when students are unable to run fast enough to maintain a pre-determined pace. Thus, this test has a motivational component, and it is possible that there were motivational differences among the students.

Pedometers are worn at the hip and are most sensitive to ambulatory activities, such as walking or running (31). Therefore, pedometers are less able to record movement from activities such as bicycling or skating. Despite the fact that these two activities were found to be popular with the Cree children from a pilot study, for almost all children in Mistissini, walking is the primary form of transportation around the community and is the predominant form of physical activity. Specifically, the intention of this study was to determine the daily or habitual quantity of physical activity. However, the inability of pedometers to record some physical activities is a limitation that is recognized and may have contributed to the lack of relationship with body mass status. In addition, pedometers are unable to measure intensity or duration of activity. Thus, it was not possible to explore the relationships between these parameters of physical activity in relation to obesity, adiposity, or fitness.

This community-based study permitted us to obtain a variety of anthropometric measures for a large proportion of First Nation children in grades four to six in a Cree community. Few studies in First Nations children have collected such broad data on adiposity, physical activity and fitness levels. This knowledge will facilitate the development of interventions to prevent obesity. As only two First Nations community in Canada have formally tested school-based obesity prevention programs (22,32), it is important to develop a more substantial evidence base so that culturally appropriate interventions may be developed.

Conclusions

In conclusion, there is a high prevalence of overweight and obesity among this sample of Aboriginal children living in northern Quebec. Of particular concern is the level of central adiposity, as demonstrated by high waist circumferences and truncal skinfold thicknesses that are associated with the development of metabolic and cardiovascular diseases. This risk profile is intensified by the accompanying low physical fitness and inadequate activity levels. Further research is necessary to investigate the extent of the impact of excess body mass and unfavourable body fat distribution on disease risk and health outcomes, in conjunction with its relationships with physical fitness and activity levels in Canadian First Nations children.

Acknowledgements

This research was funded by the Canadian Institutes of Health Research. We wish to thank the community of Mistissini and all the children who participated in this study. This research was funded in part by a New Emerging Team (NET) grant from the Canadian Institutes of Health Research (CIHR)-Institute of Nutrition, Metabolism and Diabetes, in partnership with the Heart and Stroke Foundation of Canada. Dr. Willows acknowledges The Alberta Heritage Foundation for Medical Research for salary support.

REFERENCES

1. Tremblay MS, Katzmarzyk PT, Willms JD. Temporal trends in overweight and obesity in Canada, 1981-1996. Int J Obes Relat Metab Disord 2002; 26: 538-43.
2. Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. Int J Obes Relat Metab Disord 1999; 23: S2-11.

