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ORIGINAL ARTICLE

Baseline measures for a school-based obesity control programme: Project Energize: Differences by ethnicity, rurality, age and school socio-economic status

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Aim: School-based interventions to tackle the rise in childhood overweight and obesity remain inconclusive and are often limited in their application to diverse populations. To inform and measure the effect of the implementation of a primary school-based longitudinal randomised controlled nutrition and activity intervention, Project Energize, baseline measures of body size and blood pressure were required.

Methods: This cross-sectional study stratified by age, sex, ethnicity, rurality and school socio-economic-status (school-SES) measured body mass index (BMI), percentage body fat (%BF), waist and resting blood pressure from 2752 5- and 10-year-old children (62% European, 31% Māori) representative of the Waikato region of New Zealand.

Result: Waikato children have a high prevalence of overweight and obesity that is linked with hypertension. Cardiovascular risk factors including raised blood pressure and hypertension, waist and arm circumference and percentage body fat (%BF) were more prevalent in 10-year-olds, lower school-SES and to some extent, urban living. In European children, BMI and waist circumference were similarly predictive of %BF, but for Māori children, waist circumference predicted %BF better than BMI.

Conclusions: A variety of stratified, baseline measurements is important when designing school-based interventions. In particular, waist circumference measures may be a more accurate predictor of %BF than BMI when determining measurement protocols that consider different ethnic groups and environments among children. The effect of targeted improvements of the school physical activity and nutrition environment on the rate of increase of weight, fatness and blood pressure in children should be examined.

Key words: children; hypertension; Māori; obesity; school.

What is already known on this topic

1 In children, overweight and obesity are linked with hypertension.
2 In New Zealand, Māori children have poorer health (and education) outcomes than European children – however, in national surveys, the European group is reported with 'European and Other'.
3 Through-school interventions are limited in their application to diverse populations.

What this paper adds

1 In a large, contemporary sample of 5- and 10-year-old New Zealand children, we show that the factors of urban living, Māori and low socio-economic status children have higher rates of obesity and overweight than rural.
2 Body fatness measured by bioimpedance analysis shows that the relationships among blood pressure, body mass index, waist and body fatness vary between Māoris and Europeans.
3 Ethnic comparisons of prevalence of overweight and obesity should not be reliant on body mass index.

With international secular trends in increasing childhood obesity and associated morbidity and mortality, various nutrition and activity programmes are being implemented and evaluated.[1] Many, however, lack methodological consistency,[2] and school-based programmes, in particular, show limited efficacy.[3–6] Singh and colleagues,[7] therefore, encourage manuscripts to include a detailed description of a study's development and the proof of need.

Within New Zealand, 9% of the population live in the Waikato region in the central North Island. Waikato is unique in demographic profile, in that: (i) two distinct ethnic groups (Māori (indigenous people) and European) make up most of the childhood population; (ii) there is a wide range of social deprivation (Māori are overly represented in both obesity statistics and lower socio-economic status (SES) scores); and (iii) the local community has a distinct urban/rural split (Māori children

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are over-represented in the rural community).[8] In 2004, the Waikato District Health Board funded the development and implementation of an evaluated school-based initiative called Project Energize. It is a through-school intervention to improve children's physical activity and nutrition, to improve their overall health.

This paper documents the baseline age, sex, ethnicity, school-SES and rurality characteristics of the cohort, and provides an impression of the body composition and blood pressure of children living in this Waikato region of New Zealand. It explores, by ethnicity and school-SES, the relationships of those measures with adverse risk factors of relative and age-adjusted fatness and raised blood pressure. The aim was to inform the strategic focus of the Project Energize programme.

Method

The Project Energize initiative, including design, programme, randomisation, evaluation methodology and baseline study population demography, has been described elsewhere.[9] Briefly, Project Energize is a through-school activity and nutrition modification programme, led and catalysed by Team Energize staff with child education or sports science qualifications and additional programme-specific training. For the randomised controlled trial sample, 124 schools agreed to participate. From 2005 to 2006, the programme was delivered to 62 primary schools in the region, representing 11 000 children, and a further 62 schools agreed to be control schools for 2 years. Ethics approval was granted by the New Zealand Northern Y regional ethics committee. Parental and child consents for measurements of children aged either 5 or 10 years of age were obtained at study commencement, with planned follow-up at age 7 and 12 years. These age cohorts were chosen to present critical periods of growth – adiposity rebound and early adolescence.

