A family-centered lifestyle intervention for obese six- to eight-year-old children: Results from a one-year randomized controlled trial conducted in Montreal, Canada

Tamara R. Cohen, RD, MSc,¹ Tom J. Hazell, PhD,² Catherine A. Vanstone, RN, MSc,¹ Celia Rodd, MD, MSc,³ Hope A. Weiler, RD, PhD¹

ABSTRACT

OBJECTIVES: Childhood obesity interventions should be family-centered and focused on lifestyle behaviours that achieve sustainable reductions in adiposity. The primary objective of this randomized controlled trial was to test a family-centered lifestyle intervention using Canada's Food and Physical Activity (PA) Guidelines to reduce body mass index-for-age z-scores (BAZ) in overweight and obese (OW/OB) children.

METHODS: Children ($n = 78$; ages 6–8.5 years) were randomized to standard (StnTx) or modified (ModTx) interventions or control (Ctrl). Measurements at baseline and every three months for one year included: anthropometry, BAZ, waist circumference (WC), and dual-energy X-ray absorptiometry scans for percent body fat (%BF), fat mass (FM) and trunk fat mass. Fatty acids measured by gas chromatography were used to assess compliance to the milk and alternatives interventions during the first six months. Six intervention sessions were based on Canada's Food and PA Guidelines and individualized to meet the needs of the family. ModTx were advised to consume four milk and alternatives/day versus the recommended two (StnTx) and to preferentially engage in daily weight-bearing PA. Ctrl were provided the guidelines.

RESULTS: Baseline anthropometry did not differ among groups. At 12 months ($n = 73$), all groups increased height ($p < 0.001$) and lean mass ($p < 0.001$). ModTx decreased BAZ ($p < 0.001$); %BF decreased in ModTx ($p = 0.018$), but not in StnTx ($p = 0.997$) or Ctrl ($p = 0.998$). FM, WC and trunk fat mass all significantly increased in Ctrl ($p < 0.001$). At baseline and three months, fatty acids did not differ among groups, however they did decrease in ModTx at six months [C14:0 (–0.07%, $p = 0.053$), C15:0 (–0.04%, $p = 0.049$), C17:0 (–0.09%, $p = 0.036$)].

CONCLUSION: Participating in a family centered-lifestyle intervention that focused on Canadian dietary and PA Guidelines and emphasized increasing milk and alternatives and weight-bearing PA had positive effects on reducing adiposity in OW/OB children. Guidelines are appropriate for the obese pediatric population but need to be individualized to meet the needs of the family. Additional studies are warranted to test the use of biochemical indices to assess compliance to milk and alternative intakes in OW/OB children participating in lifestyle interventions.

KEY WORDS: Childhood obesity; overweight; obese; interventions; dairy; body mass index

La traduction du résumé se trouve à la fin de l'article.

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Childhood obesity is a public health concern in Canada.¹ Obese children are at a greater risk of health complications later in life, including premature death,² however treatment is challenging due to its complex etiology.³ Evidence demonstrates that intervention programs should be family-centered and focus on physical activity (PA), diet and lifestyle behaviours.³ Furthermore, these programs should include discussions concerning self-monitoring, goal setting, problem solving, and relapse prevention.³

Current Canadian clinical practice guidelines for the management of childhood obesity suggest that interventions be administered by primary care providers or through a weight management program.⁴ Readily available educational resources include Canada's Food Guide⁵ and PA guidelines.⁶ However, a recent review of Canadian primary care providers estimates that only 50% of providers discuss weight management with families and that information is simply offered, not individualized.⁷ Furthermore, there exist few family-centered weight management programs that have utilized or evaluated these Canadian resources as the primary treatment of childhood obesity.⁷

In Canada, it is recommended that children 4–8 years of age consume two servings of milk and alternatives/day,⁵ however only one third meet this recommendation.⁸ While a milk serving is

Author Affiliations

1. School of Dietetics and Human Nutrition, McGill University, Sainte-Anne-de-Bellevue, QC
2. Department of Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON
3. Children's Hospital, University of Manitoba, Winnipeg, MB

Correspondence: Hope A. Weiler, PhD, School of Dietetics and Human Nutrition, Macdonald Campus, McGill University, 2111 Lakeshore Road, Sainte-Anne-de-Bellevue, QC H9X 3V9, Tel: 514-398-7905, E-mail: hope.weiler@mcgill.ca

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defined as 250 ml, servings of alternatives such as yogurt are dependent on the product. Increasing servings of milk to 3–4 servings per day has positive effects on weight management in children.^{9–12} However, these randomized controlled trials ranged from 16 weeks to six months in duration and thus the sustained benefits are not clear.^{10–12} Physical activity recommendations are 60 minutes of moderate-to-vigorous PA seven days per week, with weight-bearing activities performed during three of those days.⁶ Physical activity, specifically weight-bearing PA (i.e., skipping, dancing or soccer), not only affects body composition, but also strengthens muscles and bones.⁶

To date, there are no trials that use current dietary and PA recommendations as a basis of an intervention program and explore the effects of increased milk products and weight-bearing PA on changes in adiposity in children. The primary objective of the randomized controlled trial (RCT) was to test the effects of a family-centered lifestyle intervention using Canada's Food Guide and PA guidelines to reduce body mass index (BMI)-for-age z-scores (BAZ) in overweight and obese (OW/OB) children. It is hypothesized that children randomized to increased milk and alternatives and focus on daily weight-bearing PA will have a lower BAZ at 12 months compared to children counselled to meet current Canadian dietary and PA recommendations, and the control group.

