

ORIGINAL RESEARCH

Obesity, energy intake and physical activity in rural and urban New Zealand children

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ABSTRACT

Introduction: Concerns have been raised about childhood obesity and its long-term impact on the health of children. The objective of this study was to investigate rural–urban differences in body composition, energy intake, physical activity and screen time in New Zealand children.

Methods: This study reports on data collected in a large national cross-sectional population survey of 5-15 year-old New Zealanders (the 2002 National Children's Nutrition Survey, CNS02). Schools were randomly selected to participate, as were pupils from the selected schools. Measurements of body composition were taken at school. Energy intake, physical activity and screen time information were taken from interviews and questionnaires undertaken by the child and parent/guardian. Means and standard deviations were calculated in the Statistical Analysis System (SAS Inst; Cary, NC, USA). Differences between groups were analysed using Proc Mixed after adjusting for socio-economic status and ethnicity. Data indicating differences between groups were presented as least square means \pm 95% confidence limits (CL); unless otherwise stated, and the α was set at $p < 0.05$.

Results: Rural children had a significantly lower BMI, smaller waist circumferences and thinner skinfold measurements than urban children. The differences in skinfold thicknesses remained after controlling for ethnicity and socioeconomic status. Furthermore, urban boys were 1.3 times more likely to be overweight or obese than rural boys (95% confidence limits 1.1-1.6, $p < 0.01$) and urban girls were 1.4 times more likely to be overweight or obese than rural girls (95% CL 1.2-1.7, $p < 0.01$). There was no significant difference in the energy intake per day of rural and urban children. Similarly, there was no significant difference in the frequency of bouts of physical activity undertaken by rural and urban children.



Conclusions: Differences were found in body composition with rural children being leaner than urban children. This finding is different from other Western countries and may be due to differences in the physical and social environment in New Zealand. More research is required to understand these potential environmental rural–urban differences.

Keywords: energy, obesity, pediatric, physical activity, screen time, urban/rural.

Introduction

The increasing prevalence of obesity, and detrimental health behaviours of high dietary energy intakes and low physical activity levels have been causing concern in Western countries, including New Zealand. In 2003, 21% of New Zealand adults over the age of 15 years were obese, an increase from the 17% recorded in 1997¹. For New Zealand children, there is also a trend of increasing obesity^{2,3}, with reports of 21% of children being overweight and 9.8% being obese in the latest national survey⁴. The impact of rising obesity levels in the population is a cause for great concern.

The relationship between obesity, energy intakes and inactivity in disease prevalence is well documented⁵. Considerable effort has been devoted to understanding the underlying determinants of obesity and its associated health behaviours. For example, physical inactivity is associated with age, sex, socioeconomic status and ethnicity^{6,7}. One determinant that has recently been gaining attention is location of residence, that is, rural or urban dwelling.

There are a number of reports that rural dwelling adults have higher levels of obesity and lower levels of physical activity than their urban counterparts⁸⁻¹⁰, although the findings for physical activity may not be generalisable¹⁰. There is mixed and contradictory evidence of rural–urban differences in children. A cross-sectional study¹¹ of American adolescents found that rural children had higher obesity levels (16.5%) compared with urban children (14.3%). This study also found that urban children had higher levels of physical inactivity compared with rural children. This finding is supported by a study of 8-12 year old children from a Midwestern state of America where more rural children were

overweight (25.1%) than urban children (19.4%), and urban children were less active. Furthermore a cross-sectional study of Canadian 11-15 year olds found that levels of overweight and obesity increased with increasing ‘rurality’¹². No rural–urban difference was reported in this Canadian study for physical activity participation, although rural children had lower levels of ‘screen time’ (television and video watching and computer use). Rural–urban differences in physical activity participation have been reported for Australian adolescent girls in the summer but not the winter; no differences were found for boys¹³.

There are no reports referenced on Medline comparing obesity, and associated health behaviours such as energy intake and physical activity levels between rural and urban New Zealand children. There is, however, a report indicating rural New Zealand children are leaner than urban children¹⁴. The objective of the current study was to further document and investigate rural–urban differences in body composition, energy intake, physical activity and screen time in New Zealand children.

