The Centre for Sustainable Transportation

Le Centre pour un transport durable

SETTLEMENT PATTERN, PHYSICAL ACTIVITY, AND THE BODY WEIGHTS OF CHILDREN AND YOUTH

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Chapter 1. Introduction

1.1 Overview of this report

This report addresses the question, 'Do body weights of Canadian children and youth vary according to where they live?'. The report also discusses factors that might contribute to variation in body weights of children and youth with settlement type, notably amounts of walking and cycling, and other physical activity.[1†]

Section 2 reviews the relevant literature. Section 3 provides new analysis of data from the latest cycle of the National Longitudinal Survey of Children and Youth. Section 4 sets out a preliminary proposal for further work to answer some of the questions arising out of Sections 2 and 3.

1.2 The Centre's interest in children and transport

The Centre for Sustainable Transportation's mission is "to provide leadership in achieving sustainable transportation in Canada by facilitating cooperative actions, and thus contributing to Canadian and global sustainability". It has developed a well-regarded definition of sustainable transportation.[2]

The Centre's interest in children (here including youth) and transport developed with the awareness that child-friendly transport is usually more sustainable than other transport. Children who travel sustainably may be more likely to do so when they are adults. Children are transport's 'canaries'. They are more vulnerable to adverse impacts, e.g., air pollution, and thus provide warnings of heightened unsustainability. Last but not least, sustainability is about intergenerational equity, which implies equal consideration for all generations, those living now and those to come.

Work on children and transport in the Regions of Halton and Peel,[3] west of Toronto, alerted The Centre to the possibility of considerable differences in physical activity between children who live in suburban contexts and those who live in urban and other contexts, and of the value of exploring these differences to understanding of factors in children's transport.

The Centre also became aware of growing professional concern about declining physical activity in children and reports of increasing prevalence of childhood obesity.[4] There were data indicating that body weights of adults can vary according to whether they live in urban, suburban or other settings,[5] but few data on how children's body weights might vary according to where they live.

† Superscript numbers refer to 103 reference and other notes that begin on Page 49.

1.3 Project objectives

A proposal for preliminary work on these topics was developed with the following objectives:

1. Review available data and literature on the movement of children and young people from place to place in affluent societies, with a focus on the following:
   (a) how this movement has changed over the years, particularly in the amounts of active or non-motorized transportation, e.g., walking and bicycling;
   (b) how it varies according to settlement pattern, e.g., between city centre, suburban, and rural areas;
   (c) how it varies with age, household income, household car ownership, transit availability and use, and across seasons;
   (d) how changes across the years in the patterns of this movement may have contributed to changes in the prevalence of overweight and obesity among children and young people; and
   (e) how changes in this movement could be reversed, particularly but not only through changing settlement patterns.

2. Identify methods for tracking the movement of children and young people.

3. Scope out a study that would illuminate the relationships that may exist between settlement patterns and transport choices, on the one hand, and overweight and obesity, on the other hand.

With the cooperation of Professor Eric Miller of the University of Toronto, funding for this preliminary work was secured from the Institute for Nutrition, Metabolism and Diabetes (Canadian Institutes of Health). The present report presents work done by The Centre to meet the above objectives.

Chapter 2. Review of literature and available data

There are few available reports on the precise topics set out above in Section 1.3. They are reviewed in the present section together with relevant work, including work on adults. Most of the material bearing directly on the Topics 1(a)-1(e) in Sub-section 1.3 is discussed in Sections 2.8 below, which concerns links among settlement pattern, transport arrangements, physical activity, and body weight in children and youth.

Sections 2.1 to 2.7 provide necessary or useful context. They concern changes in body weight and physical activity, and links between them, in adults and in children and youth (Sections 2.1-2.6). Also reviewed, in Section 2.7, data for adults on the topic of Section 2.8, namely links among settlement pattern, transport arrangements, physical activity, and body weight.

As well as reviewing relevant literature, the following discussions provide new analyses of available survey data.

2.1 Changes in the body weights of adults

More than 50 years ago, the American Heart Association identified obesity as a cardiac risk factor modifiable through diet and exercise.[6] The prevalence of obesity in affluent countries had become a concern by the early 1970s, but it was regarded chiefly as a nutritional disease.[7]

More recently, Canadian adults have been said to be in the grip of an obesity epidemic. This message was in the title of a 2002 article in the *Canadian Medical Association Journal*.[8] The article noted that "Canada has recently experienced a major epidemic of obesity, with the population prevalence more than doubling between 1985 and 1998". The actual reported increase was from 5.6 per cent to 14.8 per cent. The latter percentage represented 3.3 million of 22.2 million adult Canadians. An obese adult was one whose Body Mass Index (BMI) was 30.0 or more where BMI is the person's weight in kilograms divided by the square of the person's height in metres. This is the definition used here unless otherwise noted.

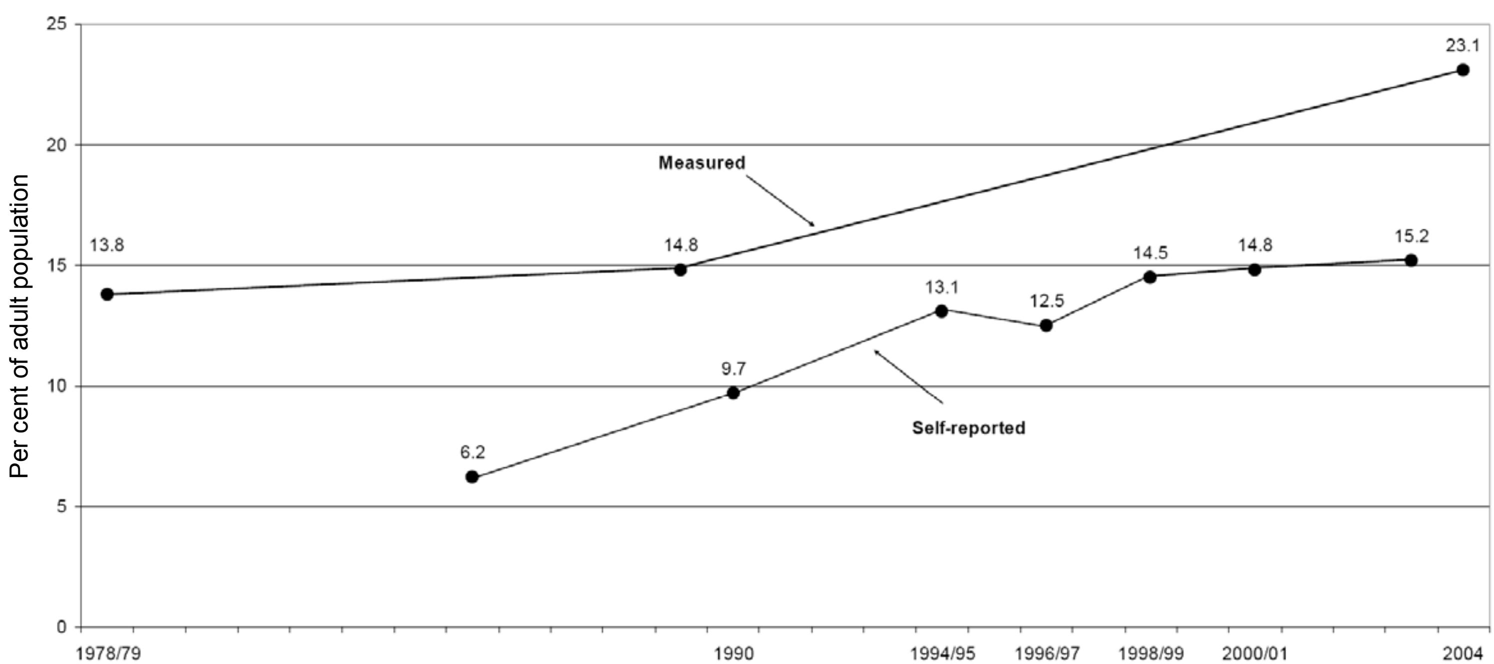
These observations were reinforced by a 2004 publication by the Canadian Population Health Initiative, part of the Canadian Institute for Health Information.[9] It included the following: "The dramatic increases in overweight and obesity among Canadians over the past 20 years have been deemed to constitute an epidemic" (Page v). This report included an additional data point beyond those discussed in the previously noted article: from the Canadian Community Health Survey, showing an obesity prevalence of 14.9 per cent in 2000-2001.

The adult prevalences noted so far have been based on *self-reported* height and weight. The report discussed in the previous paragraph stated that “body weights tend to be underreported”. At the time, the only available data that allowed comparison of same- or near-year measured *and* self-reported assessments were from the 1986-1992 Canadian Heart Health Surveys, which yielded measured data, and from the 1990 Health Promotion Survey, which yielded self-reported data. The former estimated an obesity prevalence of 14.8 per cent and the latter a prevalence of 9.2 per cent (both age-adjusted), with the former share being about 60 per cent higher than the latter share. The discrepancy could arise not only because weights can be underreported, particularly by overweight and obese people, but also because heights can be over-reported.[10]

The lack of recent data from actual measurement of adult Canadians’ height and weight was remedied by the release of data from the 2004 Canadian Community Health Survey: Nutrition (CCHS).[11] These data suggested that 23.1 per cent of the adult population of Canadian provinces were obese in 2004, an increase in share of about 55 per cent over the estimate of 14.8 per cent that came out of the 1986-1992 Canadian Heart Health Survey.

How the 2004 data compare with previous measured and self-reported data is shown in Figure 1, which is taken from the 2004 CCHS report.[12] Note that in 2004 the obese pro-

Figure 1. Per cent of population aged 18 years and over with measured or reported Body Mass Index ≥ 30.0 (i.e., who were considered obese)



Data sources: Measured: 1978/79 Canada Health Survey; 1986-1992 Canadian Heart Health Surveys (ages 18-74); 2004 Canadian Community Health Survey: Nutrition. Self-reported: 1985 and 1990 Health Promotion Survey; 1994/95, 1996/97 and 1998/99 National Population Health Survey; 2000/01 and 2003 Canadian Community Health Survey.
Notes: All survey data have been age-standardized to the 2004 CCHS. Age-adjusted obesity rates based on measured height and weight for population aged 18 to 74 are as follows: 13.7% (1978/79), 14.6% (1986-1992) and 23.1% (2004).

portion according to measured data, i.e., 23.1 per cent, was about 50 per cent higher than the proportion according to near-year self-reported data (i.e., when compared with the 2003 CCHS, which showed an obesity rate of 15.2 per cent). This is similar to the relative difference of about 60 per cent noted in the above comparison between the 1986-1992 Canadian Heart Health Surveys and the 1990 Health Promotion Survey.

The data from the 2004 CCHS also suggested the following:

- Another 36.1 per cent of the adult population were overweight, i.e., they had a BMI between 25.0 and 30.0. Thus more than half of the adult population—a total of 51.3 per cent—was overweight or obese.
- The measured obesity rate had risen between 1978-1979 and 2004 for adults in all age groups except 65 to 74 years. The largest increases were noted in adults aged less than 35 years and in adults aged over 75 years (from 8.5 to 20.5 per cent and from 10.6 to 23.6 per cent, respectively). However, the highest obesity rates in both surveys were recorded in persons aged 45 to 64 years.
- Adult obesity rates in Canada were nevertheless lower than those measured in the U.S. in 1999-2002, particularly for women. Obesity rates for women were 23.3 (Canada) and 32.6 per cent (U.S.). Those for men were 22.9 (Canada) and 26.7 per cent (U.S.).

A question that cannot be answered from the measured data—there being none for the period between 1988-1989 and 2003—is whether or not obesity rates are continuing to rise steeply. The self-reported data in Figure 1 suggest that there has been a levelling off in the 1990s and the early part of the present decade. The self-reported data appear to have some reliability in that, as noted above, they bear a consistent relationship to measured data. Thus, they can perhaps be useful as an indication of *trends* in the prevalence of obesity, although not as a direct indication of the extent of the prevalence.

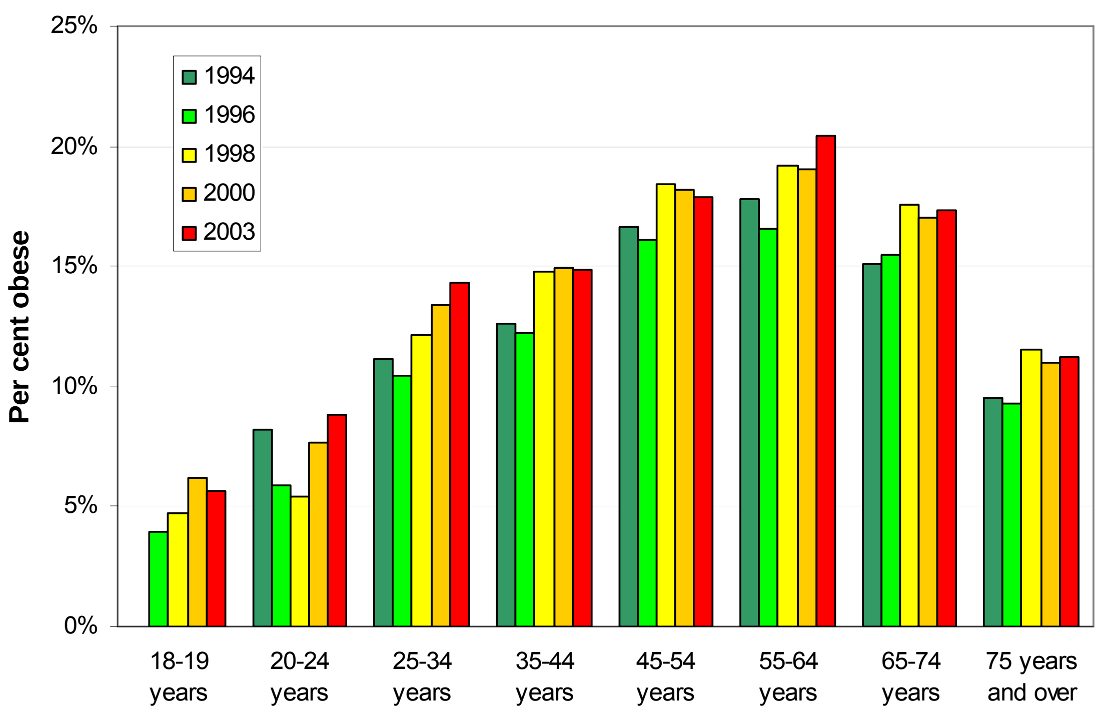
Nevertheless, a recent commentary on the prevalence of obesity in Canada suggested in its title that the prevalence was continuing to increase in 2002-2003.[13] It concerned findings from National Population Health Surveys and justified its title by arguing from these data that 1.1 million adults had joined the ranks of the obese since 1994.

This estimate of 1.1 million net additions to the number of obese adults is problematic. It was based on *longitudinal data* from the National Population Health Survey (NPHS) and perhaps on more detailed survey data provided by Statistics Canada.[14] Specifically, 202,700 adults aged 18 years and over moved from normal to obese over the period, 1,181,763 moved from overweight to obese, and 290,833, moved from obese to overweight. There was thus a net addition to the obese category of 1,073,630 adults. However, if the more complete *cross-sectional data* provided by Statistics Canada are used for 1994[15] and 2003,[16] the estimated net addition to the obese category is 850,038 adults (rising from a category total of 2,697,957 in 1994 to 3,547,995 in 2003, using 1996 for 1994 values in two cases of data absence). This difference between this estimated addition and that estimated from longitudinal data is large enough to suggest sampling bias or a weighting error. For the further analysis that follows, the lower estimate—from the cross-sectional analysis—is used because it is associated with more complete data sets (e.g., ones that include disaggregation by age) that permit a more sophisticated treatment.