Height (portable height scale PE087; Mentone Education Centre, Victoria, Australia) and weight (portable electronic scale TIHD316; Wedderburn, Auckland, New Zealand) were measured to ± 0.5 cm and ± 0.5 kg, respectively. Bioelectrical impedance analysis (ImpediMed Single Frequency 50 Hz Bioimpedance Analyser, Imp-DF50, Brisbane, Queensland, Australia) and resting blood pressure (Omron Auto Blood Pressure monitor T8, Kyoti-Shi, Japan) were measured to ± 5.0 Ohm and ± 10 mmHg. All measures were recorded twice, and a third measure was taken where the predefined criterion detailed previously was exceeded.[9] Exact age at measurement was calculated from the date of birth and the date of measurement.

Percentage body fat (%BF) was calculated from hand to foot bioimpedance data, using equations previously established for New Zealand children of similar age and ethnic grouping,[10] and body mass index (BMI) was calculated as kg/m^2. Fat mass (FM) and fat-free mass (FFM) were derived from weight and %BF. The fat mass index (FMI) and fat-free mass index (FFMI) are FM and FFM divided by height squared (m^2). Age and gender-specific standard deviation scores (SDS, also known as *z*-scores) were calculated for height, weight, waist, and BMI using a British 1990 reference population.[11] Blood pressure scores were calculated using a British 1995–1998 reference population[12] and %BF values from a British sample that matched the 1990 reference population.[13] These reference values were used due to a substantial portion of New Zealand residents originating from the British Isles. Age and gender-specific BMI for 'overweight' and 'obesity' cut-offs were determined using the International Obesity Task Force (IOTF) criteria based on the equivalent centile of the 25 kg/m^2 and 30 kg/m^2 for 18-year-olds.[14] Age and gender-specific %BF SDS for 'overweight' and 'obesity' cut-offs were determined using the 85th and 95th centiles of McCarthy *et al*.[13] and raised blood pressure and hypertension classified using the British >90th centile and >95th centiles, respectively.[12] All data were entered and managed in Microsoft Access (Redmond, WA, USA), and statistical analysis was undertaken using the JMP Statistical Discovery Software Ver 5.1 (SAS Institute Inc., Cary, NC, USA), SAS Ver 9.1 (SAS Institute Inc.) and StatsDirect Ver 2.5.7 (StatsDirect Ltd, Altrincham, Cheshire, UK). All data were analysed separately as either 5 or 10 years old. All continuous measurements were approximately normally distributed ($-1 <$ Skewness < 1, $-1 <$ Kurtosis < 1, Median – Mean $< \pm 6\%$), except height, weight, BMI, %BF, FM, FMI, FFM and FFMI measures which were right skewed (Skewness > 1) by a small number of children with relatively high measures, and %BF *z*-scores which were left skewed (Skewness < -1). The skews, however, were minimal, and analyses using log10 transformation made no material difference to the results. So, for clarity and ease of interpretation, we present the untransformed arithmetic means (and SD) for all measures. Nevertheless, where skewed variables were incorporated in multivariate analysis, we used log10 transformed data.

The sample frequencies of children obtained were within 5% of expected both overall and for subgroups of gender, ethnicity and rural-urban mix, and considered representative of school-children in the Waikato region (regional data supplied by the Ministry of Education, 2007). For school-SES, the collected sample under-represented decile 4–7 (higher SES) and over-represented decile 8–10 (lower SES) by about 10%. For analysis purposes, however, the data were statistically weighted by a combination of age, ethnicity and school-SES to more closely match the Waikato school population.

Comparisons were made using the SAS surveymeans, surveylogistic, surveyreg and surveyfreq procedures as appropriate. The data were weighted to correct for stratification and clustered by school; *P*-values are uncorrected for multiple testing, but we suggest a nominal level of statistical significance of <0.005. All results are reported for programme and control groups combined because these are baseline data.

This clinical trial has been registered with the Australian New Zealand Clinical Trials Registry; ACTRN12610000132044, http://www.anzctr.org.au/trial_view.aspx?ID=335127.