METHODS

Ethics statement

Ethics approval was obtained from the McGill University Faculty of Medicine Institutional Review Board, Lester B. Pearson School Board (Montréal, QC) and the English Montreal School Board (Montréal, QC) [Trial registration: ClinicalTrials.gov: NCT01290016].

Setting

Participants were recruited (January 2011–January 2013) for the McGill Youth Lifestyle Intervention with Food and Exercise (MY LIFE) from Montréal (QC). The study was conducted at the Mary Emily Clinical Nutrition Research Unit (Sainte-Anne-de-Bellevue, QC). Details on the study protocol, including recruitment strategy, are published elsewhere.¹³

Study population

Eligible participants included healthy children 6–8 years of age with no known illnesses, classified as overweight or obese according to the World Health Organization (WHO) BMI cut-off criteria.¹⁴ At baseline, parents completed a consent form; children completed an assent form.

Study design

At baseline, children were randomized (allocation ratio 1:1:1) to one of three groups (Standard [StnTx], Modified [ModTx] or Control [Ctrl]) by a computer-generated list and stratified by sex and BMI percentile-for-age (overweight: 85–97 percentile; obese: >97 percentile).¹⁴ Study measurements occurred every three months for one year. Pubertal stage was reported by caregiver using Tanner Staging images¹⁵ and confirmed using fasting serum concentrations of luteinizing hormone and estradiol. Caregivers completed a socio-demographic questionnaire and self-reported their height and weight.

Intervention

All families received the same standard teaching of Canada's Food and PA Guidelines at baseline. StnTx and ModTx participated in six monthly interventions with a dietitian; details concerning the interventions have been published elsewhere.¹³ Briefly, interventions were family-centered and focused on overall lifestyles, including discussions concerning both diet and activity. Specifically, all sessions included different educational components that covered various diet and PA topics. Despite each family receiving the same teachings, dietitians focused on individualizing goals and relapse prevention techniques using Health Canada's SMART Goals approach. Further, the dietitian facilitated discussions concerning self-monitoring and problem solving in order to successfully meet diet and PA recommendations. All sessions were conducted in either English or French and were designed to be appropriate for the Level 1 literacy level to ensure that participants and all family members irrespective of education would be able to actively participate in and understand the sessions. This ensured that goals were attainable and realistic given the family-specific needs and capabilities.

The dietitian guided families to either provide their child with two servings (StnTx) or four servings (ModTx) of milk and alternatives/day, preferably consuming products with lower percentage of milk fat (%MF) (i.e., 1%MF milk, 15%–18%MF cheese, 1%–2%MF yogurt). Both groups were encouraged to meet current PA guidelines (60 minutes of moderate-to-vigorous activity/day) and limit screen time (<2 hours/day); daily weight-bearing activities (i.e., skipping rope, jumping types of activities) were emphasized in ModTx. The Ctrl received the same interventions after completing the study.

Main measurements and outcomes

At each visit, children presented having fasted the previous 12 hours. Weight was measured using a standard balance beam scale (Detecto, Webb City, MO, USA); height was measured to 0.1 cm using a stadiometer (model 213, SECA Medical Scales and Measuring Systems, Hamburg, Germany). BMI (kg/m²), BMI-for-age z-scores (BAZ) and height-for-age z-scores (HAZ) were computed using the WHOAnthroPlus Software.¹⁶ Waist circumference (WC) was measured to the nearest 0.1 cm at the umbilicus.¹⁷

Body composition was assessed using whole body dual-energy X-ray absorptiometry (DXA) (Hologic Discovery A fan beam with APEX software [version 13.3:3], Hologic Inc., Bedford, MA, USA) for fat mass (FM; kg), lean mass (LM; kg), percent body fat (%BF; %), trunk fat mass (kg), android/gynoid ratio and fat mass index (FMI; kg/height²). FMI estimates excess fat versus the conventional BMI that measures excess weight.¹⁸ Values were compared to the Hologic normative database (National Health and Nutrition Examination Surveys). Quality assurance scans using Hologic lumbar spine phantom no. 14774 were performed at each visit, with coefficients of variability of 0.5% for bone mineral content and 0.3% for bone mineral density.

Biochemistry

Every three months, blood samples were obtained by venipuncture between 8 am and 12 pm, following 12 hours fasted. Samples were analyzed for luteinizing hormone, estradiol, and other health indicators, via auto-analyzers (Beckman Access and Beckman

Figure 1. CONSORT diagram for the MY LIFE study

DXC600, CA, USA) at the Montréal Children's Hospital Clinical Chemistry laboratory (Montréal, QC).