Two factors seem to have been overlooked in this search for explanations of the growth in the number of obese people. One was the 11.6 per cent growth in the sampled population—i.e., all Canadian adults—between 1994 and 2003.[15,16] Assuming no bias in this group in relation to weight, the growth would be expected to produce an increase of 303,994 in the number of obese persons, with no change in the overall prevalence of obesity.

The second factor is more complex. It is the ageing of the population. Figure 2 shows average NHPS data for each of the five cycles: 1994,[15] 1996,[15] 1998,[15] 2000,[17] and 2003.[16] There were larger differences among age groups than among cycles. The population's age composition changed between 1994 and 2003 such that the share aged more than 44 years rose from 43.5 per cent to 48.8 per cent. Up to about age 65 years, obesity prevalence increases with age. Thus, other things being equal, an older population has more obese people. Putting it another way, an aging population—i.e., one whose mean age is rising—might be expected to manifest more obesity than a population whose age is not rising.

Figure 2. Prevalence of obesity by age group for five NHPS cycles



Applying this 'ageing' effect to the 1994 NHPS data results in an estimated increase of in the number of obese people by 2003.

Thus, there are two factors, population growth and ageing, that could account for, respectively 303,994 and 361,006 of the adjusted total of 850,038 persons who became obese between 1994 and 2002-2003, leaving a net addition of 'only' 185,038 adults to the obese category to be explained by other factors, notably reduced activity or increased food intake, or both. This is rather less than the 1.1 million net additions argued by Statistics Canada, but still represents a not inconsiderable increase of 6.9 per cent over the number of obese adults in 1994.

The increase in body weight with age needs to be explained, even if it is a population norm. Increases in body weight with age have been reported frequently.[18-22] Such increases can be offset partially,[18-20] or even completely,[21] by intensive physical activity. Explanations for the weight gain include replacement of muscle by fat and associated reduction in overall metabolic rate.[23] Gaining a slight amount of weight with increasing age has been associated with a longer life span.[24] Among persons with chronic disease, being overweight or obese has been associated with better outcomes.[25] Such considerations call into question the use of one BMI standard for all adult age groups.[18] Perhaps the cut-offs for overweight and obesity should vary for adults by age—as can they do for young people (see Section 2.2 below)—in a way that preserves the ability to track whether an individual in becoming overweight or obese.

A reasonable conclusion about changes in the body weights of Canadian adults is this. Since the 1980s, average body weights have increased considerably, although there may have been a slowing down in the rate of increase in the later part of this period. Now major factors in the growth in the number of obese people are the growth in and ageing of the population. However, there appear to be other contributing factors, including insufficient physical activity among all age groups and dietary factors.

2.2 Changes in the body weights of children and youth

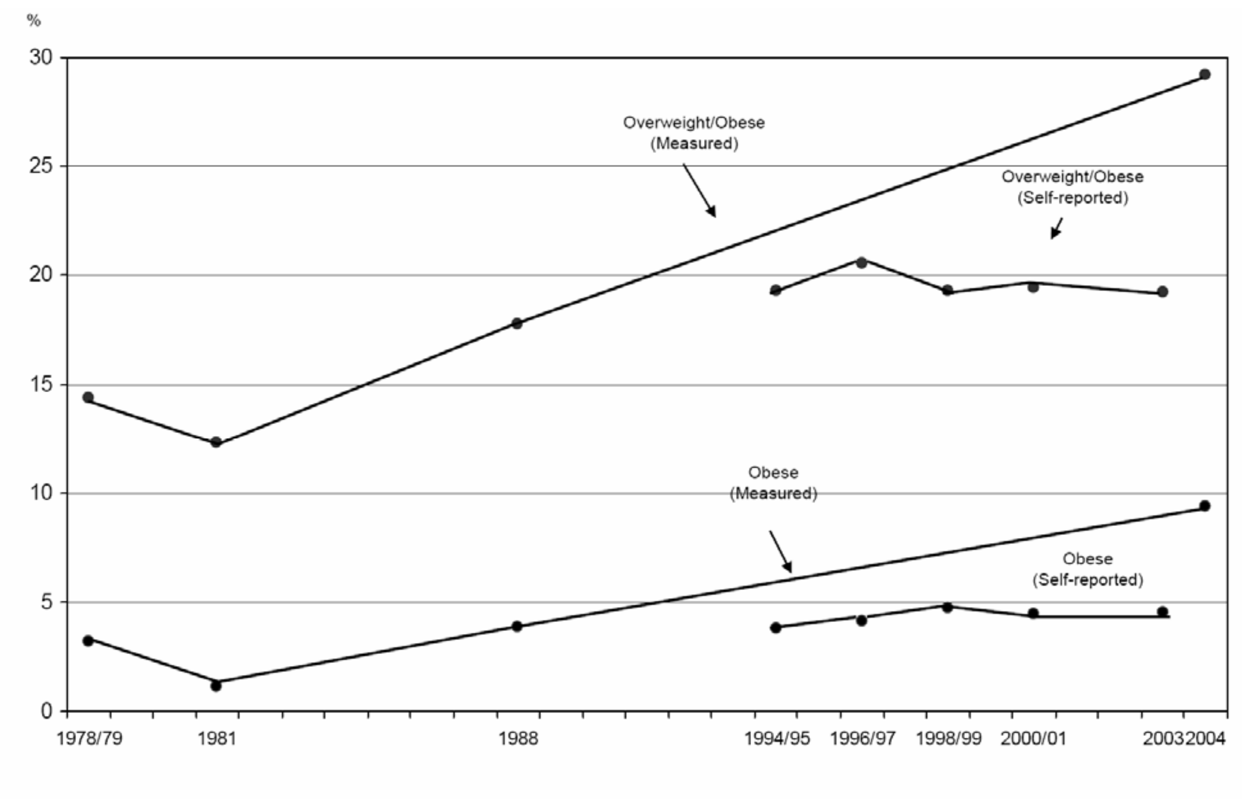
Canadian children and youth have also been described as manifesting an obesity epidemic.[26] This was based on an assessment that the prevalence of *obesity* tripled among Canadian children aged 7-13 years—from 5 per cent to about 15 per cent—across the period 1981 to 1996.[27] The reported obesity prevalence of 15 per cent among these children and youth may be compared with the prevalence of about 5 per cent for people aged 18-19 years illustrated in Figure 2 for the period 1994-2003.

The 1981 data discussed in the previous paragraph were measured data and the 1996 data were reported data (either by the child or a care-giver). If, as in the case of adults, measured data for children and adolescents reveal higher prevalences of obesity the increase in obesity prevalence may have been underestimated.

Recently available *measured* data suggest that self-reported data from adolescents tend to produce lower estimates of prevalences of obesity and overweight than measured data, as for adults. Data on 12-17 year-olds from the 2004 CCHS suggest an obesity rate that was about twice as high as self-reported data gathered during the period 1994-2004 (just under 10 vs. just under five per cent).[28] The measured prevalence of overweight was also higher: 20 vs. 15 per cent for the prevalence based on self-reported data.

However, for younger children, reported data—by care-givers—give rise to *higher* estimates of prevalences of obesity and overweight than measured data. The difference is apparent in Figure 3 and Figure 4,[29] which show similar rates for obesity prevalence for 6-11 and 12-17 year-olds from measured data in 2004 (between five and 10 per cent in each case) and also for overweight prevalence (between 25 and 30 per cent in each case), but higher rates than these from reported data across the period 1994-2001.

Figure 3. Trends in overweight/obese and obesity rates, household population aged 12 to 17, Canada excluding territories, selected years 1978/79 to 2004



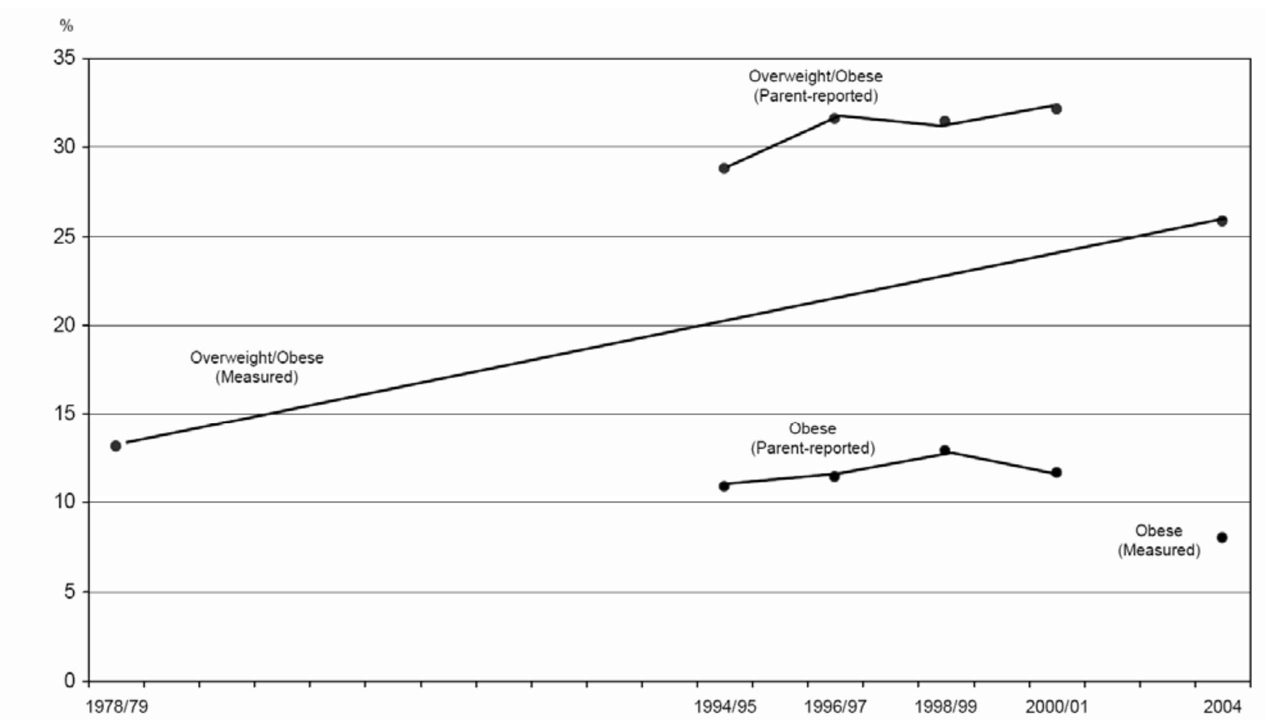
Data sources: 2004 Canadian Community Health Survey: Nutrition; 2000/01 and 2003 Canadian Community Health Survey; 1994/95, 1996/97 and 1998/99 National Population Health Survey; 1988 Campbell's Survey on Health and Well-being; 1981 Canada Fitness Survey; 1978/79 Canada Health Survey

The measured data in the 2004 CCHS survey also suggested the following:

- Trends for boys and girls were the same, but not the trends for different age groups. Compared with the measured data gathered in 1981, adolescents aged 12-17 years evidenced a particularly large increase, while the percentages of children aged 2-5 years who were overweight or obese remained essentially unchanged.
- There was more similarity between Canadian and U.S. children and adolescents than between Canadian and U.S. adults. Also, if ethnic differences between the countries are taken into account, the differences for children and adolescents are smaller still. Nevertheless, as in the case of adults, U.S. girls were more likely to be obese than U.S. boys, and than Canadian girls and boys.

A different presentation by the authors of the two papers noted in the first paragraph of this section had concluded that the prevalence of obesity among children in this age range had risen from about two per cent in 1981 to about 10 per cent in 1996.[30] Different criteria for obesity were used. In the above-mentioned work, obesity was defined as being at or above the age-specific 95th percentile for BMI using the 1981 data as a baseline.[31] The work producing the lower estimates of obesity prevalence used age-specific BMI cut-off

Figure 4. Trends in overweight/obese and obesity rates, household population aged 6 to 11, Canada excluding territories, selected years 1978/79 to 2004



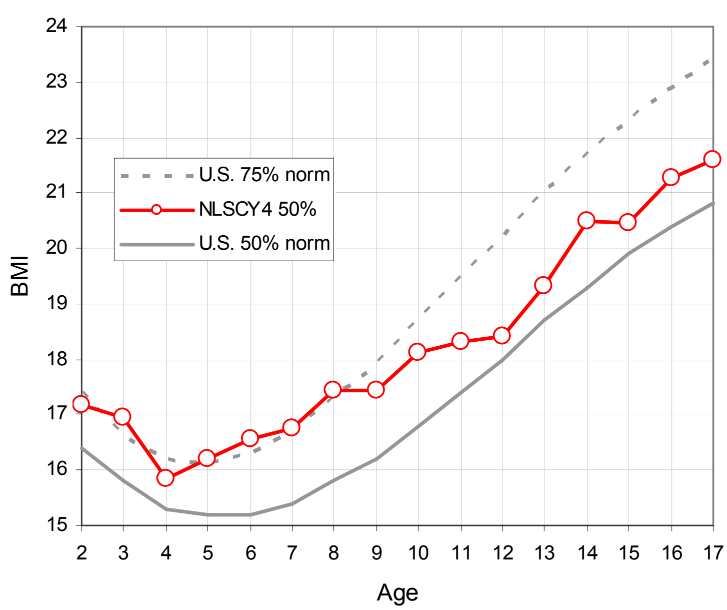
Data sources: 2004 Canadian Community Health Survey: Nutrition; 1994/95, 1996/97, 1998/99, 2000/01 National Longitudinal Survey of Children and Youth; 1978/79 Canada Health Survey
Notes: The obesity rate of the 6-11 age group from the 1978/79 Canada Health Survey has a coefficient of variation greater than 33.3%, and therefore, the estimate is not releasable. The 2002/03 NLSCY cross-sectional file has records only for children aged 0 to 5.

points based on anticipated BMI at 18 years; e.g., an eight-year-old boy was considered obese if he was on a trajectory to have a BMI of ≥30.0 at age 18. The trajectories were estimated using pooled data from surveys in six jurisdictions.[32] This estimate of obesity prevalence is referred to here as the 'international method'.

The 1996 estimates of obesity prevalence referred to in these reports were based on data from the second cycle of Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY).[33] One of the authors recently reported estimates of obesity prevalences among children in this age range from the fourth cycle of the NLSCY (2000-2001).[34] They are essentially the same as those for 1996—i.e., about 10 per cent. The author had already noted a possible plateauing of childhood obesity prevalences in the late 1990s.[9]

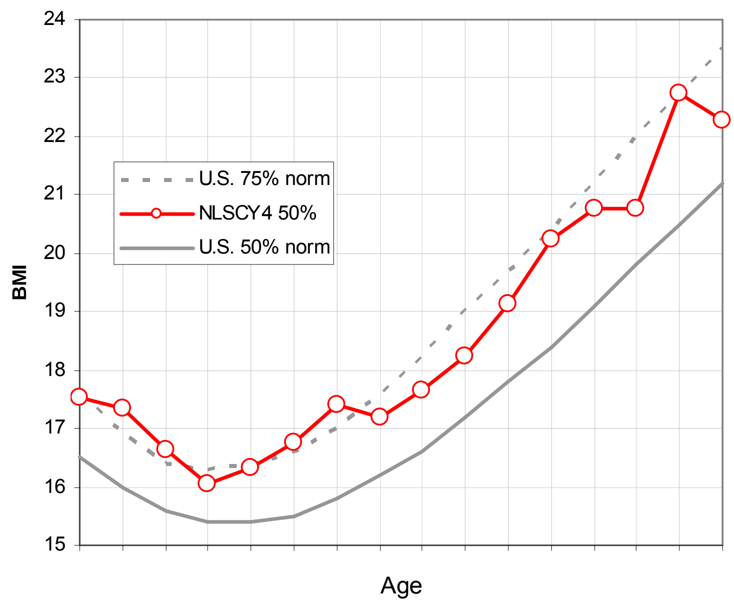
Obesity prevalence may be especially high among Canadian children, when compared to children in other countries. A recent Canadian study of prevalences in 34 countries began: "Countries throughout the world experienced a marked increase in the prevalence of overweight and obese children and adolescents from the 1980s to the 1990s, and evidence from the United States suggests that this upward trend has continued into the 21st century".[35] During this study, weights, heights, and other information were gained by classroom questionnaire from 11-, 13-, and 15-year olds in 2000-2001. In the responses from the 34 countries, Canada ranked fifth in the prevalence of obesity—the international method was used—with a reported prevalence of 4.1 per cent. The four jurisdictions reporting higher prevalences were Malta, the United States, England, and Wales, with those for Malta and U.S. being respectively 7.9 per cent and 6.8 per cent. The lowest obesity prevalences—0.6 per cent or below—were reported by four republics of the former Soviet Union.