Results

Consent was received from 3034 children and their parents, of whom 2752 (90.7%) were available for study participation on the measurement days. The un-weighted measured group was split evenly by age and sex, and age, sex, ethnicity, rurality and randomisation distributions were similar to the original consenting group (data not shown). The weighted distributions are given in Table 1. The predominant ethnic groups were European (62%) and Māori (31%), consistent with the overall local ethnic proportions.[15] The Other ethnic group (6%) comprised a

Table 1 Weighted† demographics of measured sample

	5-year-olds		10-year-olds	
	n	%	*n*	%
All	1344	100	1408	100
Girls	685	51	683	49
Boys	659	49	725	51
Rural	870	65	908	64
Urban	474	35	500	36
School decile‡ 1–3	497	37	531	38
School decile 4–7	589	44	608	43
School decile 8–10	258	19	269	19
European	829	62	855	62
Māori	415	31	428	31
Other	85	6	87	6
European				
Girls	423	51	417	49
Boys	407	49	438	51
Māori				
Girls	208	50	207	48
Boys	207	50	221	52
Other				
Girls	43	51	42	49
Boys	42	49	45	51

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] ‡A government-ascribed measure of socio-economic status. 1 is the poorest status.[9]

diverse range of ethnicities (mostly Asian and Pacific), and are not included in the ethnic group analyses presented. The mean age of the 5-year-old cohort was 5.7 years (SD 0.3), and of the 10-year-old cohort, 10.7 years (SD 0.3). Neither cohort varied by sex, ethnicity, rurality or randomisation.

Physical measures are summarised in Table 2. Compared with the British reference populations, our study group of Waikato children had greater BMI, %BF and diastolic blood pressure, but lower systolic blood pressure. Using the IOTF BMI-based criteria,[14] at 10 years, 7.9% of the children were obese and a further 21.4% were overweight. Waist-Height index was near identical and %BF SDS and pulse were lower ($P < 0.0001$).

Compared across subgroups, BMI was highest in children who attended the lowest socio-economic schools and who were Māori (Table 3). The prevalence of overweight and obesity was lower in European normotensive children and schools of higher SES and in the 5-year-old compared with the 10-year-old children (Table 4).

Compared across subgroups, %BF was highest in girls, urban-living, and Māori children (Table 5). Using the %BF obesity criteria, at 10 years, 2.2% of the children were obese (less than the IOTF cut-off) and a further 27.0% were overweight (more than the IOTF cut-off) (Table 6). At 5 years, both obese and overweight rates were higher than defined by IOTF BMI cut-off (Table 6).

Systolic and diastolic blood pressures increased with age, but were not significantly different across gender, school SES or ethnicity. Systolic and diastolic blood pressures were higher in rural compared with urban 10-year-olds ($P < 0.001$, data not shown).The urban–rural effect remained when adjusted for gender, obesity and school SES (data not shown). Relative risk (RR) for elevated BP (>90th centile) for overweight and obese children combined by BMI criteria was 2.9 (95% CI 1.9 to 4.4) and 2.7 (95% CI 1.9 to 3.8) for 5- and 10-year-olds, respectively. RR for elevated BP (>90th centile) for overweight and obese children combined by %BF criteria was 1.6 (95% CI 1.1 to 2.5) and 2.4 (95% CI 1.7 to 3.4) for 5- and 10-year-olds, respectively.

Using %BF as the reference, we investigated how effectively BMI and waist and arm circumference measure body composition relative to each other. In a multivariate model controlled for age, gender, ethnicity, rural–urban and school decile, in the entire study population each measure contributed independently to %BF (BMI, waist and arm *P*-value < 0.0001, <0.0001, 0.05, respectively). As contributors to the variance of the model (as determined by the partial (type III) sum of squares), waist circumference (19%) has a greater effect than BMI (10%), and arm circumference contributed little (1%). Similarly as predictors of %BF (as determined by standardized coefficients), waist contributed 1.4 times more than BMI, and 4.6 times more than arm circumference. However, the relative contribution differed between European and Māori children. In European children, BMI (12%) had a similar effect to waist (11%), and arm contributed 3%. As predictors, BMI and waist were identical and contributed 1.9 times more than arm. In Māori children, waist (38%) had a greater effect than BMI (7%), and arm contributed <1%. As predictors in Māori, waist contributed 2.4 times more than BMI, and 9.4 times more than arm circumference. This is evidence that BMI in Māori children is not as biologically relevant, or predictively effective, as waist circumference for determining %BF.