Valid biomarkers of dairy fat were used to complement dietary records as a measure of compliance to the increased milk and alternative intervention (ModTx).^{19,20} Myristic (14:0), pentadecanoic (15:0), heptadecanoic (17:0) and stearic (18:0) acids were measured in red blood cells (RBC) using a gas chromatography (Varian CP-3800, Walnut Creek, CA, USA) with a flame-ionization detector. RBC lipids were prepared using direct methylation;²¹ recovery was determined to be 99.8% based on added C21:0 (Nu-Chek Prep, Inc., Elysian, MN, USA). Chromatogram peaks were identified against standard GLC 461 (Nu-Chek Prep, Inc., Elysian, MN, USA); fatty acids were expressed as percentage of total fatty acids, with coefficients of variation ranging from 4.9% to 15.4%.

Dietary intake and physical activity

Dietary intakes were assessed using three-day food diaries (3DFD). Caregivers recorded dietary intake for three non-consecutive days

including a weekend day, as instructed by a registered dietitian. The first 3DFD was recorded the week after the study visit; all other 3DFD reflected diet prior to study visits. Data were analyzed using Nutritionist Pro software (Axxya Systems, Stafford, TX, USA) and the Canadian Nutrient File 2010b. Intakes were analyzed according to Canada's Food Guide (CFG) food groups. Children were classified as not meeting, meeting or exceeding CFG recommendations.

Physical activity was captured using the Physical Activity Questionnaire for Children [PAQ-C]²² modified to include measures of time and intensity [mPAQ-C]. The mPAQ-C, completed by caregivers, reflected the child's PA the week prior to study visits and included questions concerning total screen time per week.

Statistical analysis

Data were analyzed using SAS version 9.3 (SAS Institute, Cary, NC, USA). Based on previous studies,^{12,23} 116 overweight or obese children were needed to provide 80% power at a 5% significance

Table 1. Participant baseline characteristics according to randomization

Variable	StnTx	ModTx	Ctrl	Total sample	F-test or χ^2 *	R ²	p-value
Age (years)	7.7 ± 0.8 (25)	8.1 ± 0.7 (25)	7.7 ± 0.8 (28)	7.8 ± 0.8 (78)	1.38	0.035	0.258
Ethnicity, white (% , n)	71% (17)	92% (22)	81% (22)	81% (78)	2.44*	–	0.294
Gender, female (% , n)	56% (14)	60% (15)	57% (16)	57% (78)	0.09*	–	0.958
Family income > \$75,000/year (% , n) [†]	38% (8)	81% (17)	57% (15)	59% (68)	7.98*	–	0.018
Education, higher education [‡]							
Mother (% , n)	79% (19)	84% (21)	85% (23)	83% (76)	0.35*	–	0.836
Father (% , n)	40% (9)	77% (17)	81% (17)	65% (66)	10.59*	–	0.005
Parental self-report BMI [§]							
Mother, BMI >25 kg/m ² (% , n)	68% (13)	70% (14)	61% (13)	70% (61)	0.09	0.003	0.912
Father, BMI >25 kg/m ² (% , n)	93% (13)	83% (15)	94% (16)	88% (49)	0.14	0.001	0.872
Waist circumference (cm)	81.3 ± 8.4 (25)	81.6 ± 8.7 (25)	80.7 ± 9.1 (28)	81.2 ± 8.6 (78)	0.07	0.002	0.932
Weight z-score	3.4 ± 1.3 (25)	3.0 ± 1.2 (25)	3.1 ± 1.0 (28)	3.2 ± 1.2 (78)	0.68	0.017	0.507
Height z-score	1.1 ± 0.9 (25)	1.1 ± 0.9 (25)	1.2 ± 0.9 (28)	1.1 ± 0.9 (78)	0.06	0.002	0.945
BMI (kg/m ²)	25.2 ± 3.9 (25)	24.1 ± 2.8 (25)	24.1 ± 3.2 (28)	24.4 ± 3.3 (78)	0.98	0.025	0.381
BAZ	3.6 ± 1.4 (25)	3.1 ± 1.0 (25)	3.2 ± 1.1 (28)	3.3 ± 1.2 (78)	1.13	0.029	0.329
BMI classification OW/OB [§]	2/25	1/25	3/28	6/78	–	–	–
Lean body mass (kg)	25.5 ± 3.8 (25)	26.1 ± 4.2 (25)	25.6 ± 4.3 (28)	25.7 ± 4.0 (78)	0.16	0.004	0.852
Total fat mass (kg)	17.2 ± 5.6 (25)	15.9 ± 3.5 (25)	15.6 ± 4.4 (28)	16.2 ± 4.6 (78)	0.89	0.023	0.415
Percent body fat (%)	38.5 ± 5.5 (25)	36.8 ± 5.6 (25)	36.4 ± 4.9 (28)	37.2 ± 4.9 (78)	1.43	0.037	0.246
Fasting glucose (mmol/L)	4.9 ± 0.5 (18)	4.8 ± 0.4 (21)	4.8 ± 0.3 (24)	4.8 ± 0.4 (63)	1.14	0.045	0.253
Insulin (pmol/L)	53.1 ± 28.5 (18)	44.8 ± 24.9 (19)	36.2 ± 15.5 (24)	43.9 ± 26.3 (61)	2.83	0.089	0.067
Total cholesterol (mmol/L)	4.2 ± 0.7 (19)	5.5 ± 6.2 (21)	4.2 ± 0.9 (24)	4.6 ± 3.6 (64)	0.91	0.029	0.407
HDL (mmol/L)	1.2 ± 0.4 (18)	1.2 ± 0.3 (21)	1.3 ± 0.3 (24)	1.2 ± 0.3 (63)	0.51	0.017	0.604
LDL (mmol/L)	2.5 ± 0.7 (18)	2.5 ± 0.7 (21)	2.6 ± 0.9 (24)	2.5 ± 0.8 (63)	0.1	0.036	0.897
Triglycerides (mmol/L)	1.1 ± 0.7 (19)	0.9 ± 0.5 (21)	0.8 ± 0.4 (24)	0.9 ± 0.5 (64)	1.78	0.055	0.176