Methods

This study reports on data collected in a large national cross-sectional population survey of 5-15 year-old New Zealanders (the 2002 National Children’s Nutrition Survey, CNS02). Full details of survey methods have been provided elsewhere⁴.

The survey used a two-stage sampling procedure whereby schools were randomly selected and invited to participate; children were then randomly selected from participating schools. For reasons of cost, some schools were excluded



(schools with <50 students, correspondence schools and schools on a remote island). Overall 172 schools agreed to take part in the study, representing a 91% response rate. The total number of children recruited was 4728, of which 3275 finally participated (response rate 69%: 2792 urban children [85.3%], 483 rural children [14.7%]). In the CNS02 study, 'urban' was classified as any school located in either a main urban or secondary urban area, while 'rural' was classified as any school located in either a minor urban or rural area according to Statistics New Zealand geo-coding criteria⁴.

Data for this study were collected from Food Habits and Physical Activity interviews, the 24 hour diet recall questionnaires, and standard anthropometric measurements⁴. Most of the interviews were undertaken at the children's homes in the presence of their parent or guardian. The data from the 24 hour diet recall questionnaires were used to determine energy intake⁴. Physical activity recall data from the previous 7 days were collected using the Physical Activity Questionnaire for Children (PAQ-C)⁴. The PAC-Q asked children to complete a range of questions relating to the type, frequency and intensity of physical activity undertaken at various times during the past week. The survey contained 8 physical activity questions relating to sport activities/games (such as whether they participated in netball, soccer or dancing), physical activity undertaken at morning recess, lunch time, after school and in the evenings as well as weekend physical activity. The data relating to weekly physical activity performed are the sum of all the sports or games reported as being undertaken during the week and then divided by the number of activities to determine a mean weekly frequency score. Data were assigned an arbitrary unit based on the following Likert scale (1, 0 times; 2, 1-2 times; 3, 3-4 times; 4, 5-6 times; 5, ≥ 7 times per week).

In addition, a series of questions also asked children to report their screen viewing behaviour (television or video viewing or playing video or computer games). Children reported on viewing frequency (number of days) and duration (number of hours). The time reported for each of the behaviours was summed to get an accumulated screen time and then

assigned an arbitrary unit based on the following scale (1, <1 hour; 2, 1-2 hours; 3, 3-4 hours; 4 >4 hours per week).

For anthropometric measurements children wore light clothing and no shoes. Measurements were taken at school by research assistants. Height was measured with a portable stadiometer. Two measurements were made to the nearest 0.1 cm. If these measurements differed by more than 0.5 cm, a third measurement was taken and the mean of the closest two measurements was recorded. Weight was measured on Seca scales (Seca; Hamburg, Germany) to the nearest 0.1 kg. The scales were calibrated with a standard weight prior to use. Two measurements were taken and if these differed by more than 0.5 kg a third measurement was taken and the mean of the closest two measurements was recorded. Triceps (mid-point in the length of the horizontal line between the acromion process and the tip of the olecranon) and subscapular (inferior angle of scapula) skinfold thicknesses were measured with Holtain callipers (Crymych, UK) to the nearest 0.1 mm. Two measurements were made at each site and if they differed by more than 0.5 mm a third was taken and the mean of the closest two measurements was recorded. Similarly, two waist (highest point of the iliac crest during minimal respiration) and arm (mid-point in the length of the horizontal line between the acromion process and the tip of the olecranon) circumferences were measured to the nearest 0.1 cm at each site. If these differed by more than 0.5 cm a third measurement was taken and the mean of the closest two measurements was recorded. All anthropometric measurements were made on the right hand side of the body whenever possible, and the final value was calculated as the mean of the two closest measurements.

Demographic data including ages and ethnicity were collected during the Food Habits and Physical Activity interviews, as was the residential address used to determine socioeconomic status using the New Zealand Deprivation Index (NZDep)⁴.