Discussion

This study confirms that in 2004, for children living in the Waikato region of New Zealand, the prevalence of overweight and obesity is high. According to IOTF criteria, 2 out of 10 5-year-olds and 3 out of 10 Waikato 10-year-old children were either overweight or obese. For 10-year-olds, our data are comparable with the 2002 national survey[16] where 4 out of 10 Māori and 2 out of 10 European children were either overweight or obese. For the Waikato 5-year-old Māori children in our study, the prevalence of overweight or obese was approximately 10% less than that previously reported.[16,17]

As in other population samples using BMI cut-offs, we have demonstrated a concerning prevalence of overweight and obesity in older children; particularly women, those of Māori origin, and those who attended lower SES and urban schools. Yet, while BMI is useful for describing a population, and can be used for describing differences between subpopulations, it may not necessarily be appropriate for explaining those differences. This is because BMI does not directly represent body composition. We have previously shown that Māori girls, but not boys, have a lower %BF than their European counterparts for equivalent BMI scores,[10,18] and the smaller difference in effect size when %BF and centiles are compared supports the argument that the ethnic comparison should not only be on the basis of BMI. For the same BMI, Māori adults have less fat and central adiposity than European adults.[19]

Table 2 Weighted† physical characteristics of the children by age group

	5-year olds			10-year olds		
	Mean (95% CI)‡	Range SD		Mean (95% CI)‡	Range SD	
Age (months)	68.1 (67.8 to 68.5)	58.4 to 82.2 3.7		127.8 (127.4 to 128.2)	112.5 to 142.0 4.1	
Height (cm)	114.7 (114.3 to 115.1)	98.6 to 129.8 5.0		143.7 (143.2 to 144.2)	121.9 to 172.5 6.8	
Height SDS	0.23 (0.16 to 0.30)	–3.04 to 3.72 1.0		0.28 (0.22 to 0.34)	–3.00 to 4.38 1.00	
Weight (kg)	21.9 (21.6 to 22.1)	14.9 to 44.2 3.4		40.3 (39.6 to 41.0)	20.2 to 120.2 9.8	
Weight SDS	0.56 (0.49 to 0.63)	–2.96 to 4.79 1.01		0.67 (0.60 to 0.74)	–4.02 to 4.53 1.06	
BMI (kg/m^2)	16.6 (16.4 to 16.7)	13.1 to 31.4 1.8		19.3 (19.1 to 19.6)	12.8 to 41.3 3.5	
BMI SDS	0.59 (0.53 to 0.65)	–2.42 to 5.14 0.96		0.74 (0.67 to 0.82)	–2.78 to 4.02 1.10	
Waist (cm)	55.6 (55.2 to 55.9)	45.0 to 87.1 4.8		68.4 (67.8 to 69.1)	50.3 to 124.5 9.6	
Waist SDS	0.88 (0.79 to 0.96)	–2.1 to 5.4 1.00		1.35 (1.28 to 1.42)	–1.91 to 4.38 1.06	
Waist-height index	0.48 (0.48 to 0.49)	0.41 to 0.73 0.04		0.48 (0.47 to 0.48)	0.35 to 0.75 0.06	
Arm (cm)	19.1 (19.0 to 19.3)	13.5 to 30.8 1.84		23.8 (23.5 to 24.0)	16.3 to 43.6 3.5	
%body fat	19.8 (19.3 to 20.3)	9.5 to 37.7 4.8		24.1 (23.7 to 24.6)	9.3 to 44.3 6.6	
%body fat SDS	0.78 (0.66 to 0.90)	–4.88 to 3.44 1.31		0.49 (0.39 to 0.59)	–4.69 to 2.85 1.25	
FFM (kg)	17.5 (17.3 to 17.7)	11.6 to 28.3 2.4		30.3 (29.8 to 30.7)	15.6 to 74.3 5.6	
FFMI (kg/m^2)	13.2 (13.1 to 13.3)	10.1 to 20.1 1.2		14.5 (14.4 to 14.7)	9.4 to 25.5 1.8	
FM (kg)	4.4 (4.3 to 4.6)	1.6 to 15.9 1.6		10.2 (9.8 to 10.5)	2.8 to 45.9 5.1	
FMI (kg/m^2)	3.3 (3.2 to 3.4)	1.4 to 11.3 1.1		4.8 (4.7 to 5.0)	1.5 to 17.0 2.2	
Systolic BP (mmHg)	98.8 (97.9 to 99.7)	68.0 to 137.5 10.0		106.6 (105.4 to 107.9)	79.0 to 152.0 10.7	
Systolic BP SDS	–0.61 (–0.71 to –0.50)	–4.87 to 3.31 1.17		–0.41 (–0.54 to –0.27)	–3.56 to 4.15 1.14	
Diastolic BP (mmHg)	62.5 (61.7 to 63.3)	38.5 to 102.5 8.5		67.1 (66.3 to 68.0)	40.5 to 116.0 8.5	
Diastolic BP SDS	0.84 (0.75 to 0.94)	–2.25 to 5.03 1.00		1.21 (1.11 to 1.31)	–2.09 to 6.09 0.96	
Pulse (beats/min)	90.1 (89.0 to 91.3)	48.0 to 136.0 11.9		82.1 (80.7 to 83.6)	49.0 to 130.0 12.5	
	Not overweight or obese %	Overweight %	Obese %	Not overweight or obese%	Overweight %	Obese %
IOTF BMI§	77.1	17.2	5.7	70.8	21.4	7.9
%body fat¶	59.0	33.4	7.6	70.8	27.0	2.2
	<90 cent %	90 cent %	95 cent %	<90 cent %	90 cent %	95 cent %
Systolic BP††	93.7	3.4	2.9	92.1	3.2	4.7