Figure 5. Median female BMI, ages 2-17, NLSCY Cycle 4, 2000-2001, compared with U.S. 50 per cent and 75 per cent norms



The foregoing analyses concerned prevalence of obesity among children and youth. It is also of interest to examine the extent to which the BMIs of Canadian young people conform generally to accepted reference levels for the various ages. There are no such Canadian standards, and so, in the course of the present work, comparison

Figure 6. Median male BMI, ages 2-17,
NLSCY Cycle 4, 2000-2001,
compared with U.S. 50 per cent and 75 per cent norms



was made with the accepted U.S. standards.[36] These are based on weights measured mostly during the period 1963-1988 during Cycles I and II of the National Health Examination Survey and Cycles I-III of the National Health and Nutrition Examination Survey.[37]

The comparison with the U.S. reference levels involved new analysis of all records in Cycle 4 of the NLCSY (2000-2001) for young people aged 2-17 years that contained information about age, weight, height, and postal code, a total of 18,479 records. The results are in Figure 5 (girls) and Figure 6 (boys), which show cross-sectionally weighted NLSCY data and the U.S. standards. The Canadian data correspond in a general way to the U.S. reference levels, but differ in that the Canadian median is closer to the U.S. 75th percentile than the U.S. median for boys of all these ages and for girls up to about 11 years; above this age their median BMIs are closer to the U.S. medians.

Figure 5 and Figure 6 indicate that median BMIs for this large 2000-2001 sample of Canadian young people were for every age higher than the corresponding U.S. standard, which represents U.S. young people across the period 1963-1988. The percentage of young people above the standard 95th percentile increased from 5 per cent to 16 per cent between the 1960s and the turn of the century,[38] and thus the median BMIs for age might also have been expected to increase. In other words, Figure 5 and Figure 6 should *not* be interpreted to mean that BMIs of Canadian young people are higher than their U.S. counterparts.

A reasonable conclusion about changes in the body weights of Canadian young people is this. There have been substantial increases in the prevalence of overweight and obesity among young people during the last two decades, more clearly for 12-17 year olds than for younger persons. Indeed, whereas in 1978-1979 obesity rates for persons aged 12-17 years were below those for adults aged 18-34, in 2003-2004 they were higher or as high. The fewer available data for children aged 6-11 years suggest similar increases in prevalence, but interpretation may be clouded by unusual discrepancies between reported and measured data. (These discrepancies could be consistent with even larger increases in the prevalences of overweight and obesity in 6-11 year olds than in 12-17 year olds.)

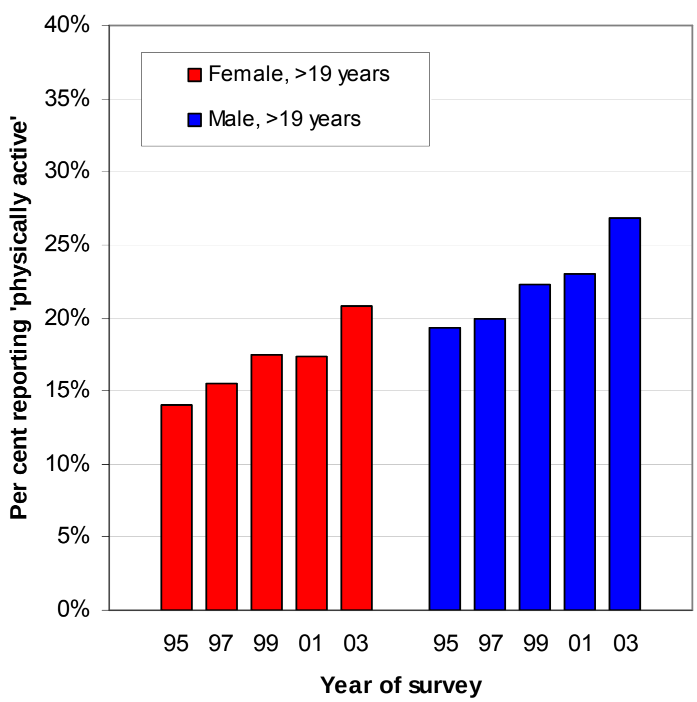
2.3 Changes in physical activity in adults

During administration of the National Population Health Survey (NPHS),[39] questions were asked of Canadians aged 12 years or more as to the frequency, duration, and intensity of their leisure-time physical activity over the previous three months. From the responses, an average daily energy expenditure for this purpose was calculated and used to derive an "index of average daily physical activity in kilocalories per kilogram of body weight per day". A respondent with an index of 3.0 or more was considered 'physically active'. One with an index of 1.5-2.9 was considered 'moderately active'. One with an index of less than 1.5 was considered 'inactive'.

Trends in the share of adult respondents who reported themselves to be physically active are shown in Figure 7. Increasing trends are evident for males and females, although with males being generally more active. Corresponding reductions in shares reporting inactivity can be seen in Figure 8, suggesting that the increases in activity are population-wide and not merely a heightening of activity among those who are already active.[40]

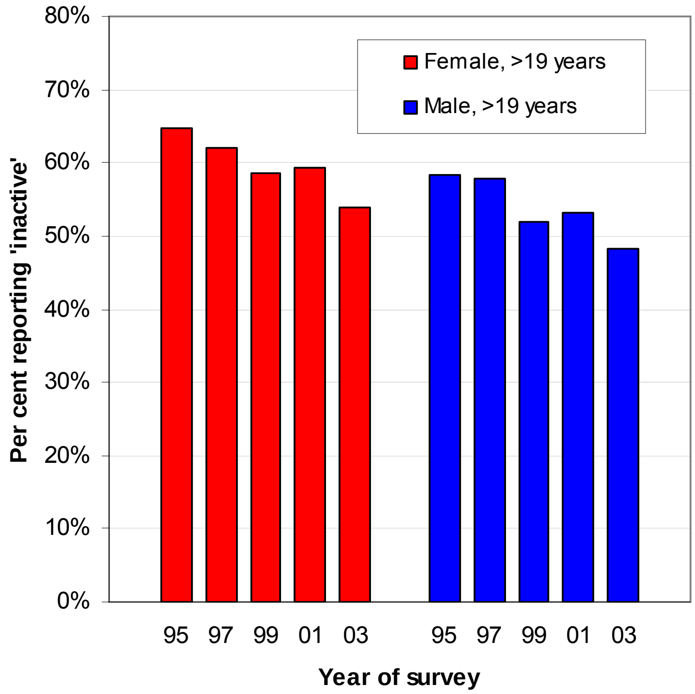
A similar decline in leisure-time inactivity has been reported across a similar period for U.S. adults.[41]

Figure 7. 'Physically active' adult Canadians as a per cent of those reporting on activity, across five surveys



In 1996, federal, provincial and territorial governments had called for a 10-per-cent reduction in the level of physical inactivity in Canada by 2003.[42] Figure 8 suggests that this objective may have been met in respect of leisure-time activity among adults. In the first two series of the NPHS (1994-1995 and 1996-1997), levels of inactivity among females and males averaged respectively 63 and 58 per cent. In the last two series (2000-2001 and 2003) these levels averaged 57 and 51 per cent.

Figure 8. 'Inactive' adult Canadians as a per cent of those reporting on activity, across five surveys



Reports by the Canadian Fitness and Lifestyle Research Institute (CFLRI) also suggest that there has been a reduction in the amount of leisure-time inactivity among adults across this period. CFLRI compared data from the 2000-2001 Canadian Community Health Survey (CCHS) and its own 1995 Physical Activity Monitor and concluded that "the level of physical inactivity decreased between the late 1990s and 2002".[43]

To the extent that physical activity is negatively associated with body weight, the reported increase in activity, and decrease in inactivity are consistent with the apparent slowing down of the increase in average body weight across the period 1994-2004 noted in Section 2.1. However, CFLRI had reported in 1996 that there had been a substantial increase in the amount of leisure-time physical activity between 1981, when 21 per cent of adults were active, and 1995, when 37 per cent active.[44] This increase corresponded to a period of weight gain among Canadian adults (see Figure 1).

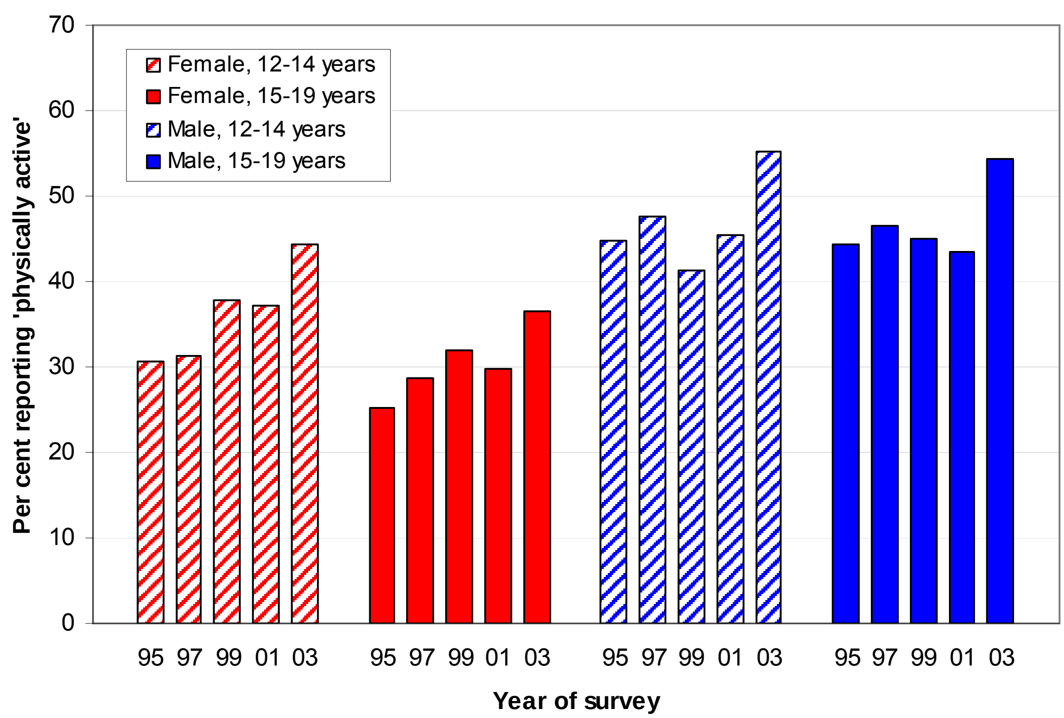
Formal data on changes in other activity than leisure time activity—e.g., work-related and transport activity—do not appear to be available for Canadian adults. Historically, North Americans were much more active. Bassett et al have provided a window on how much change may have occurred.[45] Using electronic pedometers and questionnaires, they measured the daily activity of Old Amish farming adults, who use labour-intensive methods and abstain from use of modern conveniences including motorized transportation and electrically driven equipment and appliances. According to the authors, "From the standpoint of physical activity, an Amish farmer's lifestyle might resemble that of rural residents in North America in the mid-to-late 1800s". On average, the Amish farming adults evidenced about six times as much physical activity as had been reported in respect of a group of individuals living mostly in cities.[46] Moreover, there appeared to be no age-related decline in activity, such as had been observed in other adults. The prevalences of overweight and obesity among the Amish population were relatively low.

The data on Amish farming adults suggests that over the last 150 years there may have been a substantial decline in amount of everyday activity performed by North American adults, associated with the mechanization of work and transport. Such a decline would be consistent with increases in body weight, if it were not accompanied by corresponding declines in consumption off food energy.

Data from the U.S. Census has been analyzed to track changes in the activity level of employment.[47] Occupations were classified as high activity, medium activity and low activity. There has been little change since 1950 in the proportion of the work force in high activity occupations, but the proportion in low activity occupations almost doubled between 1950 and 1970, and has since remained fairly constant.

A reasonable conclusion about changes in the physical activity of adults is this. Over the long term, there has likely been a considerable reduction in the average amount of physical activity and the overall decline could be continuing. Assessment of physical activity has mostly focussed on leisure-time practices. For these, there may have been an increase in the amount of activity, but this could be happening within the context of an overall decline in physical activity.

Figure 9. ‘Physically active’ Canadians aged 12-19 years as a per cent of those reporting on activity, across five surveys



2.4 Changes in physical activity in children and youth

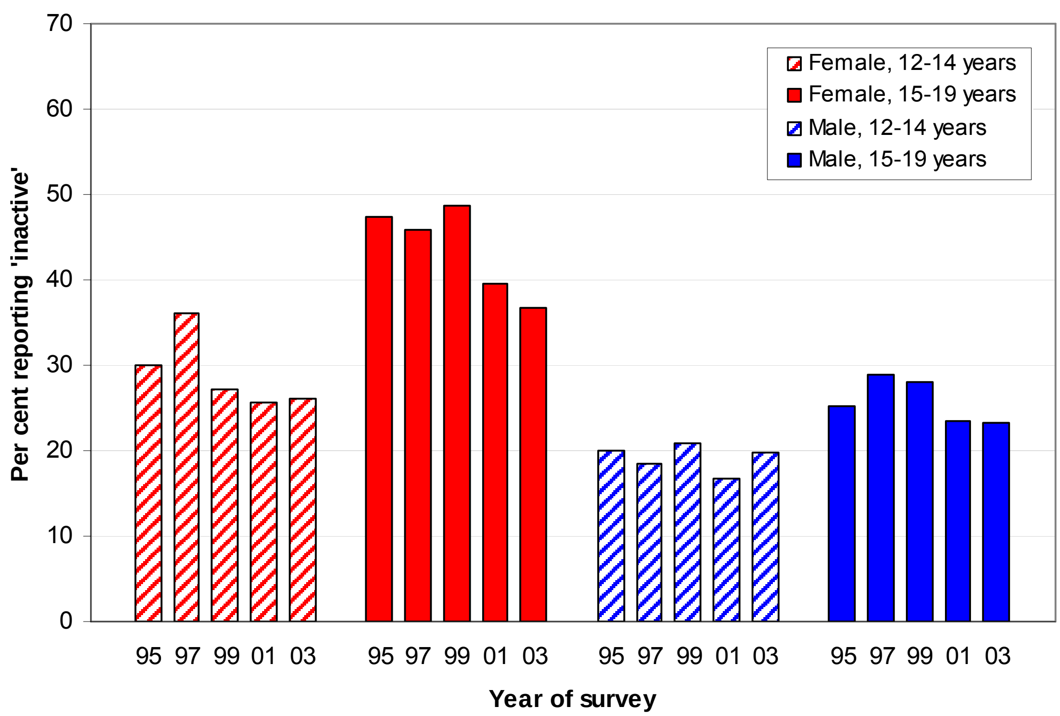
As in the case of adults, reported in Section 2.3, data on leisure-time physical activity among Canadian young people aged 12-19 years are available from the NPHS.[48] The data are summarized in Figure 9 and Figure 10.[49] In general, as for adults, females were less physically active and more inactive than males. Females aged 15-19 years were particularly inactive. The trends towards more activity and less inactivity across the period 1994-2003 noted in adults are less noticeable in these young people. Males aged 12-14 and 15-19 years showed no consistent trend across this period. Trends towards more activity and less inactivity were evident in females of these ages, but not to the extent that they were evident in adults of either gender.