The large National Children's Nutrition Survey dataset obtained from the Ministry of Health as a Microsoft Excel spreadsheet was initially transferred to the Statistical



Analysis System v9.1.3 (SAS Inst; Cary, NC, USA) for further analysis. Changes in the means of variables between the urban and rural groups were estimated using a mixed modelling procedure (Proc Mixed) within the SAS software. To control for the confounders of ethnicity and socioeconomic status, these two variables and their interactions were added to the model statement as covariates. In addition, nominal variables representing the proportion of children (and subgroups) meeting overweight and obesity cut-offs were compared by categorical modelling using the proc freq procedure in SAS. A type I error of 5% was chosen for declaration of statistical significance; precision of estimates were represented by the 95% confidence limits (CL, the likely range of true value).

Ethics approval

Ethics approval for the original study was gained from all the thirteen New Zealand Regional Health Ethics Committees. Informed written consent was received from all parents or guardians of participating children.

Results

The proportion of differing ethnic groups in the sample population are shown (Table 1). An over-sampling technique produced approximately equal numbers of urban Maori, Pacific and European/other children, but did not sample equal numbers of Polynesian children compared with other ethnicities in rural areas. For this reason Pacific children were excluded from ethnicity comparisons of urban and rural groups.

The physical characteristics of the urban and rural groups in this study are presented (Table 2). Although no significant effects were found with geographical location in age, weight, height or energy intake, significant differences were found in BMI, circumferences and skinfolds. Using well-established international cut-offs¹⁵ urban boys were found 1.3 times more likely to be overweight or obese than rural boys (95%

confidence limits 1.1-1.6, $p < 0.01$) and urban girls were 1.4 times more likely to be overweight or obese than rural girls (95% CL 1.2-1.7, $p < 0.01$).

Differences in body composition (sum of triceps and subscapular skinfolds), physical activity, screen time (television and computer/video game usage) and energy intake between the two geographical groups is shown (Table 3). Urban children had significantly higher levels of subcutaneous fat than rural children, which is evident in both males (approximately 8% higher) and females (approximately 14% higher). Children from rural areas tended to have lower subcutaneous fat levels regardless of ethnicity, age or socioeconomic status. Indeed, when the analysis was adjusted to account for differences in ethnic make-up and socioeconomic status of children from the two groups, the difference in the overall sum of skinfolds between the groups remained (urban 23.9 mm, rural 19.9 mm, difference -4.0 mm, $p = 0.01$). Significant interactions were found between sum of skinfolds, ethnicity ($p = 0.004$) and socioeconomic status ($p = 0.05$).

Overall weekly physical activity was similar in rural and urban children; however, differences were found between children in the various subgroups. Rural children identified as European/other, or from higher socioeconomic families were more active than their urban counterparts. Conversely, urban Maori children were more active than rural Maori children. Accounting for ethnicity or socioeconomic status in the model had little effect on weekly physical activity with no significant interactions found. Overall screen time tended to be lower in the rural children; however, this was only statistically significant in children aged 5-7 years. Accounting for ethnicity and socioeconomic status decreased the total screen time in the rural group to 2.3 but had little effect on the urban groups' screen time (2.8). Therefore, after accounting for these confounders it was found that rural children watched significantly less total screen time than urban children ($p = 0.02$).



Table 1: Ethnicity characteristics of sample population (subject number in each category)

Urban						Rural					
European/Other		Pacific		Maori		European/Other		Pacific		Maori	
M	F	M	F	M	F	M	F	M	F	M	F
441	350	508	538	496	459	111	91	6	6	135	134

M, male; F, female.

Table 2: Participant characteristics

Characteristic	Male			Female		
	Urban (N=1445)	Rural (N=252)	Difference; ± 95% CL	Urban (N=1347)	Rural (N=231)	Difference; ± 95% CL
Age (years)	9.2	9.3	0.1; ± 0.3	9.4	9.5	0.1; ± 0.4
Weight (kg)	40.6	40.1	-0.5; ± 2.3	43.5	41.8	-1.7; ± 2.6
Height (cm)	140.4	140.7	0.3; ± 2.4	141.8	141.5	-0.3; ± 2.8
BMI	19.7	19.3	-0.4; ± 0.6	20.7	19.8	-0.9; ± 0.7
Waist (cm)	66.6	65.0	-1.6; ± 1.8	69.3	67.1	-2.2; ± 1.9
Arm (cm)	22.7	22.2	-0.5; ± 0.7	23.6	23.0	-0.6; ± 0.6
Tricep (mm)	12.5	11.6	-0.9; ± 0.8	15.3	14.6	-0.7; ± 0.9
Subscapular (mm)	9.7	8.8	-0.9; ± 0.9	12.6	10.3	-2.3; ± 1.2
Energy intake (kJ)	9318	9652	334; ± 450	8135	8309	174; ± 470
Overweight/obese (%)	40.2	30.1	-10.1	49.2	35.2	14.0

Data are means for each group and the estimated difference between groups, except for overweight/obesity which is the proportion of children classified as overweight or obese using Cole et al. cut-offs[15].