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] ‡95% Confidence intervals calculated taking into account the clustered (by school) study design.[9] §Cole *et al*.[14] ¶McCarthy *et al*.[13] ††Jackson *et al*.[12] BMI, body mass index; BP, blood pressure; FFM, fat free mass; FFMI, fat free mass index; FM, fat mass; FMI, fat mass index; IOTF, International Obesity Task Force; SDS, standard deviation score.

Table 3 Mean and SD of BMI and BMI SDS by age group and demographic characteristics†

	5-year-olds						10-year-olds					
	BMI			BMI SDS			BMI			BMI SDS		
	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
Girls	16.6	1.9	0.59	0.55	0.96	0.19	19.5	3.6	0.12	0.66	1.10	0.007
Boys	16.5	1.6	–	0.62	0.96	–	19.2	3.5	–	0.82	1.09	–
Rural	16.5	1.7	0.10	0.57	0.95	0.29	19.2	3.5	0.07	0.70	1.09	0.07
Urban	16.7	1.9	–	0.62	0.97	–	19.6	3.6	–	0.81	1.11	–
Decile 1–3	16.8	2.0	0.0004	0.71	1.02	0.0008	20.0	3.9	<0.0001	0.93	1.13	<0.0001
Decile 4–7	16.5	2.0	–	0.54	1.14	–	19.2	3.9	–	0.73	1.25	–
Decile 8–10	16.3	1.1	–	0.46	0.65	–	18.3	2.2	–	0.41	0.81	–
European	16.3	1.5	<0.0001	0.47	0.89	<0.0001	18.6	2.9	<0.0001	0.52	1.02	<0.0001
Māori	17.0	2.1	–	0.84	1.03	–	20.6	4.2	–	1.13	1.16	–
European												
Girls	16.4	1.7	0.47	0.45	0.90	0.54	18.7	3.1	0.25	0.42	1.04	0.005
Boys	16.3	1.3	–	0.49	0.88	–	18.5	2.8	–	0.62	0.99	–
Māori												
Girls	17.0	2.3	0.82	0.78	1.04	0.24	20.8	4.0	0.45	1.07	1.12	0.28
Boys	17.0	1.9	–	0.90	1.01	–	20.5	4.4	–	1.19	1.19	–

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] BMI, body mass index; SDS, standard deviation score.

Table 4 Weighted† percentage children overweight and obese by IOTF BMI criteria‡ by age group and demographic characteristics

	5-year-olds				10-year-olds			
	Not overweight or obese %	Overweight %	Obese %	*P*	Not overweight or obese %	Overweight %	Obese %	*P*
Girls	73.0	19.6	7.4	0.001	67.9	24.4	7.7	0.03
Boys	81.4	14.7	3.9	–	73.5	18.4	8.0	–
Rural	77.7	17.0	5.3	0.70	72.8	20.5	6.7	0.08
Urban	76.0	17.6	6.3	–	67.1	22.8	10.1	–
Decile 1–3	73.9	18.6	7.5	0.007	65.1	23.0	11.9	<0.0001
Decile 4–7	77.0	18.0	5.0	–	70.3	23.8	6.0	–
Decile 8–10	83.7	12.6	3.6	–	83.2	12.5	4.2	–
European	81.6	14.9	3.4	<0.0001	78.7	17.4	3.9	<0.0001
Māori	69.3	21.3	9.3	–	56.8	28.2	14.9	–
European								
girls	77.6	17.3	5.1	0.005	76.4	20.2	3.4	0.05
Boys	85.8	12.5	1.6	–	80.9	14.6	4.5	–
Māori								
girls	65.4	23.7	10.9	0.21	53.8	29.8	16.3	0.55
Boys	73.2	19.0	7.8	–	59.6	26.8	13.6	–
BP Sys <90 centile	79.0	16.0	5.0	<0.0001	72.8	20.4	6.7	<0.0001
90 centile	59.9	24.8	15.3	–	61.9	22.7	15.4	–
95 centile	46.2	39.8	14.0	–	37.3	39.2	23.5	–