The above-noted national target of a 10-per-cent reduction in the extent of inactivity was met in the case of girls aged 12-19 years, but not in the case of boys.

As in the case of adults, there are few data on trends in other physical activity in children and youth. Limited data are available for youth aged 11-21 years from the Transportation Tomorrow Survey (TTS), which collects information about travel in southern Ontario every five years, from 1986.

TTS data for the suburban regions of Halton and Peel for 2001 are in Figure 11. Data for

Figure 10. 'Inactive' Canadians aged 12-19 years as a per cent of those reporting on activity, across five surveys



the same regions are shown in Figure 12 for 1986, which the travel behaviour of children aged 6-10 years was also surveyed. Comparison of Figure 11 and Figure 12 suggests that fewer trips were made by the more active modes of bicycle or walking in 2001 than in 1986, and more trips were made as a car driver or passenger. Transit can also be considered a more active mode, in that it usually involves walking to and from and between transit vehicles.

Transit use also declined across the two survey dates, and the age at which transit use began appeared to increase.

The TTS data for Halton and Peel are consistent with U.S. data showing a decline in walking to school from 20.2 per cent in 1977 to 12.5 per cent

Figure 11. Weekday travel by mode and age in Halton and Peel, 2001

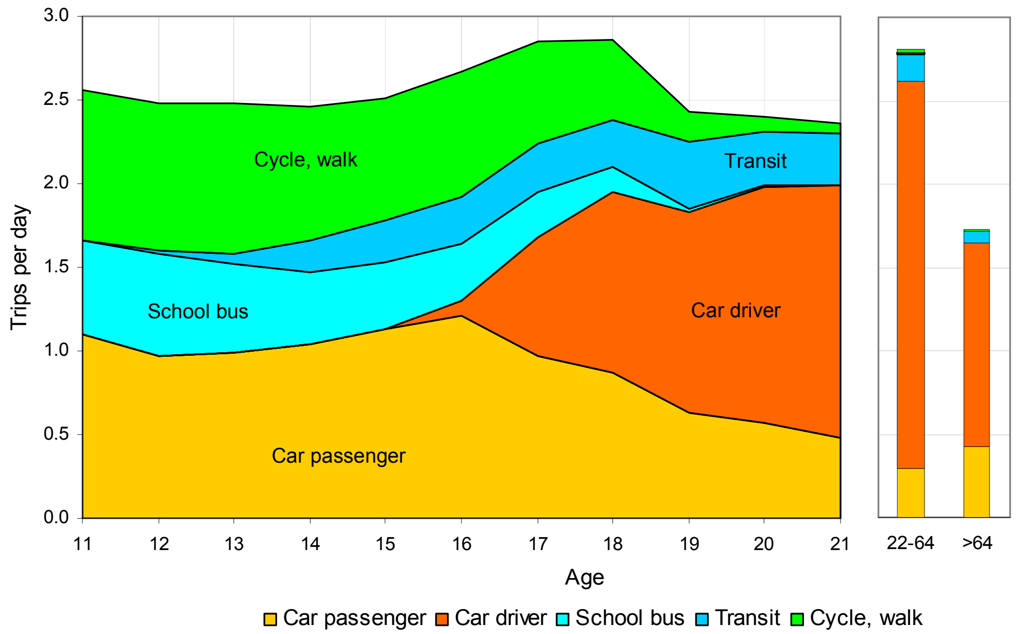
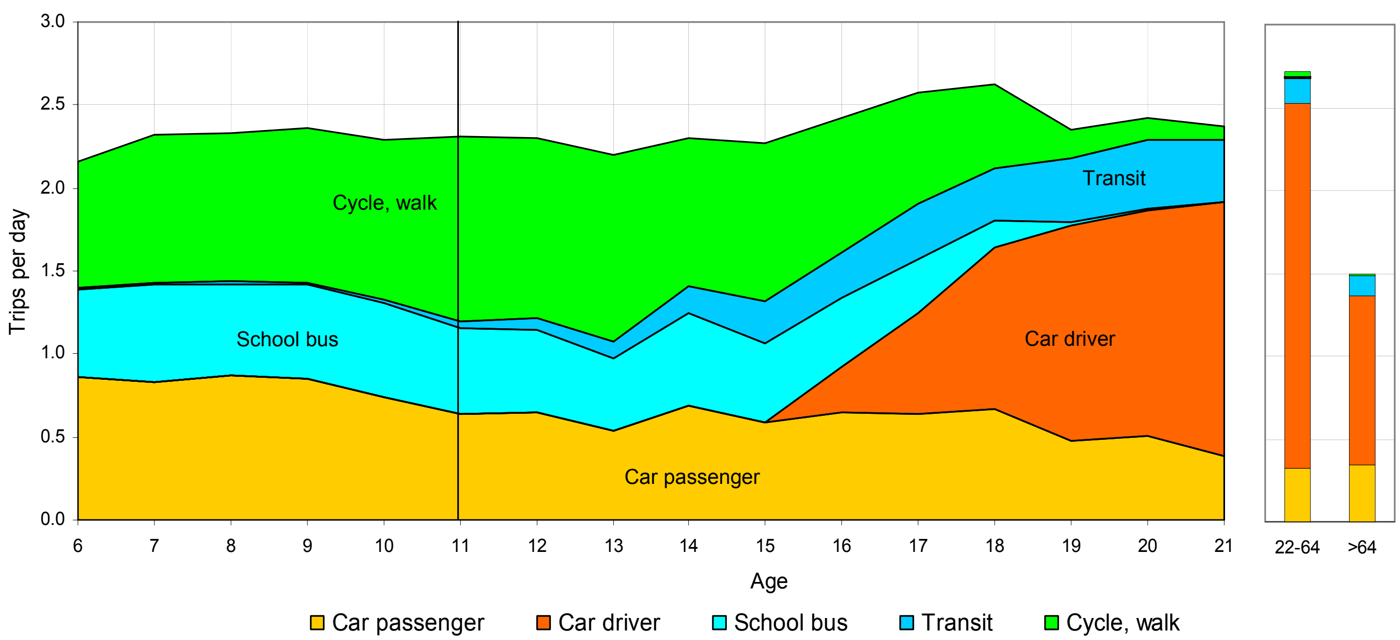


Figure 12. Weekday travel by mode and age in Halton and Peel, 1986



in 2001.[50] (This U.S. analysis also concluded that there had been little change between 1991 and 2001 in participation in high-school physical education classes or in overall physical activity by high school students.)

Available data on the activity children and youth are too few to allow a reasonable conclusion.

2.5 Links between physical activity and body weight in adults

Lack of information about trends in physical activity and their possible relationship to trends in body weight has led to a focus on assessment of associations between body weight (or BMI) within populations, for both adults and young people.

Available data on adults from the National Population Health Survey (NPHS), discussed in Sections 2.1 and 2.3, do not allow analysis of associations between reported physical activity and prevalence of overweight and obesity. However, a report on the later Canadian Community Health Survey: Nutrition (CCHS),[51] discussed in the same sections, did include such analysis. The results suggest a positive association between obesity and leisure-time physical inactivity. Men and women who reported their leisure time as sedentary were more likely to be obese than those who reported being physically active. Women but not men who reported being moderately active were more likely to be obese than women who reported being active.

Such a link between adult physical activity and body weight has been reported elsewhere: e.g., in respect of the extent of all walking by Colorado adults,[52] and in respect of leisure-time activity and non-motorized commuting in France and the UK.[53] The latter study appeared to find that walking and bicycling to work were more effective in avoiding weight gain than recreational activity.

Another line of research has examined body posture and movement in obese and lean adults.[54] Obese individuals sat for 164 minutes a day more than lean individuals, and total body movement was negatively correlated with fat mass. These features of posture and movement associated with the routines of daily life were variables referred to as ‘non-exercise activity thermogenesis’ (NEAT). The lean individuals were reported as averaging higher NEAT levels equivalent to 350 kilocalories per day, equivalent over a year to a body weight difference of 15 kilograms.

However, most of the conclusions about the role of physical activity as a factor in overweight and obesity have relied more on the absence of other potential contributing factors, particularly increases in food intake and in consumption of particular foods. One study noted the decline in average recorded food intake in the UK and the increase in sedentary activities such as television watching and concluded that "modern inactive life-styles are at least as important as diet in the aetiology of obesity".[55]

Similarly, evidence of no increase in energy intake from food in the U.S. has been used to argue that "declines in physical activity are more likely than increases in energy intake as the explanation for the recent increase in obesity prevalence".[56] The authors of the latter study concluded that "average energy expenditure has probably declined, despite the fact that participation in sports and fitness activities appears to have remained constant. Clearly physical activity has decreased because of increasing mechanization on the job, labor-saving devices at home, and changing personal practices". In support of the last point, they contrasted 'sedentary' and 'active' ways of performing everyday activities, noting energy expenditure for each. For example, using a leaf blower and raking leaves for 30 minutes involved energy expenditures of 100 and 150 kilocalories, respectively; riding an escalator and taking the stairs in a shopping mall, each for three times, involved expenditures of 2 and 15 kilocalories.

The authors of yet another U.S. example of similar reasoning concluded, "The diverging trends of decreasing energy intake and increasing body weight suggest that reduced physical activity may be the most important current factor explaining the rising prevalence of obesity".[57]

In the course of an explicit attempt to link transport research to matters of public health, including overweight, several points of intersection of research activities were reviewed, including work linking non-motorized travel behaviour to body weight.[58] In general, the more walking or cycling to work the lower the BMI.

A reasonable conclusion concerning the links between physical activity and overweight in adults is this. There appears to be an association in that more active people weigh less, other things being equal. However, much of the evidence supporting a role of physical activity is indirect: chiefly, evidence that dietary changes are insufficient to explain weight gains. Much of the direct evidence on physical activity concerns leisure-time activities. However the focus of argument, and to a lesser extent data collection, is moving towards everyday activity at work, travelling, and at home.

2.6 Links between physical activity and body weight in children and youth

As for adults, the report on the data on young people from the CCHS,[59] discussed in Sections 2.2 and 2.4, includes an analysis of associations between reported physical activity and prevalence of overweight and obesity. The conclusions that can be drawn for young people from the CCHS data are less clear than those for adults.

Children aged 6-11 years and their parents were asked about the weekly extent of the child's activities that cause breathlessness or a rise in heart rate. The amount of such activity was not significantly associated with prevalence of overweight or obesity. Responses to the corresponding questioning of boys aged 12-17 (but not girls) were significantly associated with prevalences of overweight and obesity. In the case of obesity, the association was in the expected direction. Sedentary boys aged 12-17 years were more likely than active boys to be obese (16 vs. nine per cent). However, active and moderately active boys were disproportionately overweight.

Links were stronger for a particular kind of sedentary activity: sitting in front of an electronic screen as in watching television, playing video games, and using a computer. Children aged 6-11 years who reported doing this for more than two hours a day were about twice as likely to be overweight and twice as likely to be obese as children who reported less than an hour daily of this activity. Youth aged 12-17 who reported doing this for more than 20 hours a week were about 50 per cent more likely to be overweight or obese than youth who reported less than 10 hours weekly of this kind of activity. Television watching in early childhood has also been reported as a predictor of overweight during adolescence.[60]

Stronger links between obesity and physical inactivity were also found in an already-discussed study of overweight and obesity prevalence in youth in 34 countries, in which Canada had the fifth highest prevalence.[61] According to the authors, "Within most countries, physical activity levels were lower and television viewing times were higher in overweight compared to normal weight youth".

Data from the first cycle (1994) of Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY) were used to assess the relations between children's reported physical activity and reported BMI.[62] The authors concluded that in children aged 7-11 years organized and unorganized sport and physical activity were negatively associated with being overweight or obese, and TV watching and video game use were positively associated.

However, another study using data from the first cycle of the NLSCY concluded, "the proportion of children who were physically active did not differ significantly by weight".[63] This study was primarily concerned with predictive factors for changes in reported activity across cycles of the NLSCY. It concluded that for overweight/obese children, but not for other children, a high number of physical education hours was predictive of increased activity and frequent television viewing was predictive of no change in activity.

The overall activity of U.S. preschool children (3-5 years) was assessed using observation and accelerometers and related to body weight.[64] Overweight boys but not girls were found to be significantly less active than their same-gender peers who were not overweight. As with other such studies, a causal relationship cannot be inferred. It is not known whether the boys were less active because they were overweight or overweight because they were less active, or both.

A meta-analysis of 52 independent samples of children concluded that (a) there is a "statistically small relationship" between TV viewing and "body fatness", and (b) overall there is no relationship between TV viewing and physical activity.[65] The association between activity and body weight was not directly assessed.

A reasonable conclusion concerning the links between physical activity and overweight in young people is this. There is some evidence of association between body weight and physical activity and also of association between body weight and television viewing.

2.7 Links with settlement pattern and transport arrangements in adults

Analysis of the body weights and physical activity of over 200,000 U.S. adults living in 448 counties and 83 metropolitan areas showed associations with the degree of sprawl of place of residence.[66] A sprawl index was computed for each county and area based on residential density and the length or street blocks, and, for the metropolitan areas, also on mix of land uses and degree of "centering" of development (how focussed in one or more cores). Residents of sprawling counties weighed more and walked less during leisure time than residents of less sprawling counties. Residents of sprawling metropolitan areas walked less than residents of less sprawling areas, but they did not weigh significantly more.

Other work has examined the relation between settlement pattern and physical activity. This includes the previously mentioned overview of intersections between transport and public health research.[67] It also concluded that more 'walkable' neighbourhoods are associated with higher levels of active transport—e.g., walking and cycling—but "the studies to date do not provide detailed guidance about how much of each characteristic or what combination of characteristics produce 'optimal' levels of walkability". More walkable neighbourhoods were those that tended to be denser, have shorter blocks, have more mixed land uses, and be more centred, i.e., they would be less sprawling, according to the index referred to in the previous paragraph. Another factor is the provision of better infrastructure for walking and cycling. An earlier report by this group had concluded that more walkable neighbourhoods were associated with higher levels of moderate-intensity physical activity, and lower prevalence of obesity, but not with higher levels of vigorous-intensity physical activity.[68] A more recent report by the group also concluded that community design is significantly associated with moderate levels of physical activity, and moreover that changing design could affect the amount of such activity.[69] At least one other report has noted such an association and drawn a similar conclusion.[70]

An earlier study had shown that in the U.S. rural women, especially Southern and less educated women, were more sedentary with respect to leisure-time physical activity than urban women.[71] However, a study of physical activity in eighth-grade urban and rural girls suggested that "most differences were associated with race rather than setting".[72]

An examination of data on 14,827 U.S. adults from the Third National Health and Nutrition Examination Survey indicated that adults who lived in urban or suburban homes built before 1974 were significantly more likely to walk 1.6 kilometres or more 20 times a month than residents of newer homes.[73] This difference was not significant for rural areas. The authors suggested that home age could be a proxy for aspects of settlement pattern associated with pedestrian activity.