For ± 95% CL, add and subtract this number to the mean difference to obtain confidence limits for the true difference.

Energy intake tended to be similar between the two groups, apart from rural Maori, rural children aged 11-13 years, and children from rural low socioeconomic families who all had significantly higher energy intakes than their urban counterparts. Accounting for the confounding variables of ethnicity and socioeconomic status had little effect on total energy intakes between the groups with no significant interactions found.

Discussion

Obesity and body composition

The current study reports rural and urban differences in body composition, energy intake, physical activity and screen time for New Zealand children. The study found that rural

children had a significantly lower BMI, smaller waist circumferences and thinner skinfold measurements than urban children. This finding is similar to a previous New Zealand report that found rural children had lower percent body fat in 5 year-olds and smaller waist circumferences and BMIs in 10 year-olds compared with their urban counterparts¹⁴. This finding is also similar to a cross-sectional study of body composition in Turkish children, which found that urban children had higher tricep, subscapular and supralliac skinfold thicknesses than rural children, as well as being significantly taller and heavier¹⁶. In addition, a study reporting secular trends in China and Brazil has reported a higher prevalence of overweight in children in urban areas, although these findings may reflect the changes in economic development in these countries¹⁷.



Table 3: Differences in body composition, physical activity, screen time and energy intake between urban and rural children

Variable	Skinfolds sum (mm)			Weekly physical activity			Accumulated screen time			Energy intake (kJ)		
	U	R	Diff	U	R	Diff	U	RI	D	U	R	Diff
Total	24.7	22.2	-2.5; ± 1.3*	2.9	2.9	0.0; ± 0.1	2.8	2.7	-0.1; ± 0.2	8747	9010	263; ± 321
Sex												
Male	21.9	20.3	-1.6; ± 1.6*	3.0	3.0	0.0; ± 0.1	2.9	2.9	0.0; ± 0.2	9318	9652	334; ± 440
Female	27.6	24.2	-3.4; ± 1.8*	2.8	2.8	0.0; ± 0.1	2.5	2.4	-0.1; ± 0.3	8135	8309	174; ± 460
Ethnicity												
European/other	21.5	20.6	-0.9; ± 1.9	2.8	2.9	0.1; ± 0.1*	2.8	2.5	-0.3; ± 0.3	8507	8388	-119; ± 550
Maori	23.5	23.6	0.1; ± 1.7	3.0	2.9	-0.1; ± 0.1*	2.9	2.9	0.0; ± 0.2	9054	9517	463; ± 440*
Age (years)												
5–7	19.4	17.7	-1.7; ± 2.1	3.0	3.0	0.0; ± 0.1	2.6	2.2	-0.4; ± 0.3*	7808	8002	194; ± 560
8–10	24.9	21.8	-3.1; ± 2.0*	3.0	3.0	0.0; ± 0.1	2.7	2.6	-0.1; ± 0.3	8685	8521	-164; ± 540
11–13	28.7	25.7	-3.0; ± 2.3*	2.8	2.8	0.0; ± 0.1	2.9	3.0	0.1; ± 0.3	9285	1020	917; ± 600*
14–15	30.6	27.8	-2.8; ± 3.8	2.4	2.6	0.2; ± 0.2	3.2	3.3	0.1; ± 0.5	1081	1053	-283; ± 980
Socioeconomic status												
Low	26.2	24.1	-2.1; ± 2.2	2.9	2.9	0.0; ± 0.1	2.8	2.6	-0.2; ± 0.3	8843	9899	1056; ± 580*
Middle	23.5	20.9	-2.6; ± 2.5*	2.9	2.9	0.0; ± 0.1	2.9	2.8	-0.1; ± 0.4	8563	8389	-174; ± 670
High	21.6	20.7	-0.9; ± 3.1	2.8	3.0	0.2; ± 0.1*	2.7	2.3	-0.4; ± 0.4	8618	8150	-468; ± 860

Diff, Difference; ± 95% CL; U, urban; R, rural.