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] ‡Cole *et al*.[14] BMI, body mass index; BP, blood pressure; IOTF, International Obesity Task Force.

Our cross-sectional study also showed that 10-year-old children had higher SD scores for body weight, BMI and blood pressure than 5-year-olds. This is a worrying statistic, as a recent longitudinal study[20] showed that excessive gains in BMI at any stage of the life course were associated with increased adult blood pressure. Children defined as overweight or obese by BMI or %BF were two to three times more likely to have elevated blood pressure and 10-year-old Māori children were twice as

Table 5 Weighted† mean and SD of percentage body fat (%BF) and %BF SDS by age group and demographic characteristics

	5-year-olds						10-year-olds					
	%BF			%BF SDS			%BF			%BF SDS		
	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
Girls	21.1	5.0	<0.0001	0.75	1.36	0.42	25.8	6.3	<0.0001	0.38	1.25	0.001
Boys	18.6	4.2	–	0.81	1.25	–	22.5	6.6	–	0.60	1.24	–
Rural	19.4	4.7	<0.0001	0.68	1.34	0.003	23.7	6.8	0.0009	0.39	1.32	<0.0001
Urban	20.7	4.7	–	0.96	1.23	–	24.9	6.3	–	0.68	1.09	–
Decile 1–3	20.0	5.0	0.03	0.81	1.29	0.02	24.4	6.9	0.001	0.50	1.31	0.03
Decile 4–7	20.1	5.6	–	0.84	1.51	–	24.5	7.7	–	0.56	1.40	–
Decile 8–10	19.1	3.4	–	0.57	1.09	–	22.8	4.8	–	0.32	0.93	–
European	19.4	4.5	0.0009	0.67	1.34	0.001	23.4	6.3	<0.0001	0.38	1.23	0.0002
Māori	20.4	5.2	–	0.94	1.25	–	25.2	7.3	–	0.66	1.31	–
European												
Girls	20.4	4.7	<0.0001	0.61	1.36	0.17	25.4	6.1	<0.0001	0.31	1.24	0.11
Boys	18.3	4.1	–	0.74	1.32	–	21.5	5.9	–	0.45	1.21	–
Māori												
Girls	22.1	5.4	<0.0001	1.01	1.32	0.24	26.3	6.8	0.002	0.46	1.32	0.003
Boys	18.7	4.4	–	0.86	1.17	–	24.1	7.6	–	0.84	1.27	–

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] SDS, standard deviation score.

Table 6 Weighted† percentage children overweight and obese by percentage body fat criteria‡ by age group and demographic characteristics

	5-year-olds				10-year-olds			
	Not overweight or obese %	Overweight %	Obese %	*P*	Not overweight or obese %	Overweight %	Obese %	*P*
Girls	59.9	32.8	7.3	0.81	73.3	24.9	1.8	0.19
Boys	58.1	34.1	7.8	–	68.5	29.0	2.5	–
Rural	63.3	30.4	6.3	0.0008	72.5	26.0	1.5	0.09
Urban	51.2	38.9	9.9	–	67.7	28.9	3.4	–
Decile 1–3	59.1	33.3	7.6	0.60	66.9	30.1	3.0	0.005
Decile 4–7	57.1	34.4	8.4	–	70.3	27.7	2.0	–
Decile 8–10	63.3	31.3	5.4	–	79.7	19.4	0.9	–
European	61.4	32.9	5.8	0.06	76.0	22.4	1.6	0.0002
Māori	57.1	32.4	10.5	–	63.5	33.1	3.4	–
European								
Girls	65.8	29.3	4.9	0.03	77.1	21.1	1.8	0.61
Boys	56.7	36.6	6.6	–	74.9	23.7	1.4	–
Māori								
Girls	50.9	37.8	11.3	0.07	68.4	29.6	2.0	0.12
Boys	63.3	27.1	9.6	–	59.0	36.3	4.6	–
BP sys <90 centile	60.1	32.9	7.0	0.02	72.6	25.4	2.0	<0.0001
90 centile	49.0	42.1	8.9	–	63.0	33.1	3.8	–
95 centile	45.5	31.1	23.4	–	42.1	54.7	3.3	–