Note: mean ± standard deviation (n) unless stated otherwise. StnTx = standard treatment group; ModTx = modified treatment group; Ctrl = control group; BMI = body mass index (kg/m²); BAZ = body mass index-for-age z-score; OW = overweight; OB = obese; HDL = high-density lipoprotein; LDL = low-density lipoprotein.

* Data analyzed by ANOVA for continuous data (F-test) or chi-square (χ^2) for proportions. All tests have two degrees of freedom.

[†] Total family income was less in StnTx compared to ModTx and Ctrl ($p = 0.017$).

[‡] Higher education included university, college or Cégep. Father's self-reported education was less in StnTx compared to ModTx and Ctrl ($p = 0.004$).

[§] BMI classifications are denoted as n/total.

level (two-sided) to detect a mean change in BAZ of -0.2 (SD 0.3) at 12 months. Estimating a 10% drop-out rate, 39 children were needed per group. Differences at baseline among groups were assessed using analysis of variance (ANOVA). Mixed-model ANOVAs were used to determine group and time interactions for anthropometry, body composition, dietary and PA measures with Tukey-Kramer adjustments. Similar models excluding time were examined to test changes (Δ) at six months and 12 months from baseline for BAZ, %BF, WC, trunk fat mass and FM. All models were tested for covariance structure using best-fit statistics. Fixed effects included group, time, BMI classification (i.e., overweight or obese) and gender; random effects included age, subject nested in group, family income, and parent education. Associations between measured RBC fatty acids and milk and alternative intakes were analyzed by Spearman correlations. Analyses were performed as intent-to-treat and presented as mean ± standard deviation, unless otherwise noted. Significance was set at <0.05 .

RESULTS

Seventy-eight children (7.8 ± 0.8 years of age) participated in the study (Figure 1). StnTx had families with lower household incomes ($p = 0.018$) and fathers with lower education ($p = 0.005$) compared to ModTx and Ctrl (Table 1). Children were prepubescent (Tanner Stage 1) with normal luteinizing hormone and estradiol. The majority of caregivers had self-reported BMI classified as overweight/obese (Table 1).

At baseline, PA reported by caregivers revealed that 21% of children met while 46% exceeded recommendations ($n = 71$).

Weight-bearing PA was performed on average 4.6 ± 3.3 times/week and screen time was 6.9 ± 3.2 hours/week.

Intervention effects on anthropometry and body composition

In all groups, HAZ increased at 12 months ($p < 0.001$); Δ HAZ was greater in StnTx ($p = 0.004$) and Ctrl ($p = 0.013$) compared to ModTx (Figure 2A). Both intervention groups decreased BAZ at six months (StnTx: $p = 0.017$; ModTx: $p < 0.0001$) and 12 months (StnTx: $p < 0.001$, ModTx: $p < 0.001$). However, ModTx resulted in greater reductions in Δ BAZ at six months ($p = 0.001$) and 12 months ($p = 0.001$) compared to Ctrl (Figure 2B).

ModTx decreased %BF at six months ($p = 0.032$) and 12 months ($p = 0.018$). The Δ %BF from baseline to 12 months showed greater reductions in ModTx ($p = 0.034$) compared to Ctrl (Figure 2C). At 12 months, Ctrl increased FM ($p < 0.001$); there was a greater decrease in Δ FM in ModTx compared to Ctrl at six months ($p = 0.051$) and 12 months ($p < 0.001$) (Figure 2D). At 12 months, WC increased in both StnTx ($p = 0.004$) and Ctrl ($p < 0.001$); the Δ WC in Ctrl was greater at 12 months ($p = 0.002$) compared to ModTx (Figure 2E). In Ctrl, trunk fat mass increased at 12 months ($p = 0.003$); Δ trunk fat mass was greater in Ctrl compared to ModTx at 12 months ($p = 0.009$) (Figure 2F). At 12 months, Ctrl gained 0.29 kg FM in the android region ($p = 0.028$); there were no other significant group $\times$ time interactions for FM in the gynoid region or android/gynoid ratio. Fat mass index did not significantly change in any group at 12 months. Lean mass increased in all groups at 12 months ($p < 0.001$) ($n = 68$; median 3.3 kg, range: -1.0 to 7.6 kg); however Δ lean mass was greater in StnTx ($p = 0.001$) and Ctrl ($p < 0.0001$) compared to ModTx at 12 months.