Data are means for each group and the estimated difference between groups with the 95% confidence limits ± 95% CL, add and subtract this number to the mean difference to obtain confidence limits for the true difference. *Sum of skinfolds*, sum of triceps and subscapular skinfolds; *weekly physical activity*, weekly sport and games frequency in arbitrary units which range from 1 (no sport or games during the week) to 5 (over 7 times per week); *accumulated screen time*, daily television and computer/video game usage in arbitrary units which range from 1 (less than 1 hour per day) to 4 (over 4 hours per day); energy intake, children's energy intake estimated from the 24-hour diet recall questionnaire.

*Significantly different between geographical groups ($p < 0.05$).

There is, however, research that shows a different relationship. Lewis et al. studied the prevalence and extent of obesity in school age children from Georgia, USA, and found that children in rural areas had a higher prevalence of overweight than those in the suburban and urban areas¹⁸. Similarly, McMurray et al. found that rural children have a significantly higher BMI, sum of skinfolds and a greater proportion of rural children were obese¹⁹. Studies outside the

USA have also generally found that rural children had a higher prevalence of obesity than urban children^{12,17,20-25}.

The disparity between the results of the current study and other reports could be related to the demographic differences in rural and urban populations in the different studies. This is because socioeconomic status and ethnicity are correlates of obesity²⁶ and it is possible that the rural-urban differences found are reflections of the demographics of the populations.



Despite controlling for ethnicity and socioeconomic status, the current study found that rural children were leaner than their urban counterparts. Other studies report the converse finding, despite controlling for socioeconomic status^{11,12} and ethnicity¹¹. Other explanations for the reported rural–urban differences in body composition could be differences in the physical or social environment¹². These potential environmental differences warrant further investigation because this may provide useful insights in terms of obesity interventions.

Physical activity

The current study did not find any differences in the frequency of bouts of physical activity but it was found that rural children had lower screen time. However, some studies have found physical activity differences. In 1996, urban dwelling Cameroon children tended to be more sedentary and total physical activity scores were two times higher in the rural children²⁷. These results contrast with an Icelandic study that found rural students were involved in less strenuous and more sedentary leisure time activities²⁸.

These conflicting results have a number of possible explanations. First, differences could be due to demographic differences such as socioeconomic status or ethnicity, as mentioned previously. This highlights the importance of controlling for these variables in studies of rural and urban differences in obesity or physical activity. Second, in large population studies like the present one, physical activity is usually measured by self-report. Self-reports are an easy and efficient method of data collection but may lack accuracy. An issue to bear in mind when interpreting self-reported physical activity data for urban and rural residents is that urban and rural people are likely to interpret physical activity differently. While physical activity is often seen as a leisure or recreation time activity for urban residents, it is often associated with work for rural residents (eg farm work) and, therefore, may not be reported as physical activity²⁹.

Those studies that found urban children to have higher levels of physical activity may have had easier access to

interventions such as community sports programs or sports facilities²⁸. Those studies that found rural children to be more active may be due to an increased opportunity to spend time outdoors for rural children^{29,30}.

There are a number of limitations to this study. The study population is not representative, in that there were high proportions of Maori and Pacific (particularly urban Pacific) children sampled. To overcome this non-representation, differences between urban and rural children were controlled for ethnicity. In addition, rural children form a relatively small percentage (13.7%) of the sample and they could have been oversampled. The study also excluded very small schools and very remote areas and this may have influenced the results. The study used only two skinfold measurements and a self-reported measure of physical activity frequency. Differences between the rural and urban children may have been revealed if activity frequency and duration had been measured.

Conclusion

Differences were found in body composition, with rural children being leaner than urban children (despite no differences in energy intakes and frequency of physical activity). This New Zealand finding is different from other Western countries and may be due to differences in the physical and social environment. More research is required to understand these potential environmental rural–urban differences because this may provide useful insights in terms of obesity interventions.

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