†Weighted by a combination of age, ethnicity and school-decile to match the Waikato school population.[8] ‡McCarthy *et al*.[13]

likely to be overweight or obese as European children. Other work undertaken in adolescents aged 11–13 years shows ethnic differences in the relationship between high blood pressure and overweight and obesity.[21] It can therefore be inferred from our data that in adolescence, as obesity prevalence increases, this ethnic gap may be amplified, particularly among women and those living in rural locations. Elsewhere, SES has also been reported as a further confounder of blood pressure.[22]

High blood pressure is present in the majority of middle-aged and older Māori.[23] Bullen *et al*.[24] identified that BMI was the major modifiable factor for this higher prevalence of raised blood pressure.[25] Our data show slightly higher measures of systolic and diastolic pressures in 10-year-old Māori children compared with their European counterparts. This is of concern, as in the 2006/2007 national health survey[26] Māori men and women were 1.3 times more likely than European men and women to report medicated high blood pressure and were also twice as likely to smoke and be obese (41.7% vs. 24%). The higher blood pressure in our 10-year-old rural children is not readily explained by gender, ethnicity, obesity or school-SES. For a physical activity and nutrition intervention with children, therefore, a more appropriate outcome may be to lower blood pressure rather than weight gain in isolation; as this is not only a more sensitive early outcome measure but may also contribute to significant independent health gain.[27,28]

To address the concern of ethnic differences in body composition and growth rates, we suggest that normative BMI for Māori (including cut-offs for overweight and obesity based on %BF) children should be derived. A recent paper (also from the Waikato region) identifying optimal cut-offs for risk of metabolic risk factors and dysglycaemia for adult Māoris shows that BMI and waist circumference are higher than the accepted cut-offs for Europeans, that is, ~32 kg/m^2 and ~100 cm for men and women.[29]

Conclusions

Primary school children in the Waikato, New Zealand, have a high prevalence of overweight and obesity that is linked with hypertension. Cardiovascular risk factors increase with age, school-SES and to some extent, urban living. This supports the need to maximise the opportunities for physical activity and improved nutrition by creating supportive environments and targeting rural and more deprived areas to slow the increase in weight, fatness and blood pressure, and prevent or delay the onset and severity of chronic disease.[30] As Project Energize evolves, it is recommended that the physical activity and nutrition needs of schools of lower SES, with higher Māori rolls and who are urban, are a priority.