Figure 2. Anthropometric and body composition changes (Δ) from baseline (BL) at six months and 12 months [median, confidence interval] (+ mean); Panel A: Height-for-age z-scores; Panel B: BMI-for-age z-score; Panel C: Percent body fat; Panel D: Total fat mass; Panel E: Waist circumference; Panel F: Trunk fat mass. * $p < 0.05$; ** $p < 0.001$

Intervention effects on lifestyle: Diet and physical activity

Fifty (64%) week-1 3DFD were returned. There were no differences for anthropometric or body composition measures between participants who returned 3DFD versus those who did not. Diet did not conform to CFG or differ among groups in proportions below, meeting or exceeding recommendations (Figure 3). However, week-1 intakes differed (1 $\times$ 1 comparisons): ModTx consumed ~ 340 kcal/day less compared to Ctrl ($p = 0.018$) (Table 2) while StnTx ($p = 0.025$) and ModTx ($p = 0.014$) consumed less protein compared to Ctrl (Table 2).

Only 41% and 33% of 3DFD were returned at six months and 12 months respectively (Table 2); there were no differences among groups for macronutrient intakes. Similarly, diet analyzed by food group servings did not differ among or within groups over time after age adjustments. Data analyzed categorically to describe dietary intakes as percentage below, meeting or exceeding the food groups are presented in Figure 3. At 12 months ($n = 24$), fruit and

vegetable recommendations were met by 30% of StnTx and 29% ModTx, but remained at 0% for Ctrl (Figure 3). Grain product intakes were met by 20% StnTx, 14% ModTx and 0% Ctrl (100% exceeded recommendations in Ctrl). Thirty percent StnTx, 43% ModTx and 29% Ctrl met milk and alternative recommendations. Finally, 50% StnTx, 57% ModTx and 57% Ctrl met the meat and alternative recommendations.

Saturated fatty acids were analyzed at baseline ($n = 65$), three months ($n = 35$) and six months ($n = 52$) as an objective measure of compliance to the milk and alternative intervention. At three months, there were no differences in C15:0 among groups. At six months, there was a decrease (0.04%) in C15:0 in ModTx ($p = 0.049$). Paired C15:0 values to 3DFD ($n = 8$) at six months showed no relationship to total dairy intake ($\rho = 0.26$; $p = 0.547$). Although C17:0 decreased (0.09%) in ModTx from baseline to six months ($p = 0.036$), C17:0 did not associate with dairy intakes at any time. C14:0 decreased (0.07%) in ModTx at six months ($p = 0.053$); at three months, C14:0 positively associated

Figure 3. Dietary assessment of three-day food diaries by percentage below, meeting or exceeding Canada Food Guide Food Groups adjusted for age at week 1, six months and 12 months; Panel A: Fruits and vegetables; Panel B: Grain products; Panel C: Milk and alternatives; Panel D: Meat and alternatives

with dairy intake in Ctrl ($n = 4$; $\rho = 1.0$; $p < 0.0001$). Finally, C18:0 decreased in Ctrl at three months (1.38%, $p = 0.005$) and six months (0.93%, $p = 0.038$); C18:0 did not associate with dietary intake.

PA assessed by caregivers did not change from baseline. At six months ($n = 68$), 25% of children met while 54% exceeded recommendations. Similarly, at 12 months ($n = 72$), 26% met while 53% exceeded PA targets. There were no significant differences throughout the study for activities classified by intensity or type (weight-bearing) as well as time spent engaged

in screen time. Average screen time per week at 12 months was 6.5 ± 3.1 hours/week.

DISCUSSION

This study demonstrated that children who participated in a family-centered lifestyle intervention that was based on current health guidelines sustained losses in adiposity: StnTx and ModTx attained greater decreases in BAZ compared to the control group. However, ModTx also achieved losses in %BF, whereas at

Table 2. Macronutrient intakes* and Canada's Food Guide Food Groups† assessed by three-day food diary at week 1, six months and 12 months

	StnTx			ModTx			Ctrl		
	Week 1 n = 19	6 months n = 10	12 months n = 10	Week 1 n = 19	6 months n = 12	12 months n = 7	Week 1 n = 12	6 months n = 8	12 months n = 7
Total energy (kcal)	1669 ± 379	1661 ± 384	1635 ± 325	1567 ± 271 [‡]	1598.7 ± 337	1449.8 ± 173	1909 ± 312 [‡]	1947 ± 443	1938 ± 463
Protein (g)	69.7 ± 13.8 [§]	69.6 ± 13.6	71.7 ± 7.7	68.4 ± 10.5 [§]	72.9 ± 19.2	62.6 ± 8.2	83.5 ± 18.3 [§]	88.0 ± 26.3	87.3 ± 27.7
Fat (g)	57.5 ± 23.0	52.6 ± 15.9	53.6 ± 13.5	53.1 ± 14.4	59.3 ± 14.6	48.59 ± 13.6	63.9 ± 13.6	59.4 ± 17.5	68.8 ± 17.8
Carbohydrate (g)	223.9 ± 49.6	232.7 ± 56.3	223.2 ± 49.6	213.0 ± 47.3	199.1 ± 48.4	198.6 ± 29.5	253.8 ± 42.3	268.7 ± 59.2	248.0 ± 65.0
Fruits and vegetables (servings/day)	4.9 ± 1.9	6.6 ± 2.4	4.9 ± 1.3	4.4 ± 2.0	4.9 ± 2.4	4.0 ± 1.8	4.6 ± 1.9	5.6 ± 2.3	4.9 ± 1.7
Grain products (servings/day)	6.8 ± 2.0	6.1 ± 1.8	6.1 ± 1.8	6.2 ± 1.8	6.0 ± 1.8	6.2 ± 2.0	7.2 ± 2.2	6.9 ± 1.9	7.0 ± 2.0
Milk and alternatives (servings/day)	2.2 ± 1.2	1.6 ± 0.8	1.9 ± 0.7	2.0 ± 0.9	2.3 ± 1.2	2.8 ± 1.1	2.8 ± 1.6	3.3 ± 2.5	3.6 ± 2.6
Meat and alternatives (servings/day)	1.8 ± 0.7	2.3 ± 1.0	2.1 ± 0.6	1.9 ± 0.6	1.7 ± 0.7	1.0 ± 0.4	2.2 ± 0.9	2.0 ± 0.6	2.2 ± 0.6