Recently, the U.S. Transportation Research Board issued a special report on the question as to whether and how the built environment influences physical activity,[74] pulling together several commissioned papers on the topic.[75] The findings of this work were these:

- Physical activity levels have declined sharply over the past half-century because of reduced physical demands of work, household management, and travel, together with increased sedentary uses of free time.
- The built environment can facilitate or constrain physical activity.
- The relationship between the built environment and physical activity is complex and operates through many mediating factors, such as sociodemographic characteristics, personal and cultural variables, safety and security, and time allocation.
- The available empirical evidence shows an association between the built environment and physical activity. However, few studies capable of demonstrating a causal relationship have been conducted, and evidence supporting such a relationship is currently sparse. In addition, the characteristics of the built environment most closely associated with physical activity remain to be determined.
- Weaknesses of the current literature include the lack of a sound theoretical framework, inadequate research designs, and incomplete data.
- The built environment in place today has been shaped by longstanding policies and the practices of many decision makers (e.g., policy makers, elected officials, planners, developers, traffic engineers).

Canadian data relevant to the question of adult physical activity, body weight, and settlement pattern remain undeveloped and, where they exist, unanalyzed. Table 1 shows data from Statistics Canada's *Health Indicators 2003* for parts of Canada's three largest urban regions,[76] in each case including the central city and an adjacent suburban region with a similar number of residents. In each region, persons aged 18 years or older living in the suburban area were more likely to be overweight or obese. This is consistent with the U.S. finding mentioned at the beginning of this section in that the suburban areas

Table 1. Overweight and physical activity in the central city and suburbs of Canada's three largest urban regions, 2003

	Overweight/obese		Physically active	
	City	Suburbs	City	Suburbs
Montreal	44%	50%	22%	23%
Toronto	42%	47%	22%	27%
Vancouver	31%	40%	30%	33%

Note: Overweight/obese based on heights and weights reported by persons 18 years and over. Physically active in leisure time, as reported by persons 12 years and over.
Montreal: city is Montreal Centre Health Region; suburbs is Montérégie Health Region.
Toronto: city is Toronto District Health Council; suburbs is Halton-Peel District Health Council.
Vancouver: city is Vancouver and Richmond Health Services Delivery Areas; suburbs is Fraser North and NorthShore/Coast Garibaldi Health Service Deliver Areas.

Source: Statistics Canada, *Health Indicators*, 2003

would be more like the sprawling counties and metropolitan areas. In each of the three Canadian regions, persons aged 12 years or older living in the suburban area were more likely to be physically active in their leisure time. Thus, this limited analysis—there was no correction for income, age distribution, and other factors— points to a paradoxically positive association between being active and being overweight. One explanation for this paradox is that residents of the suburban parts of the three regions were more active in their leisure time but less active overall. The central city residents may have been more active while at work, and particularly during travel.

A cautionary note in the literature as to potential confounding with socio-economic condition was provided by a Scottish study that compared four neighbourhoods varying in "socio-residential advantage".[77] It concluded that adults "living in the most deprived neighbourhood were significantly shorter, and had bigger waist circumferences, waist-hip ratios and BMIs". One indicator of deprivation was lack of a household car, evident in 64 per cent of households in the most deprived neighbourhood and 33 per cent of the least deprived neighbourhood.

Another cautionary note may come from economic analysis suggesting that overweight persons choose to live in suburbs to take advantage of larger properties.[78] Where the data comprise no more than an association between settlement pattern and body weight, this can be as valid as a conclusion that settlement pattern contributes to overweight. However, if large adults sort themselves into lower-density settlements, their children's weight may still be influenced by associated physical activity patterns.

A reasonable conclusion concerning the links between adult overweight and activity, on the one hand, and settlement pattern and travel arrangements, on the other

hand, is this. Settlement pattern and associated travel arrangements may be factors in the amount of physical activity that is performed and perhaps even in the prevalence of overweight and obesity. However, there is too little evidence to assess the extent and nature of the influence of settlement pattern on physical activity and body weight. Available data suggest that suburban living may be associated with more leisure-time physical activity but less overall physical activity than central city living.

2.8 Links with settlement pattern and transport arrangements in children and youth

Little has been published on how settlement pattern might affect travel and other activity in children and youth. The substantial exercise of the U.S. Transportation Research Board, discussed in the previous section, makes little reference to this topic. The situation with respect to children has been summarized by Susan Handy, a contributor to the TRB exercise, in this way.[79]

> What we know about community design and physical activity for children is even more limited. A substantial body of research on physical activity in children has so far focused little attention on the influence of community design on physical activity for children. Travel behaviour researchers, largely focused on problems of automobile dependence, have infrequently studied the travel behaviour of children. The limited evidence available is often contradictory, and it is unclear if the findings that have emerged for adults will hold for children.

One study comparing activity in girls living in urban and rural parts of the U.S. has been noted, and its finding that most differences were race-based.[80] Another such comparison, of urban and rural adolescents in Norway, found that both groups spent more time on sedentary activities and there were no differences in regular activity patterns.[81] However, urban adolescents walked or cycled three times longer to school or a bus stop for school than rural adolescents, and the urban adolescents also walked and cycled more to other activities.

Another U.S. study compared activities of urban and suburban children through questionnaires administered to caretakers.[82] Suburban children spent more time outdoors, and the older suburban children spent more time playing sports. Urban children watched television more.

A UK study of urban 10-year-olds found that boys but not girls who walked to school were significantly more active, as measured with accelerometers, including being more active after school and throughout the evening.[83] A study of Filipino adolescents, also using accelerometers, found that both males and females who walked to school engaged in more physical activity than those who did not, equivalent to a body weight difference in each case of about 1.0 kilogram/year.

Available data on overweight and activity in young people, on the one hand, and settlement pattern and travel arrangements, on the other hand, are too few or too inconsistent to allow a conclusion.

2.9 Conclusions from the literature review

A conspicuous feature of the relevant literature is the relative lack of reliable data, especially in respect of physical activity at all ages, young people in particular. Body weights do seem to have increased, for almost all ages, and heavier people do seem to perform less physical activity. However, evidence of trends in physical activity, particularly activity other than during leisure time, is scant, as is evidence for causal links between body weight and activity.

A priori, weight gain is likely to be associated with reduced activity or increased energy intake from food, or both. Energy intake from food may not be increasing, at least in adults, and so a reasonable supposition is that overall activity levels are declining, but evidence for this is lacking. There has been a focus on leisure-time physical activity, including organized sports, but this may not be where the changes in activity are occurring. There are intriguing hints that the significant changes—in both adults and children—may have been in everyday physical activity, including travel.

There are also intriguing hints in available data that, for adults, overall activity levels—and perhaps body weights—are associated with settlement pattern. Settlement patterns requiring little automobile use may give rise to more physical activity that those requiring much automobile use, often characterized as ‘sprawl’. Whether settlement pattern has such an influence in young people is less clear.

Chapter 3. Analysis of NLSCY data

3.1 Overview

This chapter presents new analysis of data from Cycle 4 of Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY4).[84] This survey provides the only available Canadian data—and possibly the only data worldwide—that relate the (reported) body weights and heights of children and youth to places of residence, allowing the possibility of examining associations with types of settlement pattern. Also, there are survey responses to questions about leisure-time physical activity, travel modes to and from school, television watching, and household income. Data-gathering for NLSCY4—the latest cycle—occurred between September 2000 and May 2001.

The basic questions asked are whether the body mass indices (BMIs) of children and youth vary according to the settlement pattern of geographic area in which they live, and, if they do, what might contribute to the variation.

The most potent indicator of settlement pattern is residential density (see Section 2.7). Areas of high density are qualitatively different from areas of low density, even in the same region. Indeed, within a region one can often distinguish on the basis of density between older, denser areas at or near the region's historic centre and newer, lower-density areas at the periphery of the region, often characterized as 'sprawl'. There are other characterizations of settlement pattern—e.g., size of community and degree of mixing of land uses—but none of these is as generally useful as residential density.

Lower BMIs of children and youth —i.e., lower body weights for height and age—may be associated with living in higher-density areas because children who live in these areas may engage more in active transport. Their households have fewer cars and destinations are typically nearer—a feature of the more compact settlement pattern—making walking and cycling more feasible and likely. Moreover, for longer journeys they are more likely to travel by public transit, again because fewer cars are available but also because higher-density settlement patterns make public transit operation more feasible. Travel by public transit appears to involve more active transport than travel by car. Transit users often walk some distance to a stop, between connection points, and to the final destination. Car riders, by contrast, may require almost no walking.

There is also a potential *opposite* effect, arising from opportunities for play and other physical activity, which may be greater in *lower*-density areas. Houses may have large yards, streets may be quieter, and open space may be nearby. Thus, children and youth may engage in more *non*-transport-related physical activity in lower-density areas.

NLSCY4 was thus interrogated to determine how three things might vary with residential density: (i) BMI; (ii) amount of active transport; and (3) amount of other physical activity. As well, to further illuminate the relationships between BMI and settlement pattern, there was consideration of these variables: household income, participation in organized and unorganized physical activity, travel mode to school, and television watching.

3.2 Assignment of residential densities to postcodes

The first task was to figure out the residential density of the area containing the home of each child and youth in the survey. Each survey record includes the postal code of the home address in the form A1A 1A1. Postal codes can be grouped by mostly contiguous forward sortation areas (FSAs), indicated by the first three characters of the postal codes (i.e., A1A in the present example). Across Canada, FSAs each contain between 330 and 132,425 residents, although the middle two quartiles contain between 10,925 and 28,635 residents.

Both the residential population[85] and the geographic area[86] of almost all FSAs are known. Thus the residential density of almost all FSAs is also known. In practice, 1,428 FSAs of known residential density were identified containing 98% of the Canadian population in 2001.

3.3 Derivation of the NLSCY4 sub-sample used in this analysis (1)

This and the next section describe how the sub-sample used in the analyses below (Sub-sample 2) was developed, and also the development of an intermediate sub-sample that was used to test for bias in NLSCY sampling and weighting procedures (Sub-sample 1).

There are 30,502 records in NLSCY4. Of these, 4,008 were for children aged 0 and 1 year at the time Cycle 4 of the NLSCY was conducted. These records were not used here because the BMIs of children of this age may not be meaningful and because in any case they may not be susceptible to the factors of interest including settlement pattern (residential density) and opportunity for outside play. Also, 182 records had no information about age, and were not used. Of the remaining 26,312 records, 108 had no information about postal code and a further 1,158 records had postal codes for which the residential density could not be determined. These 1,266 records were not used. (They comprised 4.8 per cent of the records for which age was known.)

The sub-sample at this point, comprising 25,046 records, known as Sub-sample 1, was used to test the representativeness of the NLSCY sampling and weighting procedures as they applied to the key variable under investigation—residential density—as described below.

3.4 Derivation of the NLSCY4 sub-sample used in this analysis (2)

Sub-sample 1 could not be used for the substantive analysis reported here because 6,567 of the 25,046 records in Sub-sample 1 have no information about height or weight, or both, thus precluding estimation of BMI. These records were removed to leave Sub-sample 2, containing 18,479 records distributed across 1,312 FSAs.

These 1,312 FSAs were ordered according to gross residential density and divided into deciles containing 131 or 132 FSAs. Decile 1 containing the lowest residential densities and Decile 10 the highest densities. Table 2 shows the range of densities and, for Sub-sample 2, the number of NLSCY4 records associated with each density decile. It also provides illustrative place names for FSAs at or near the limits of each density decile. Except for the analysis in the next section, which was performed on Sub-sample 1, the analyses reported here were performed on Sub-sample 2.

Table 2. Density deciles

Density Decile	Density range (persons/ per square kilometre)		Place names for FSAs		Number of Records
	Low	High	Lower density	Higher density	
1	0.01	6.41	Kuujjuaq, PQ	Lower Woods Harbour, NS	4,189
2	6.44	25.5	Sooke, BC	Renfrew, ON	3,218
3	25.5	79.6	Corunna, ON	Trois Rivières, PQ	1,860
4	80.3	230	Yellowknife, NT	St. John, NB	1,712
5	232	568	New Waterford, NS	Sydney Mines, NS	1,511
6	569	1,117	Calgary, AB	Richmond, BC	1,422
7	1,121	1,726	L'Île Bizard, PQ	Edmonton, AB	1,626
8	1,733	2,585	Winnipeg, MB	Lasalle, PQ	1,420
9	2,594	3,927	London, ON	Vancouver, BC	997
10	3,933	18,541	East York, ON	Montréal, PQ	524
				Total	18,479

3.5 Representativeness of NLSCY4 with respect to residential density

This section describes the testing of NLSCY4 for sampling bias in respect of the key variable in the analysis conducted here: residential density. If there were no bias in the sampling procedure, an estimate from NLSCY4 of the population disaggregated by residential density would not vary systematically with density. **The testing reported here showed systematic variation with density indicating bias in the construction or implementation of NLSCY4, or both.**

As noted above, creation of Sub-sample 1 involved non-use of less than five per cent of available records, and so this sub-sample—which had a density value for each of its 25,046 records—was used to provide the alternative population estimates require for the testing of bias.

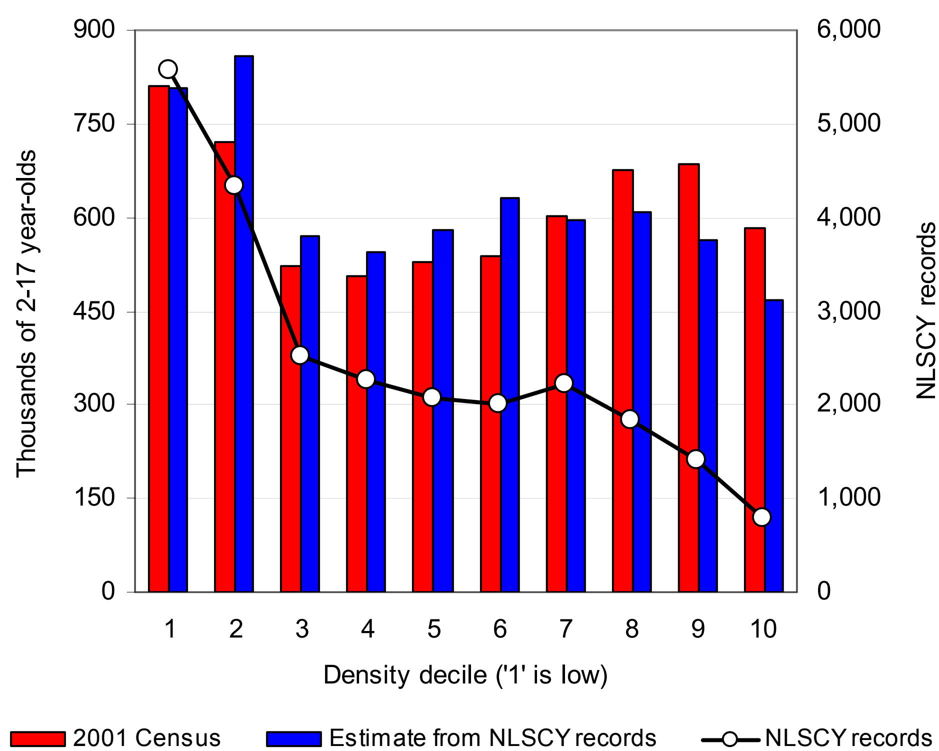
The results of the assessment are presented in Figure 13. (Note that the record counts in Figure 13—solid line, right-hand scale—include records for which a BMI could not be calculated whereas the record counts in Table 2 do not include these records.)

The first thing to notice in Figure 13 are the large differences in number of records per decile, as plotted in the line graph against the right-hand vertical axis. There are almost exactly eight times as many records for Decile 1 (the lowest residential densities) as for Decile 10 (the highest densities). This represents a major bias in the construction of the sample.[87]

The bias is somewhat corrected for by provision of weightings by the survey managers that can be applied to 'factor up' each record to an appropriate number of individuals in the general population.