3. Dean H. Type 2 diabetes in youth: a new epidemic. Adv Exp Med Biol 2001; 498: 1-5.
4. Young TK, Dean HJ, Flett B, Wood-Steiman P. Childhood obesity in a population at high risk for type 2 diabetes. J Pediatr 2000; 136: 365-9.
5. Shields M. Measured obesity. Overweight Canadian children and adolescents. Statistics Canada. Catalogue no. 82-620-MWE2005001: Ottawa 2005.
6. First Nations Centre. Children's survey: preliminary findings of the First Nations Regional Longitudinal Health Survey (RHS) 2002-2003. National Aboriginal Health Organization: Ottawa 2005.
7. Willows ND. Overweight in First Nations children: prevalence, implications, and solutions. J Aborig Health 2005; 2: 76-86.
8. Strauss RS. Comparison of measured and self-reported weight and height in a cross-sectional sample of young adolescents. Int J Obes Relat Metab Disord 23(8):904-8 1999; 23: 904-8.
9. Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. Arch Pediatr Adolesc Med 1995; 149: 1085-91.
10. Willows ND, Johnson MS, Ball GDC. Prevalence estimates of pediatric overweight and obesity in First Nations preschool children using international and U.S. reference criteria. Am J Public Health (in press).
11. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000; 320: 1240-3.
12. National Center for Health Statistics. Third National Health and Nutrition Examination Survey (1988-1994). Public Health Service: Hyattsville, Maryland 1998.
13. Leger L, Lambert J, Goulet A, Rowan C, Dinelle Y. Aerobic capacity of 6 to 17-year-old Quebecois - 20 meter shuttle run test with 1 minute stages. Can J Appl Sport Sci 1984; 9: 64-9.
14. Lohman TG, Roche AF, Martorell R, eds. Anthropometric Standardization Reference Manual. Human Kinetics: Champagne, IL 1988.
15. Fitness Canada. Canadian Standardized Test of Fitness (CSTF) Operations Manual. 3rd Ed. Fitness and Amateur Sport, Canada: Ottawa 1986.
16. Tudor-Locke C, Pangrazi RP, Corbin CB, et al. BMI-referenced standards for recommended pedometer-determined steps/day in children. Prev Med 2004; 38: 857-64.
17. Willms JD, Tremblay MS, Katzmarzyk PT. Geographic and demographic variation in the prevalence of overweight Canadian children. Obes Res 2003; 11: 668-73.
18. Fitness Canada. Canada Youth Fitness 1981. Canada Fitness Survey. Fitness & Amateur Sport: Ottawa 1985.
19. Hanley AJ, McKeown-Eyssen G, Harris SB, et al. Cross-sectional and prospective associations between abdominal adiposity and proinsulin concentration. J Clin Endocrinol Metab 2002; 87: 77-83.
20. Wang Z, Hoy WE. Body size measurements as predictors of type 2 diabetes in Aboriginal people. Int J Obes Relat Metab Disord 2004; 28: 1580-4.
21. Wang Z, Hoy WE. Waist circumference, BMI, hip circumference and waist-to-hip ratio as predictors of cardiovascular disease in Aboriginal people. Eur J Clin Nutr 2004; 58: 888-93.
22. Macaulay AC, Paradis G, Potvin L, et al. The Kahnawake Schools Diabetes Prevention Project: intervention, evaluation, and baseline results of a diabetes primary prevention program with a native community in Canada. Prev Med 1997; 26: 779-90.
23. Smith C, Rinderknecht K. Obesity correlates with increased blood pressures in urban Native American youth. Am J Hum Biol 2003; 15: 78-90.
24. Lohman TG, Caballero B, Himes JH, et al. Estimation of body fat from anthropometry and bioelectrical impedance in Native American children. Int J Obes Relat Metab Disord 2000; 24: 982-8.
25. Connelly PW, Hanley AJ, Harris SB, Hegele RA, Zinman B. Relation of waist circumference and glycemic status to C-reactive protein in the Sandy Lake Oji-Cree. Int J Obes Relat Metab Disord 2003; 27: 347-54.
26. Daniel M, Marion SA, Sheps SB, Hertzman C, Gamble D. Variation by BMI and age in waist-to-hip ratio associations with glycemic status in an aboriginal population at risk for type 2 diabetes in British Columbia, Canada. Am J Clin Nutr 1999; 69: 455-60.
27. Hanley AJ, Harris SB, Gao XJ, Kwan J, Zinman B. Serum immunoreactive leptin concentrations in a Canadian aboriginal population with high rates of NIDDM. Diabetes Care 1997; 20: 1408-15.
28. Young TK. Obesity, central fat patterning, and their metabolic correlates among the Inuit of the central Canadian Arctic. Hum Biol 1996; 68: 245-63.
29. Hanley AJ, Harris SB, Gittelsohn J, Wolever TM, Saksvig B, Zinman B. Overweight among children and adolescents in a Native Canadian community: prevalence and associated factors. Am J Clin Nutr 2000; 71: 693-700.
30. Young TK, Gelskey DE. Is noncentral obesity metabolically benign? Implications for prevention from a population survey. JAMA 1995; 274: 1939-41.
31. Tudor-Locke C, Williams JE, Reis JP, Pluto D. Utility of pedometers for assessing physical activity: convergent validity. Sports Med 2002; 32: 795-808.
32. Saksvig BI, Gittelsohn J, Harris SB, Hanley AJ, Valente TW, Zinman B. A pilot school-based healthy eating and physical activity intervention improves diet, food knowledge, and self-efficacy for native Canadian children. J Nutr 2005; 135: 2392-8.

Dru Marshall, Ph.D.
E407 Van Vliet Centre
Edmonton, Alberta T6G 2H9
CANADA
Email: dru.marshall@ualberta.ca