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References

1 Livingstone MB, McCaffrey TA, Rennie KL. Childhood obesity prevention studies: lessons learned and to be learned. *Public Health Nutr.* 2006; **9**: 1121–9.
2 Katz DL, O'Connell M, Njike VY, Yeh MC, Nawaz H. Strategies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. *Int. J. Obes. (Lond.)* 2008; **32**: 1780–9.
3 Summerbell CD, Waters E, Edmunds LD, Kelly S, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Database Syst. Rev.* 2005; (3): CD001871.
4 Campbell KJ, Hesketh KD. Strategies which aim to positively impact on weight, physical activity, diet and sedentary behaviours in children from zero to five years. A systematic review of the literature. *Obes. Rev.* 2007; **8**: 327–38.
5 Sharma M. International school-based interventions for preventing obesity in children. *Obes. Rev.* 2007; **8**: 155–67.
6 Van Cauwenberghe E, Maes L, Spittaels H *et al*. Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature. *Br. J. Nutr.* 2010; **103**: 781–97.
7 Singh AS, Chin APMJ, Kremers SP, Visscher TL, Brug J, van Mechelen W. Design of the Dutch Obesity Intervention in Teenagers (NRG-DOiT): systematic development, implementation and evaluation of a school-based intervention aimed at the prevention of excessive weight gain in adolescents. *BMC Public Health* 2006; **6**: 304.
8 Statistics New Zealand. New Zealand: An urban/rural profile: Statistics New Zealand. 2001.
9 Graham D, Appleton S, Rush E, McLennan S, Reed P, Simmons D. Increasing activity and improving nutrition through a schools-based programme: Project Energize. 1. Design, programme, randomisation and evaluation methodology. *Public Health Nutr.* 2008; **11**: 1076–84.
10 Rush EC, Puniani K, Valencia ME, Davies PSW, Plank LD. Estimation of body fatness from body mass index and bioelectrical impedence: comparison of New Zealand European, Maori and Pacific Island children. *Eur. J. Clin. Nutr.* 2003; **57**: 1394–401.
11 Freeman JV, Cole TJ, Chinn S, Jones PR, White EM, Preece MA. Cross sectional stature and weight reference curves for the UK, 1990. *Arch. Dis. Child.* 1995; **73**: 17–24.
12 Jackson LV, Thalange NK, Cole TJ. Blood pressure centiles for Great Britain. *Arch. Dis. Child.* 2007; **92**: 298–303.
13 McCarthy HD, Cole TJ, Fry T, Jebb SA, Prentice AM. Body fat reference curves for children. *Int. J. Obes. (Lond.)* 2006; **30**: 598–602.
14 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.
15 Statistics New Zealand. *2001 Census, Cultural Diversity Tables*. Wellington: Statistics New Zealand, 2002.
16 Ministry of Health. *NZ Food NZ Children, Key Results of the 2002* National Children's Nutrition Survey. Wellington: Ministry of Health, 2003.
17 Turnbull A, Barry D, Wickens K, Crane J. Changes in body mass index in 11–12-year-old children in Hawkes Bay, New Zealand (1989–2000). *J. Paediatr. Child Health* 2004; **40**: 33–7.
18 Rush EC, Scragg R, Schaaf D, Juranovich G, Plank LD. Indices of fatness and relationships with age, ethnicity and lipids in New Zealand European, Maori and Pacific children. *Eur. J. Clin. Nutr.* 2009; **63**: 627–33.

19 Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. *Br. J. Nutr.* 2009; **102**: 632–41.
20 Li L, Law C, Power C. Body mass index throughout the life-course and blood pressure in mid-adult life: a birth cohort study. *J. Hypertens.* 2007; **25**: 1215–23.
21 Harding S, Maynard MJ, Cruickshank K, Teyhan A. Overweight, obesity and high blood pressure in an ethnically diverse sample of adolescents in Britain: the Medical Research Council DASH study. *Int. J. Obes. (Lond.)* 2008; **32**: 82–90.
22 Grotto I, Huerta M, Sharabi Y. Hypertension and socioeconomic status. *Curr. Opin. Cardiol.* 2008; **23**: 335–9.
23 Simmons D, Thompson CF. Prevalence of the metabolic syndrome among adult New Zealanders of Polynesian and European descent. *Diabetes Care* 2004; **27**: 3002–4.
24 Bullen C, Tipene-Leach D, Vander Hoorn S, Jackson R, Norton R, MacMahon S. Ethnic differences in blood pressure: findings from the Fletcher Challenge-Auckland University Heart and Health Study. *N. Z. Med. J.* 1996; **109**: 395–7.
25 Gentles D, Metcalf P, Dyall L *et al*. Blood pressure prevalences and levels for a multicultural population in Auckland, New Zealand: results from the Diabetes, Heart and Health Survey 2002/2003. *N. Z. Med. J.* 2006; **119**: U2318.
26 Ministry of Health. *A Portrait of Health: Key Results of the 2006/07 New Zealand Health Survey*. Wellington: Ministry of Health, 2008.
27 Torrance B, McGuire KA, Lewanczuk R, McGavock J. Overweight, physical activity and high blood pressure in children: a review of the literature. *Vasc. Health Risk Manag.* 2007; **3**: 139–49.
28 Short KR, Blackett PR, Gardner AW, Copeland KC. Vascular health in children and adolescents: effects of obesity and diabetes. *Vasc. Health Risk Manag.* 2009; **5**: 973–90.
29 Rush EC, Crook N, Simmons D. Optimal waist cutpoint for screening for dysglycaemia and metabolic risk: evidence from a Maori cohort. *Br. J. Nutr.* 2009; **102**: 786–91.
30 Delmis J. [Effect of diet and salt intake on the development of hypertension in children and adolescents]. *Acta Med. Croatica* 2010; **64**: 111–4.