The right-hand (blue) bar of each pair in Figure 13 shows the result of applying the pro-

Figure 13. Census populations of young people aged 2-17, estimates of these populations from NLSCY records with postal codes (Sub-sample 1), and numbers of records in this sub-sample, all arranged according the 10 density deciles used in the current analysis.



vided (cross-sectional) weights to the relevant records. Thus, these bars are estimates of the populations of 2-17 year olds for each of the ten deciles, For comparison, the actual 2001 Census populations of 2-17 year-olds for the deciles are shown in the left-hand, red bar of each pair.

Figure 13 demonstrates what appears to be a bias in the way the weightings were applied. Weightings applied to records in Deciles 2-6 overestimated the population corresponding to these deciles by 7-19 per cent, whereas weighting applied to records in Deciles 8-10 underestimated the corresponding populations by 10-20 per cent. Thus there appears to be a further bias in the NLSCY. **Not only are there relatively many fewer records for children in higher-density areas, these records are weighted in a way that under-represents their share of the actual Canadian population.**

A further check on the validity of the sample and weighting process involved a similar analysis to that conducted for Figure 13 but using age-year as the record category. The results are in Figure 14. There are age-years for which there are more records than usual, a planned feature of NLSCY. Application of the weightings—done as described for Figure 13—shows no evidence in Figure 14 for age of the kind of systematic deviation from Census population estimates revealed in Figure 13 for residential density. The maximum deviation in Figure 14 is in respect of two-year-olds, for whom the population

Figure 14. Census populations of young people aged 2-17, estimates of these populations from NLSCY records with postal codes (Sub-sample 1), and numbers of records in the total NLSCY sample, all arranged according the age-years of the young people.

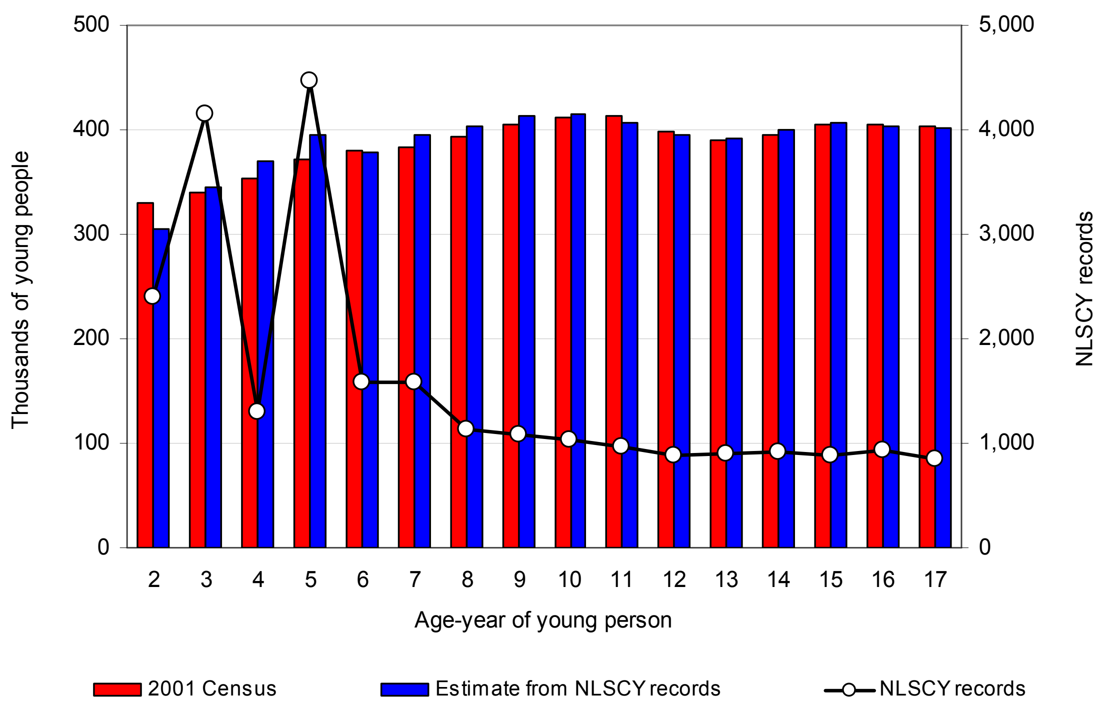
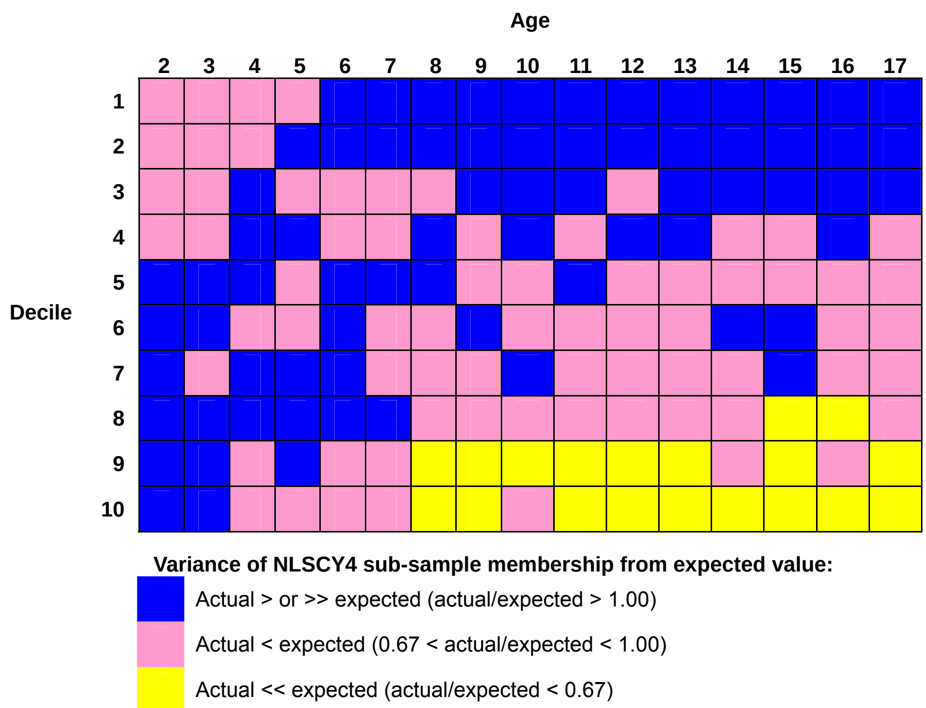


Figure 15. Analysis of NLSCY4 records with postal codes (Sub-sample 1) showing variation in actual frequencies of records for particular age-years and density deciles from expected frequencies.



estimated from weighting of NLSCY41 records is seven per cent below the population estimated from the 2001 Census of Canada. The absence of a systematic deviation in respect of age may strengthen the argument that the presence of systematic deviation in respect of residential density means that the NLSCY cross-sectional weightings may have been biased against representation of young people living in higher-density areas.

Next, an assessment was made as to whether there was an *interaction* between residential density and age in how NLSCY4 represented the population of 2- to 17-year-olds. Such an interaction is suggested in Figure 15, which shows for each age-year and decile the ratio of the actual number of young people to the number that would be expected from the overall distributions across ages and deciles. A ratio above one means that young people of a particular age-year and decile are overrepresented in the sample, and vice versa. Figure 15 shows that young people over about five or six years of age living in higher density areas tend to be under-represented in NLSCY4, as do children under about four years living in lower-density areas. Young people aged eight years and over living in the two or three highest density deciles seem to have been particularly underrepresented. Thus, analyses based on NLSCY4 run the risk of confusing an effect related to density with an effect related to age, and vice-versa, because of biases in the sampling procedures.

Table 3. Shares of records with postal codes of those without an estimate of BMI, by density decile

Decile	1	2	3	4	5	6	7	8	9	10
Records without BMI	25%	26%	26%	24%	27%	29%	27%	23%	30%	34%

Yet another source of bias concerning residential density appeared when the counts of records represented in Figure 13 (Sub-sample 1) are compared with those in Table 2 (Sub-sample 2). The difference between the two is that Sub-sample 1 includes all records with a postal code for ages 2-17, whereas Sub-sample 2 includes only those records in Sub-sample 1 for which a BMI could be calculated. Table 3 shows for each decile the per cent of records in Sub-sample 1 for which BMI could *not* be calculated. The deciles containing the two highest residential densities have the highest shares of records without BMI estimates. This serves to reduce further the representation of young people living in higher-density areas beyond that already noted. This further source of bias reduces the value of NLSCY4 data for analyses of the relationship between residential density and BMI.

3.6 Conclusion regarding the representativeness of NLSCY sample in relation to residential density

The biases in the survey sample and the weighting procedure evidenced in Figure 13, in the representation of age-years across deciles evidenced in Figure 15, and in the availability of BMI estimates evidenced in Table 3 all compel caution in the proposed analysis and interpretation of information in NLSCY4. To avoid compounding the biases through statistical manipulations, the following analysis will for the most part be descriptive. This fits the basic purpose of the present undertaking, which is to point to matters requiring and amenable to further work rather than to provide definitive analysis of available data.

3.7 Variation in BMI with residential density

The core analysis conducted here, using the 18,479 NLSCY4 records that had both residential density and BMI (Sub-sample 2), involved examination of the relationship between these two variables. The correlation coefficient of the two variables is -0.042. This correlation is low but nevertheless significant at the one-per-cent level.[88]

The records in Sub-sample 2 are represented by decile for each age year in Figure 16 (ages 2-9 years) and Figure 17 (ages 10-17 years). Slight declines in median BMI are visible in both sets of graphs in moving from lower- to higher-density deciles. However, in each case the data for Deciles 9 and 10 are variant, possibly reflecting the sampling deficiencies noted earlier. Because the NLSCY sample was constructed to have relatively few records in Deciles 9 and 10, and because weights or heights or both were less likely

Figure 16. Median BMI by density decile, for each of age-years 2-9

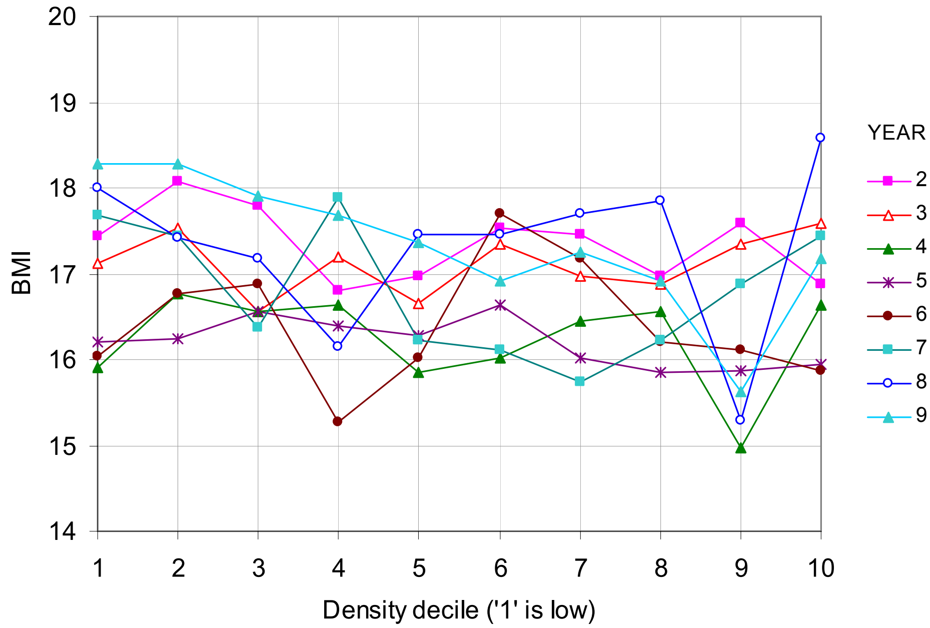
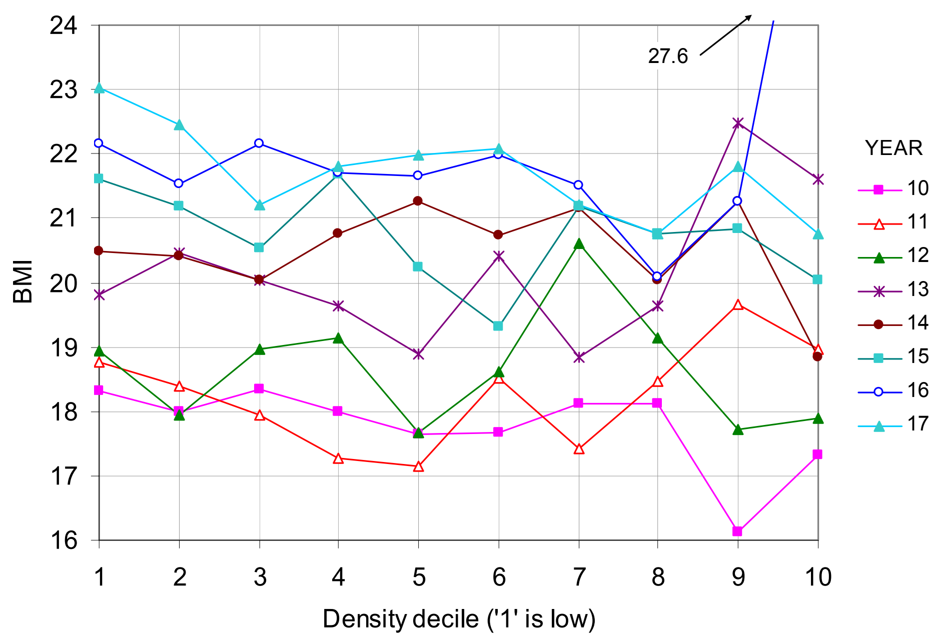
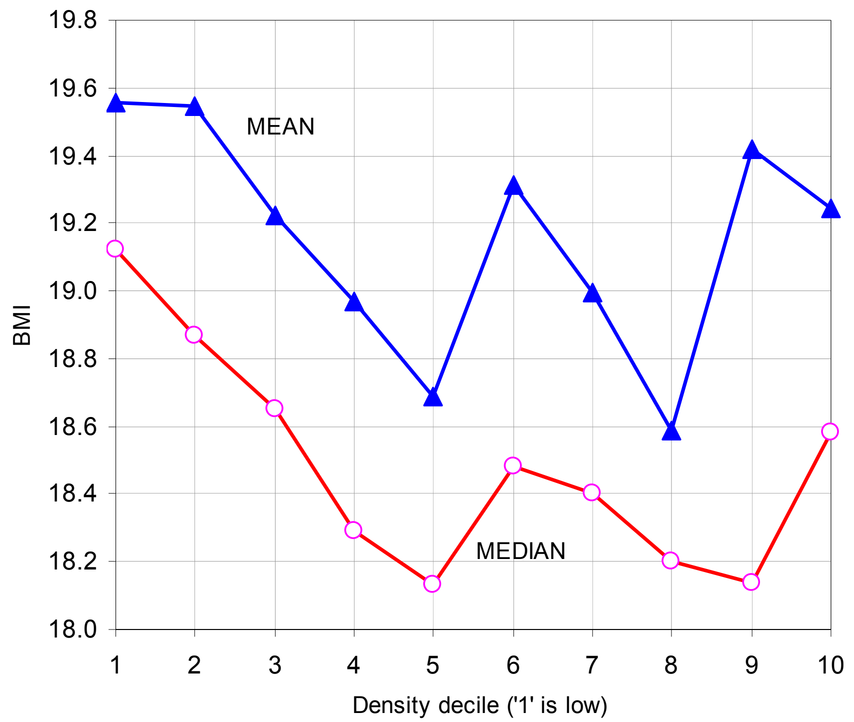


Figure 17. Median BMI by density decile, for each of age-years 10-17



to have been recorded for Deciles 9 and 10, the numbers of records for these two deciles were unusually low, thus inviting greater variation in the data and unreliability in respect of any conclusion.