Note: mean ± standard deviation.

* Week-1 food diaries were completed the week after the baseline visit; all subsequent diaries were completed and reflect the week prior to study visit.

† Canada's Food Groups: servings/day.

‡ *p*-values for comparison of total energy (kcal) at week 1 between ModTx and Ctrl (*p* = 0.018).

§ *p*-values for comparison of total protein (g) at week 1 between Ctrl and StnTx (*p* = 0.025) and Ctrl and ModTx (*p* = 0.014).

12 months, Ctrl increased WC and trunk fat mass. Simply providing dietary and physical activity guidelines with a brief education at baseline to the Ctrl group did not reduce obesity in any way.

The interventions used in this study were based on current Canadian guidelines but allowed for individualization and included caregivers. After baseline education sessions, both StnTx and ModTx had lower energy intakes compared to Ctrl, showing early signs of success. Furthermore, irrespective of intervention group, at 12 months both StnTx and ModTx were closer to meeting CFG recommendations compared to Ctrl. This study yielded similar results to those of other studies: when diet and PA goals are realistic and attainable, treatment groups experience a decrease in BAZ^{12,24} while control groups experience an increase.²⁵ Similarly, the magnitude of reductions in BAZ were greater in children randomized to higher dairy intakes,¹² however unique to this study was the addition of weight-bearing PA.

To our knowledge, this was the first intervention in obese children to include a biochemical analysis of saturated fatty acids to complement dietary intake assessments.^{19,26} Although ModTx were guided to increase servings of dairy, C15:0 decreased at six months. The interventions in this study focused on choosing lower %MF options, and although the percentage of children meeting the milk and alternative recommendations in the ModTx increased from 21% to 43% at 12 months, the decrease in C15:0 suggests children were possibly consuming diets with lower %MF.²⁶ Furthermore, C15:0 is found in ruminant meat.¹⁹ At 12 months, all children in the ModTx were either below (43%) or meeting (57%) the meat and alternative recommendation compared to 74% exceeding the recommendation at baseline. Other studies have shown moderate correlations (*r* = 0.45–0.46) of C15:0 with dairy fat from dietary assessment in adults²⁰ and children.¹⁹ In this study, the dietary assessments were underpowered, thus limiting similar analyses. Future RCTs are warranted to evaluate these biomarkers and associations with different percentages of milk fat.²⁷

Strengths and limitations

Interventions aimed at obese children often face many challenges with recruitment and follow-up. There is evidence to suggest that caregivers may be reluctant to enrol their OW/OB child in an

intervention that targets weight due to possible adverse effects.²³ Our study focused on developing a safe, non-judgemental environment for children, which is evident by the high retention rate (94%). Nevertheless, this study has a small sample size below target despite various recruitment efforts and a lengthy recruitment period. Additionally, there were imbalances in family income and father's education. However, we accounted for these imbalances in our statistical analyses. Further, we did not survey number of siblings in our questionnaires, which may impact or influence the child's success. However, the interventions were designed to address any barriers or limitations to meeting goals that may arise specifically due to the challenges of the family dynamics (i.e., single parent versus dual; single child versus siblings). As seen in studies of OW/OB children,²⁸ this study had a low return of diet records by parents, limiting dietary intake analyses. Although mean intakes at 12 months appear similar, dietary data presented as below, meeting or exceeding the CFG recommendations suggest that monthly interventions helped children attain diets closer to Canadian guidelines. Similarly, PA was subjectively assessed by caregivers. Given the obesogenic nature of the parents participating in the study, it is possible that PA levels were overestimated, and/or children's perceptions of intensity or duration of activity were not accurate.²⁹ The relationships between PA and anthropometry thus require confirmation using more objective assessments. We therefore caution interpretation of our PA data. Objective measures of PA by accelerometer or pedometer are more valid and should be used with OW/OB children.³⁰ Finally, the study design did not permit for distinguishing the effects of either dietary (increased milk and alternatives) or PA (weight-bearing PA) on benefits of reducing adiposity as we did not use a step-wise approach to adding these during the interventions.

CONCLUSION

This study suggests that Canadian dietary and PA guidelines are suitable to form the basis of treatment programs for OW/OB children. In order to achieve and sustain goals, interventions need to be realistic for the participating children and caregivers. A follow-up study is warranted to evaluate whether these changes were sustained, an important first step in achieving healthy habits prior to adolescence and adulthood.