Figure 18. Median and mean BMI by density decile, all ages 2-17 years



The tendency for a decline in BMI with increased residential density is clearer in Figure 18, where data from all ages are aggregated and both the mean and the median are shown.

3.8 Conclusion concerning variation in BMI with residential density

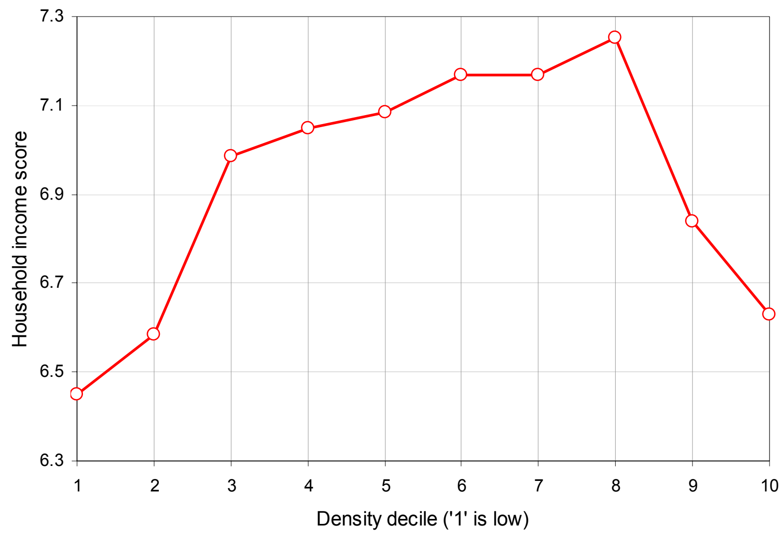
The reasonable conclusion from the data on the relation between young people's BMI and the residential density of their home neighbourhoods is that there appears to be a loose relationship. As density increases, BMI declines. However, the data in respect of Deciles 9 and 10, the highest density deciles, are too 'noisy' to allow extension of this conclusion across the whole range of residential densities

In many ways, Deciles 9 and 10 are the most interesting deciles because they embrace parts of the country where transit use is relatively high and automobile use is relatively low, chiefly the denser inner cities and their surroundings. The inadequacies in the NLSCY data for these two deciles are thus especially frustrating.

3.9 Variation in household income with residential density

A possible explanation for the slight negative association noted above between residential density and BMI is that density varies with household income. Previous work, based on data from an earlier cycle of the NLSCY, had shown a negative association between in-

Figure 19. Mean household income score by density decile

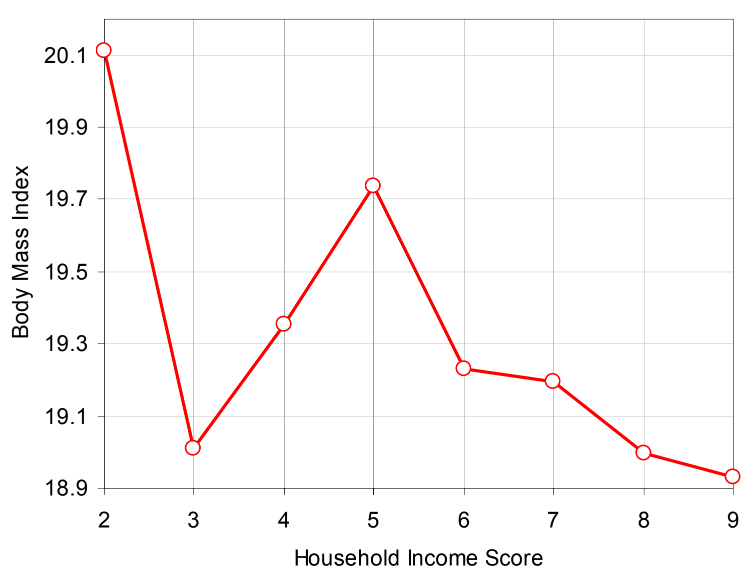


come and BMI.[89] Thus, the above-noted changes in BMI with density decile could well reflect no more than the changes in household income with density decile.

NLSCY4 provides two indications of annual household income. One is for all households and one is for households with couples. These were combined to provide a household income score[90] that was then plotted against density decile in Figure 19. A score of '6' corresponds to a household income of $40,000-$50,000. A score of '7' corresponds to a household income of $50,000-$60,000.

The inverted U-shaped curve in Figure 19 corresponds somewhat to the inverse of the U-

Figure 20. BMI and household income score



shaped curves in Figure 18, with a peak or a trough at Decile 8. Thus, the suggestion that BMI might be inversely related to income receives some support, as does the suggestion that the weak inverse association between BMI and density may reflect an income effect.

3.10 Variation in BMI with household income

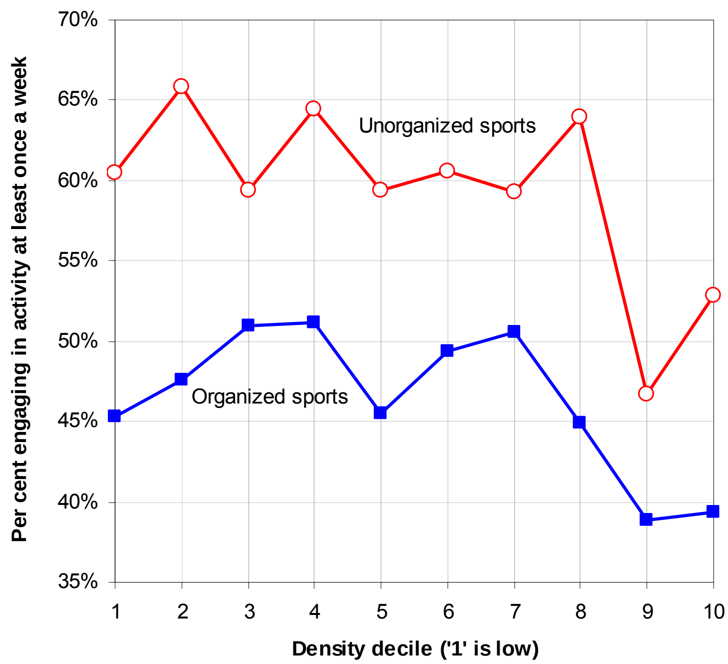
Also relatively strong is the negative association between BMI and household income. This is shown in Figure 20, which is based on data from all records with postal code and BMI (Sub-sample 2).

3.11 Physical activity outside school hours

The NLSCY4 provided responses for children 3-9 years as to how often they engaged in sports or physical activities outside of school hours. One question concerned "sports with a coach or instructor". Another concerned "unorganized sports or physical activities without a coach or instructor".[91] These questions were answered in respect of 11,610 and 11,608 children aged 3-9 years for whom there were postal code and BMI data (i.e., within Sub-sample 2).

Figure 21 shows that for both kinds of activity there was little difference among the deciles except the two highest-density deciles. Children in Decile 9, and particularly in Decile 10, were less like to be reported as participating in these activities at least once a week.

Figure 21. Per cent of 3-9 year olds who engaged at least once a week in organized or unorganized sports or physical activity outside of school hours.



3.12 Travel to school

A question in NLSCY4 concerned the journey to and from school, for 4-15 year-olds only. There were 11,392 responses to this question where there were also postal code and BMI data (Sub-sample 2). The results are in Figure 22. They show that travel by modes involving physical activity (walking, bicycling, and public transit) increased with settlement density. Travel by school bus declined with settlement density.

Paradoxically, travel by car to and from school mostly increased with settlement density, although less steeply than travel by active modes, and with a sharp decline between Deciles 9 and 10.

3.13 Watching television

This might be considered to be an indicator of inactivity, and thus correlated with lack of engagement in organized or unorganized sports. It would therefore be expected to be relatively flat across most density deciles but to increase for the two highest density deciles (pace Figure 21).

Data from NLSCY4 on television watching are presented in Figure 23 by density decile and in Figure 24 by household income score.[92] The latter effect is evidently stronger in that it results in more variation.

Figure 22. Travel modes used in the journey to and from school, 4-15 year olds, by decile

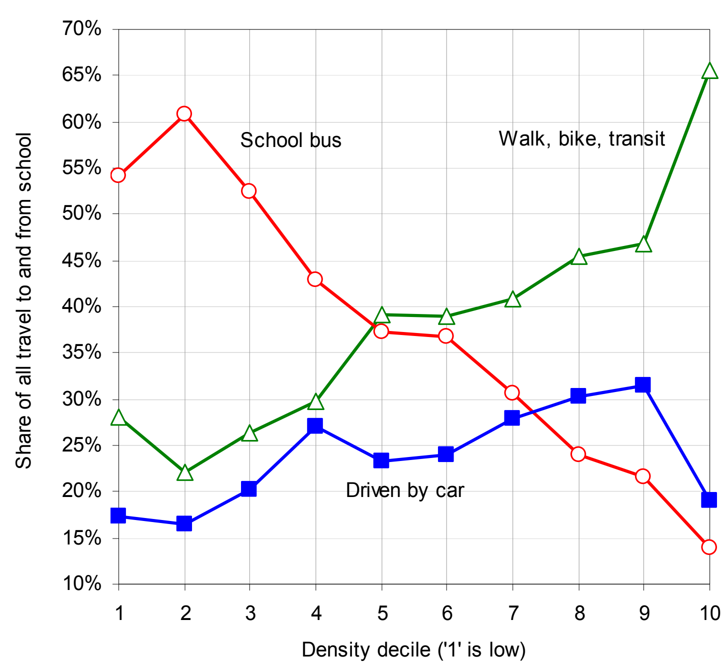


Figure 23. Hours spent watching television, by density decile

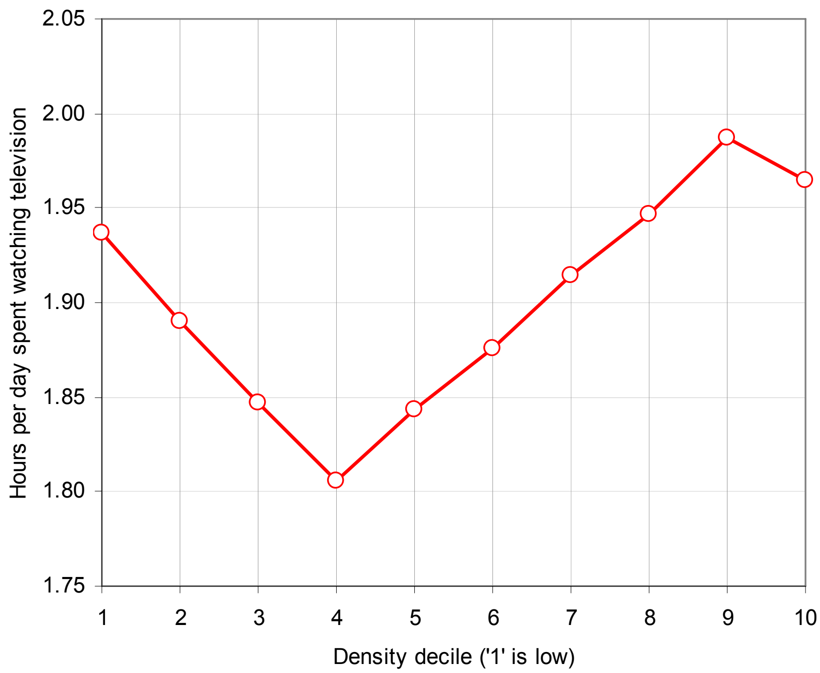
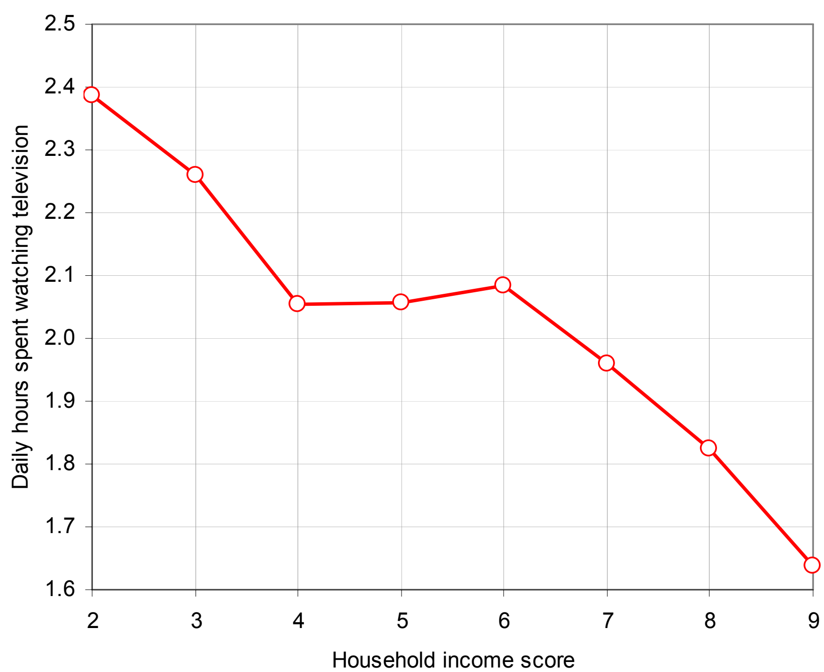


Figure 24. Hours spent watching television, by income



3.14 Conclusions from the analysis of NLSCY data

The primary purpose of use of the NLSCY4 was to examine how the body weights of children and youth, and also their physical activity, might vary with settlement density. Meeting this purpose was impeded by discovery that the NLSCY4 sample selection was deliberately biased against higher-density parts of Canada, and that the weighting factors proposed for compensating for this bias were themselves biased. Moreover, the weighting of the NLSCY4 sample particularly under-represented young people aged 8-17 years in the highest density areas. In addition to the foregoing, other things being equal, body weights and heights were less likely to have been provided for young people in the highest density areas.

These profound manifestations of apparent bias in the NLSCY4 sampling and weighting, and in the way the survey was conducted, make suspect use of the survey data for the indicated purpose (and perhaps for other purposes). Accordingly, and because of the preliminary nature of this work, the treatment of the available data has been almost entirely descriptive.

The bias in the weighting of the sample could perhaps be remedied by re-weighting, which would have to be done by Statistics Canada. The bias in the conduct of the survey may be beyond remedy.

In the meantime, it is possible to note that there is a slight effect whereby the BMI of children and youth declines with increased residential density. This could at least in part be a matter of household income rather than density, and it is in any case an especially tenuous conclusion for the two highest density categories.

Another possible slight effect concerns participation in organized and unorganized physical activity outside of school hours. This appears to decline with increased density, at least for the highest density categories. (This could also be related to income, but that was not tested.)

The possible combination of declining BMI with settlement density and declining leisure-time physical activity is paradoxical if it is believed that such physical activity is a factor in overweight. Less paradoxical is the steep increase in active transport to and from school with settlement density. Indeed, the potential importance of this kind of activity, as opposed to leisure-time physical activity, as a factor in body weight has already been noted.[93]

The challenges posed by the NLSCY4 data make firm conclusions difficult. However, they and other work suggest that a focus of further work on overweight in young people could be factors in everyday activity, including travel behaviour.

Thus, notwithstanding the data difficulties noted above, the present exercise has been of value in establishing the limits of the most recent, best available data on the body weights and some of the physical activity of young people in relation to a critical feature—residential density—of the settlements they live in. It has also been of value in provoking suggestions for further work, the subject of Chapter 4.

Chapter 4. Proposals for further work

4.1 Research directions indicated by the literature review and the analysis of NLSCY4 data

A salient feature of the literature review was its inconclusiveness, particularly with regard to young people. It seems reasonably clear that the body weights of young people have risen, but this change cannot be readily related to changes in physical activity. Overweight and obesity appear to have a loose relationship to physical activity, but it is not clear whether children are overweight because they are inactive or inactive because they are overweight, or both (or, indeed, neither). There is insufficient evidence to draw a conclusion about the influence of settlement pattern or related transport practices on the activities and body weights of young people.

The analysis of data from Cycle 4 of the National Longitudinal Survey of Children and Youth did not provide much illumination. Evident biases in the sampling and weighting created challenges for any analysis. Setting the biases aside, the only clear and consistent changes with residential density concerned modes of travel to school, with active modes favoured at higher densities.

The literature review and the NLSCY4 analysis do nevertheless suggest a mechanism for differences in the body weights of young people:

- As for adults, excess body weight results from an imbalance of energy intake and physical activity.
- As for adults, the changes in body weight may be more than could be expected from changes in energy intake alone; i.e., some part is related to changes in physical activity.
- The amount and nature of physical activity is related to settlement pattern, particularly to settlement density, but not in a straightforward manner. Some kinds of activity are more likely in suburban and rural settings, e.g., outdoor play and organized and unorganized sports. Some kinds of activity are more likely in urban settings, e.g., walking to school and other active travel. Whether play and everyday activity cumulate to provide a young person with sufficient physical activity in relation to energy intake depends on a complex of factors, including socio-economic factors.

Two things are particularly lacking. One is some understanding of how physical activity in young people changes over time, particularly in relation to where they live. The other is fine-grain analysis of physical activities, again in relation to where young people live.

A two-pronged approach is proposed to remedy these deficiencies. One direction would comprise analysis of data from all four NLSCY cycles. The other direction would consist of detailed examination of the daily activity of young people who live in different settlement patterns. These two elements of possible further work are elaborated in the next two sections. Two further sections speak to the budget and timing of the proposed work and to its potential uses and implications.

4.2 Further consideration of NLSCY data

The main reason for pursuing NLSCY data is that given earlier. This survey provides the only available Canadian data—and possibly the only data worldwide—that relate the (reported) body weights and heights of children and youth to places of residence, allowing the possibility of examining associations with types of settlement pattern. Also, there are survey responses to questions about leisure-time physical activity, travel modes to and from school, television watching, and household income.

The sampling and weighting biases found in Cycle 4 data are discouraging, but reweighting may be possible and weighting biases at least may be found not to exist in earlier cycles.

If weighting biases were found not to be a factor, or could be corrected, use of data from several NLSCY cycles could also allow for longitudinal analysis in which groups of young people are tracked across years. Questions that could be answered concern, for example, travel to school. Is travel mode to school affected more by the immediate circumstance of the home or by the history of using a particular mode? If the data were available and reliable, an answer might be derived from comparisons of young people who had moved from one density level to another with young people who had not moved.

As well, cross-sectional analyses could be re-done for Cycle 4, improved, and expanded, and performed also for earlier cycles.

4.3 Fine-grain analysis of young people's travel and other behaviour in relation to settlement pattern

A more substantial direction for further work could involve detailed examination of children's everyday behaviour. The main purpose of this work would be to determine whether patterns of physical activity in young people vary with different types of settlement pattern and, if so, how.

The assessment of physical activity would involve two elements. One would be the quantitative determination of the amplitude of physical activity in time, achieved by fitting young people with triaxial accelerometers. The other would be characterization of the activity by the young people themselves through travel and activity diaries.

This work would build in particular on that of Roger Mackett of University College London, who would be associated with the project. Mackett and colleagues have used a combination of accelerometers and diaries in several studies of children's physical activity. One, for example, concluded that the place where children are least active in is their own homes. Thus any travel away from home is beneficial from the perspective of activity. Moreover, walking is the travel mode that provides the most activity not only while travelling but also at the destination.[94] This repeated for both boys and girls an earlier, already-noted finding for boys.[95] The activities of 200 children aged 10-13 were monitored in Mackett's investigation.

Accelerometers and diaries have been used with effect in several other assessments of children's physical activity.[96,97] An examination of methods for monitoring physical activity in children and youth concluded that accelerometers are indicated "in clinical or research applications in which patterns of ambulatory activity are the desired outcome".[98] Moreover, "the frequently employed single-plane (vertical) accelerometer may be potentially limited in its ability to detect the variable movement patterns of children and adolescents". More sophisticated three-dimensional (triaxial) accelerometers are required—such as have been used in the above-referenced studies.

No investigation to date has used this methodology to examine children's activity in relation to settlement pattern, as is proposed here. The closest ongoing work is an investigation by the Canadian Fitness and Lifestyle Research Institute, entitled 'Physical Activity Levels Among Youth', also known as CAN PLAY.[99] This will involve annual assessment of 10,000 children and youth aged 5-19 years across the period 2005 to 2008. Participants wear pedometers for seven consecutive days. A few children will wear accelerometers. Parents complete a brief questionnaire about participants' circumstances (not their activities), including postal codes of residences. Thus, much quantitative information about amounts of activity will be available, and in some cases its amplitude, in a manner that can be related to settlement pattern.

What is proposed here is a much more intensive assessment of physical activity in fewer children, selected according to the circumstances of their residence. **The specific hypothesis that would be tested is that children in urban settings perform most of their physical activity as everyday activities, including travel; whereas children in other settings perform a larger share of their physical activity in organized and unorganized sports and play.** In particular, the project will enable fairly precise assessment of the contribution of different modes of travel to children's overall physical activity. Most important, the work will provide a strong understanding of the gains in activity that could be achieved through changes in travel arrangements, e.g., by requiring or encouraging more walking and cycling to school and other locations, and associated changes in infrastructure, such as bicycle paths.

An additional feature would be a cross-cultural comparison arising mostly from close association and data-sharing with Mackett's work in the UK,[100] and also from comparison with other European work.[101]

The proposed fine-grain analysis would be designed to ensure as much complementarity as possible with the above-mentioned work of the Canadian Fitness and Lifestyle Research Institute. Data from each project would support analysis of the other. For example, CAN PLAY data could indicate the extent to which our samples were typical across Canada. Our data could contribute to understanding of variances in the CAN PLAY data.

Our proposed work will focus on 10- to 13-year-olds. These children are at an age when they are well able to maintain a travel and activity diary, and engage in some measure of independent activity. It is the age range of the children examined in Mackett's work and within the range of the ages of young people in the other European work.

The basic design of the proposed project would comprise detailed observation of children in six groups, in a 3x2 design in which there would be three settlement pattern conditions and two household income conditions. The three settlement pattern conditions would correspond to urban, suburban, and exurban or rural conditions. In terms of the density deciles derived for the work reported in Chapter 3 of this report, the urban pattern would likely correspond to Decile 10, the suburban to Decile 8 and 9, and the exurban or rural to Deciles 1-7 (see Section 3.4 and Table 2). Household income would also be used as a 'treatment' variable because it was identified as an important variable in the work reported in Chapter 3 (see Sections 3.9, 3.10, and 3.13, and also Figure 19, Figure 20, and Figure 24). For each settlement form there would be a higher and lower household income condition. These would not relate to the household incomes of the particular children chosen for observation but to the general area in which the children lived and went to school.

The administration of the assessment would be school-based, as it has been in the work of Mackett and colleagues. Schools would be selected according to the requirements of the 3x2 design elaborated in the previous paragraph. Once the cooperation of school authorities had been secured, and interested teachers found, identified children would be asked to volunteer and the permission of their parents/guardians would be sought.

In each of the six schools, approximately 30 children in Grades 5-7 would be asked to wear accelerometers for four days, Friday to Monday inclusive, except while sleeping or in water. They would be asked to keep diaries of all their activities, with the cooperation of their teachers, all in a way that provided for some standardization of how the activities were described. The process would be repeated once with each participating child, with an interval of about a month between the assessments.

Accelerometer readings and diary information can be matched to provide several measures of several kinds of activity. The activities could include organized and unorganized sports, indoor and outdoor play, travel (different modes and purposes), and sedentary activities. The measures include those of duration, frequency, and amplitude.

4.4 Project timing and budget

The proposed work involves several labour-intensive activities that would require a high level of planning and coordination. Securing cooperation of school authorities and teachers would be particularly time-consuming, as would be the fitting and monitoring of accelerometers and the analysis of accelerometer output and activity diaries. Moreover, because of the cost of the accelerometers (see below), monitoring more than one group at a time may not be practicable. All in all, as much as two years may be required for this work. The analysis of all NLSCY data would be done in parallel, and would not require the full two years, even with the lengthy approval process for data access.

Triaxial accelerometers are expensive. The kind used by Roger Mackett's team are US$300 each, US$500 with a docking station (required for data extraction).[102] The minimum number required for the proposed work would be 40, including at least 10 with docking stations, for a total cost of approximately $16,500. Other expenses would notably be for three half-time research assistants (approximately $100,000 over the two years) and two researchers, one half time and one one-quarter time (approximately $150,000). Other expenses and administrative overhead would bring the total for the three years up to approximately $300,000.

4.5 Potential implications and uses of the proposed work

The work proposed in Sections4.2 and 4.3 could contribute to understanding of the factors in young people's activity and to development of policy and programs in the following ways:

- The fine-grain analysis of activity could contribute to understanding of how much physical activity is performed by young people and under what circumstances, particularly in relation to locational and economic factors.
- The detailed analysis of all NLSCY cycles could help clarify how young peoples' body weight varies according to where they live, and how this might change over time.
- Together with the data from the ongoing CAN PLAY project, the proposed work could make a contribution to overall understanding of how much of the variation in body weights of Canadian young people can be attributed to physical activity and how much can be attributed to other factors.

- The information and insights gained could contribute to the development of more appropriate policies and programs. For example, if the empirical work indicates that increasing activity in the suburbs should focus on transport arrangements and increasing activity in the inner city should focus on extra-curricular activities, programs and policies could be fashioned accordingly.
- The information and insights gained could also contribute to understanding of what constitutes 'child- and youth-friendly land-use and transport planning', thereby strengthening the *Guidelines* on this matter produced for Ontario and under development for the rest of Canada.[103]

End Notes

[1] In adults, walking in particular, and also time spent in car travel, have been noted as contributory factors to associations between settlement pattern and body weight. See, Frank LD, Andresen MA, Schmid TL, Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine*, 27, 87-96, 2004.

[2] The Centre's definition is used extensively in several countries and, with slight amendment, has been adopted as the official working definition of the European Union. It is this:
A sustainable transportation system is one that: (a) allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations; (b) is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; and (c) limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

[3] Several projects have been conducted during 2003-2005 with support from the Ontario Trillium Foundation. Reports on this work are available at The Centre's Web site at http://www.cstctd.org. They include the 72-page document *Guidelines for Child- and Youth-Friendly Land-use and Transport Planning Guidelines*. The final form of the Ontario version of these *Guidelines* is available at The Centre's Web site, and also drafts of versions for British Columbia and Nova Scotia. Versions for all provinces are to be completed during 2006 with support from the Public Health Agency of Canada.

[4] For example, the Public Health Agency of Canada, in introducing its *Physical Activity Guide for Youth* states the following: "…the rapid increase in overweight and obesity, combined with low levels of physical activity, represent a serious threat to the health of Canada's children and youth"
Available http://www.phac-aspc.gc.ca/pau-uap/paguide/child_youth/youth/index.html (accessed September 22, 2005)

[5] For example, the following was concluded in a recent review of the literature on public health and urban sprawl: "Consistently, studies show that people who live in low-density suburban areas are more overweight, walk and bicycle less, use cars more (even for short trips), and have higher rates of obesity-related illnesses. (See Bray R, Vakil C, Elliott D, *Report on Public Health and Urban Sprawl in Ontario: A review of the pertinent literature*. Toronto, Ontario: Environmental Health Committee, Ontario, College of Family Physicians, January 2005, available at the URL below.) None of the indicated studies concerned children or youth.
http://www.ocfp.on.ca/local/files/Communications/Current%20Issues/Urban%20Sprawl-Jan-05.pdf (accessed September 22, 2005)

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Available http://www.cmaj.ca/cgi/reprint/166/8/1039 (accessed September 29, 2005)

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Available: http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=GR_1130_E (accessed September 22, 2005).

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[11] Tjepkema M, Adult obesity in Canada: Measured height and weight. Issue No. 1 of *Nutrition: Findings from the Canadian Community Health Survey*. Ottawa, Ontario: Statistics Canada, Catalogue No. 82-620-MWE2005001.
Available http://www.statcan.ca/english/research/82-620-MIE/2005001/pdf/aobesity.pdf (accessed September 22, 2005).

[12] See Note 11.

[13] Statistics Canada, National Population Health Survey – Obesity: A growing issue. *The Daily*, April 7, 2005.
Available http://www.statcan.ca/Daily/English/050407/d050407a.htm (accessed September 29, 2005).

[14] Statistics Canada, *CANSIM*. Table 104-7030. Available http://cansim2.statcan.ca/cgi-win/cnsmcgi.exe?Lang=E&RootDir=CII/&ResultTemplate=CII/CII___&Array_Pick=1&ArrayId=1047030 (accessed September 22, 2005).

[15] Statistics Canada, *CANSIM*. Table 104-0007. Available http://cansim2.statcan.ca/cgi-win/CNSMCGI.EXE?regtkt=&C2Sub=&ARRAYID=1040007&C2DB=PRD&VEC=&LANG=E&SDDSLOC=&ROOTDIR=CII/&RESULTTEMPLATE=CII/CII_PICK&ARRAY_PICK=1&SDDSID=&SDDSDESC= (accessed September 22, 2005).

[16] Statistics Canada, *CANSIM*. Table 105-0029. Available http://cansim2.statcan.ca/cgi-win/CNSMCGI.EXE?regtkt=&C2Sub=&ARRAYID=1050209&C2DB=PRD&VEC=&LANG=E&SDDSLOC=&ROOTDIR=CII/&RESULTTEMPLATE=CII/CII_PICK&ARRAY_PICK=1&SDDSID=&SDDSDESC= (accessed September 22, 2005).

[17] Statistics Canada, *CANSIM*. Table 105-0007. Available http://cansim2.statcan.ca/cgi-win/CNSMCGI.EXE?regtkt=&C2Sub=&ARRAYID=1050007&C2DB=PRD&VEC=&LANG=E&SDDSLOC=&ROOTDIR=CII/&RESULTTEMPLATE=CII/CII_PICK&ARRAY_PICK=1&SDDSID=&SDDSDESC= (accessed September 22, 2005).

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[27] Tremblay MS, Willms JD, Correction. *Canadian Medical Association Journal*, 2001; 164: 970.

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Available http://www.statcan.ca/english/research/82-620-MIE/2005001/pdf/cobesity.pdf (accessed September 22, 2005).

[29] Figure 3 and Figure 4 are from the source detailed in Note 28

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[86] A file (fsaarea96s.csv, at FSA areas file) giving the geographic extent (area in square kilometres) of each of 1,438 1996 forward sortation areas (FSA, i.e., the first three letters of the postal code) was available at http://www.chass.utoronto.ca/datalib/cc96/georef96.htm (accessed August 31, 2005). Such a file for 2001 was not available.

[87] The bias is justified in the PowerPoint presentation *NLSCY Sampling Weights* (made available to users of NLSCY data) as required to meet the NLSCY objectives of "(i) Very reliable national estimates for very small proportions; and (ii) Reliable provincial and age-group estimates for small proportions". The net result may be to reduce the precision with which comparisons in respect of settlement density, such as are attempted here, can be conducted.

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[91] The NLSCY4 variables are respectively DACCQ3A (organized sports) and DACCQ3B (unorganized sports)

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[103] See Note 3.