REFERENCES

- Roberts KC, Shields M, de Groh M, Aziz A, Gilbert JA. Overweight and obesity in children and adolescents: Results from the 2009 to 2011 Canadian Health Measures Survey. *Health Rep* 2012;23(3):37–41. PMID: 23061263.
- Hirko KA, Kantor ED, Cohen SS, Blot WJ, Stampfer MJ, Signorello LB. Body mass index in young adulthood, obesity trajectory, and premature mortality. *Am J Epidemiol* 2015;182(5):441–50. PMID: 25977515. doi: 10.1093/aje/kwv084.
- Janicke DM, Steele RG, Gayes LA, Lim CS, Clifford LM, Schneider EM, et al. Systematic review and meta-analysis of comprehensive behavioral family lifestyle interventions addressing pediatric obesity. *J Pediatr Psychol* 2014;39(8):809–25. PMID: 24824614. doi: 10.1093/jpepsy/jsu023.
- Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *CMAJ* 2015;187(6):411–21. doi: 10.1503/cmaj.141285.
- Canada's Food Guide to Healthy Eating. Ottawa, ON: Health Canada, 2011.
- Canadian Society for Exercise Physiology. *Canadian Physical Activity Guidelines for Children 5–11*. Ottawa, ON, 2012. Available at: http://www.csep.ca/CMFiles/Guidelines/CSEP_PAGuidelines_child_en.pdf (Accessed January 5, 2016).
- Kuhle S, Doucette R, Piccinini-Vallis H, Kirk SF. Successful childhood obesity management in primary care in Canada: What are the odds? *Peer J* 2015;3:e1327. PMID: 26623175. doi: 10.7717/peerj.1327.
- Garriguet D. *Nutrition: Findings from the Canadian Community Health Survey (82-620-M): Overview of Canadians' Eating Habits*. Catalogue No. 2. Ottawa, ON: Statistics Canada, 2006.
- Van Loan M. The role of dairy foods and dietary calcium in weight management. *J Am Coll Nutr* 2009;28(Suppl 1):120S–29S.
- St-Onge MP, Goree LL, Gower B. High-milk supplementation with healthy diet counseling does not affect weight loss but ameliorates insulin action compared with low-milk supplementation in overweight children. *J Nutr* 2009;139(5):933–38. PMID: 19321584. doi: 10.3945/jn.108.102079.
- Albala C, Ebbeling CB, Cifuentes M, Lera L, Bustos N, Ludwig DS. Effects of replacing the habitual consumption of sugar-sweetened beverages with milk in Chilean children. *Am J Clin Nutr* 2008;88(3):605–11. PMID: 18779274.
- Kelishadi R, Zemel MB, Hashemipour M, Hosseini M, Mohammadifard N, Poursafa P. Can a dairy-rich diet be effective in long-term weight control of young children? *J Am Coll Nutr* 2009;28(5):601–10. PMID: 20439556. doi: 10.1080/07315724.2009.10719792.
- Cohen TR, Hazell TJ, Vanstone CA, Plourde H, Rodd CJ, Weiler HA. A family-centered lifestyle intervention to improve body composition and bone mass in overweight and obese children 6 through 8 years: A randomized controlled trial study protocol. *BMC Public Health* 2013;13:383. PMID: 23617621. doi: 10.1186/1471-2458-13-383.
- Growth Reference Data for 5–19 Years. Geneva, Switzerland: World Health Organization, 2007.
- Tanner JM. *Growth at Adolescence*, 2nd ed. Oxford, UK: Blackwell Scientific, 1962.
- World Health Organization. *WHO AnthroPlus for Personal Computers Manual: Software for Assessing Growth of the World's Children and Adolescents*. Geneva, Switzerland: WHO, 2009.
- WHO. *Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation (WHO Technical Report Series 894)*. Geneva, Switzerland: WHO, 2000.
- Kelly T. *Practical and Technical Advantages of DXA Visceral Fat Assessment Compared with Computed Tomography*. Bedford, MA: Hologic Inc., 2012. Available at: http://www.hologic.com/sites/default/files/white-papers/WP_00062_Visceral_Fat_06-12.pdf (Accessed January 5, 2016).
- Golley RK, Hendrie GA. Evaluation of the relative concentration of serum fatty acids C14:0, C15:0 and C17:0 as markers of children's dairy fat intake. *Ann Nutr Metab* 2014;65(4):310–16. PMID: 25402168.
- Wolk A, Furuheim M, Vessby B. Fatty acid composition of adipose tissue and serum lipids are valid biological markers of dairy fat intake in men. *J Nutr* 2001;131(3):828–33. PMID: 11238766.
- Lepage G, Roy CC. Direct transesterification of all classes of lipids in a one-step reaction. *J Lipid Res* 1986;27(1):114–20. PMID: 3958609.
- Crocker PR, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: Preliminary evidence for the physical activity questionnaire for older children. *Med Sci Sports Exerc* 1997;29(10):1344–49. PMID: 9346166. doi: 10.1097/00005768-199710000-00011.
- Hughes AR, Stewart L, Chapple J, McColl JH, Donaldson MD, Kelnar CJ, et al. Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT). *Pediatrics* 2008;121(3):e539–46. PMID: 18310175. doi: 10.1542/peds.2007-1786.
- Rodearmel SJ, Wyatt HR, Barry MJ, Dong F, Pan D, Israel RG, et al. A family-based approach to preventing excessive weight gain. *Obesity* 2006;14(8):1392–401. PMID: 16988082. doi: 10.1038/oby.2006.158.
- Reinehr T, Schaefer A, Winkler K, Finne E, Toschke AM, Kolip P. An effective lifestyle intervention in overweight children: Findings from a randomized controlled trial on "Obeldicks light". *Clin Nutr* 2010;29(3):331–36. PMID: 20106567. doi: 10.1016/j.clnu.2009.12.010.
- Hendrie GA, Golley RK. Changing from regular-fat to low-fat dairy foods reduces saturated fat intake but not energy intake in 4–13-y-old children. *Am J Clin Nutr* 2011;93(5):1117–27. PMID: 21430121. doi: 10.3945/ajcn.110.010694.
- Djoussé L. Is plasma pentadecanoic acid a reasonable biomarker of dairy consumption? *J Am Heart Assoc* 2013;2(4):e000393. PMID: 23938288. doi: 10.1161/JAHA.113.000393.
- Livingstone MB, Robson PJ, Wallace JM. Issues in dietary intake assessment of children and adolescents. *Br J Nutr* 2004;92(Suppl 2):S213–22. PMID: 23938288.
- Lichtman SW, Pisarska K, Berman ER, Pestone M, Dowling H, Offenbacher E, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *N Engl J Med* 1992;327(27):1893–98. PMID: 1454084. doi: 10.1056/NEJM199212313272701.
- Ellery CV, Weiler HA, Hazell TJ. Physical activity assessment tools for use in overweight and obese children. *Int J Obes* 2014;38(1):1–10. doi: 10.1038/ijo.2013.125.

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RÉSUMÉ

OBJECTIFS : Les interventions contre l'obésité juvénile devraient être centrées sur la famille et sur les habitudes de vie qui produisent des baisses durables de l'adiposité. L'objectif premier de notre essai comparatif randomisé était de tester une intervention sur le mode de vie centrée sur la famille utilisant le Guide alimentaire canadien et les Directives canadiennes en matière d'activité physique (AP) pour réduire les écarts Z de l'indice de masse corporelle en fonction de l'âge (ZIA) chez les enfants en surpoids et obèses (SP/OB).

MÉTHODE : Des enfants ($n = 78$; 6–8,5 ans) ont été affectés de façon aléatoire aux groupes d'intervention standard (StnTx) ou modifiée (ModTx) ou à un groupe témoin. Nous avons pris les mesures suivantes au départ et tous les trois mois pendant un an : anthropométrie, ZIA, périmètre ombilical (PO), et des scanographies d'absorptiométrie biphotonique à rayons X pour obtenir le pourcentage de masse grasse (%MG), la masse adipeuse (MA) et la masse adipeuse du tronc. Les acides gras, mesurés par chromatographie gazeuse, ont servi à évaluer la conformité aux interventions avec lait et substituts au cours des six premiers mois. Six séances d'intervention ont été fondées sur le Guide alimentaire canadien et les Directives canadiennes en matière d'AP et ont été individualisées pour répondre aux besoins de la famille. Les sujets de l'intervention modifiée (ModTx) ont reçu l'instruction de consommer quatre portions de lait et substituts par jour au lieu des deux portions recommandées (StnTx) et de pratiquer de préférence une AP de port de poids quotidiennement. Les témoins ont reçu le Guide et les Directives sans autre instruction.

RÉSULTATS : L'anthropométrie de chaque groupe n'était pas différente au départ. Après 12 mois ($n = 73$), la taille ($p < 0,001$) et la masse maigre ($p < 0,001$) ont augmenté dans tous les groupes. Le ZIA a diminué dans le groupe ModTx ($p < 0,001$); le %MG a diminué dans le groupe ModTx ($p = 0,018$), mais pas dans le groupe StnTx ($p = 0,997$) ni dans le groupe témoin ($p = 0,998$). La MA, le PO et la masse adipeuse du tronc ont tous présenté une hausse significative dans le groupe témoin ($p < 0,001$). Au départ et après trois mois, les acides gras de chaque groupe n'étaient pas différents, mais ils ont diminué dans le groupe ModTx au bout de six mois [C14:0 (–0,07 %, $p = 0,053$), C15:0 (–0,04 %, $p = 0,049$), C17:0 (–0,09 %, $p = 0,036$)].

CONCLUSION : La participation à une intervention sur le mode de vie centrée sur la famille, utilisant le Guide alimentaire et les Directives d'AP du Canada et insistant sur l'augmentation de la consommation de lait et de substituts et de l'AP de port de poids a eu des effets positifs sur la réduction de l'adiposité chez des enfants SP/OB. Les directives conviennent à la population pédiatrique obèse, mais elles doivent être individualisées pour répondre aux besoins de la famille. Il faudrait mener d'autres études pour tester l'utilisation d'indices biochimiques pour évaluer la conformité aux apports en lait et en substituts chez les enfants SP/OB qui participent à des interventions sur le mode de vie.

MOTS CLÉS : obésité juvénile; surpoids; obèse; interventions; produits laitiers; indice de masse corporelle