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Long-Run Changes in the Body Mass Index of Adults in Three Food-Abundant Settler Societies: Australia, Canada and New Zealand

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Working Paper in Economics 15/17

July 2017

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Abstract

We identify changes in body mass index (BMI) since the 19th century, for three British-origin, food abundant, settler societies: Australia, Canada and New Zealand. The onset of sustained BMI increase came later in these societies than in the US. New Zealand shows a distinctive pattern of within-country gender differences. The gap between Australian Canadian males (leading) and female BMIs remains large with some increases in the gap in the 35-39 year age group, but narrowing in the 45-49 range especially in Australia. In contrast, the BMI of both sexes in New Zealand has effectively converged for most age ranges (although it has been similar for the 45-49 age range since 1977). In terms of cross-country comparisons, the results show a remarkably similar long-term pattern for males in all three countries although the absolute differences between leading BMI countries has changed over time culminating in New Zealand being the 'top ranked' obese country for males in the 20-49 age group. For females the pattern and trends are quite different, with New Zealand women exceeding the BMI of same aged females in Australia and Canada from the 1980s onwards. If anything the results suggest that New Zealand female BMI continues to grow while that of Australia may be leveling off.

Keywords

obesity
body mass index
Canada
New Zealand
Australia

JEL Classifications

I1; J11; N3

1.0 Introduction

Body Mass Index[1] (BMI) and rates of obesity/overweight have been increasing rapidly in many societies (Zellner *et al.* 1996, Floud 1998 and Zellner *et al.* 2004). The historical trajectory of BMI is well-documented for the United States but little known for other populations (Carson 2007, 2009, 2011, 2012, Gyenis and Joubert 2004, Helmchen and Henderson 2004, Komlos and Baur 2004, Komlos and Brabec 2011, Komlos and Carson 2017, Ruhm 2007, Whitewell and Nicholas 2001 and Zagorsky 2005). Research for most countries has focused exclusively on modern periods where the emphasis seems to be on establishing correlates with obesity/overweight in large cross-sections of the population, often as part of much larger health surveys. Consequently, the medical and public health literature largely frames the the worldwide increase in obesity as a phenomenon of the past 35-40 years (Ministry of Health, 2004).

A related literature examines systematic differences within populations for example, by gender (Tremblay *et al.* 2002, Cutler *et al.* 2003, Kimhi 2003, Chou *et al.* 2004, Gyenis and Joubert 2004, Rashad *et al.* 2006, Belanger-Ducharme and Tremblay 2005, Borghans and Golsteyn 2006, Flegal 2006, Heineck 2006, Kaushal 2007 andVer Ploeg *et al.* 2007). There has been some evidence of a gender 'catch-up', as female BMI has increased at a faster pace than for males (Borghans and Golsteyn 2006). Investigators also consider BMI by race separately (Komlos and Baur 2004, Mujahid *et al.* 2005, Rashad 2006 and Ver Ploeg *et al.* 2007) and together (Chou *et al.* 2006, Rashad 2006, Rashad *et al.* 2006 and Phuong Do *et al.* 2007). Regional differences in BMI are visible in large countries such as Canada (Shields and Tjepkema 2006 and Tjepkema 2006), Germany (Komlos and Kriwy 2002 and Heineck 2006), and Russia (Huffman and Rizov 2007).

Relatively few studies have examined *trends* before the 1960s, and fewer still for the era before World War Two (WWII). Only Komlos, Carson and coauthors (above) have documented and analysed earlier periods for the United States. Both reveal that the trend to increasing BMI began well before the modern surveys of the 1970s and 1980s although health risks from being underweight were a more widespread issue prior to WWII.

The underlying causation for long-term change is not understood with any precision. Changes in the food industry made a contribution. The advent of prepared, ready-to-eat, and ready-to-heat foods and, more generally, foods which offer enhanced preparatory convenience dates from the 1950s. Secular improvements in longevity have also been accompanied by improvements in individual health; far fewer individuals today lose body mass through bouts of severe infection and chronic illness. Food security, more generally, appears to play an important role in some studies, with a recognition of the connection

[1] BMI is calculated as a person's weight in kilograms (kg) divided by his or her height in meters squared.

between BMI and income and relative prices (Chou *et al.* 2004, Drewnowski and Specter 2004 and Drewnowski and Darmon 2005). The diversity of influences suggests that the analysis of long-term change in BMI is going to be complex. The first step, inevitably, is to acquire some clarity about the changing average level of BMI and the long-term experience of age groups for more countries.

In this paper we identify the long run pattern of BMI changes in three food abundant settler societies subject to broadly similar historical forces: Australia, Canada and New Zealand. In this initial research, the causal effects of these long term and *structural factors* for BMI is not explicitly tested, but it does motivate interest in examining BMIs before these changes, i.e. prior to the 1950s. We extend combine and in some cases link a combination of data sources to produce a rich time series. The combination of historical and modern health survey data provides an unprecedented source of long-term data for these three countries of interest and acts as a significant base to compare with the results for the US and UK.

2.0 Previous Research

The BMI-related anthropometric literature has generally followed two streams examining (i) the evolution of and differences in BMI within a given population and (ii) BMI as a covariate to explain particular economic or economics outcomes including employment, wealth or earnings. Most relevant to this paper are the efforts to document and explain long-term change (James *et al.* 2001 and Cole 2003). BMI and rates of obesity/overweight have risen in many regions (Zellner *et al.* 1996, Floud 1998 and Zellner *et al.* 2004). Most reseach examines the final decades of the 20th Century (Gyenis and Joubert 2004, Helmchen and Henderson 2004, Komlos and Baur 2004, Zagorsky 2005 and Ruhm 2007) although some evidence of rising BMI in earlier decades is becoming available (Carson 2007 and Whitehall and Nicholas 2001).

Also relevant is the evidence of systematic differences within populations, for example, by gender (Tremblay *et al.* 2002, Cutler *et al.* 2003, Kimhi 2003, Chou *et al.* 2004, Gyenis and Joubert 2004, Rashad *et al.* 2006, Belanger-Ducharme and Tremblay 2005, Borghans and Golsteyn 2006, Flegal 2006, Heineck 2006, Kaushal 2007 and Ver Ploeg *et al.* 2007). Gender based differences can mask important ethnic effects; several studies report lower BMI for African-American males than females and higher BMI measures for white and Mexican-American men (Komlos and Baur 2004, Mujahid *et al.* 2005 and Phuong Do *et al.* 2007). There is some evidence of a gender 'catch-up', as female BMI increases at a faster pace than male BMI (Borghans and Golsteyn 2006).

Differences in BMI by race are considered (Chou *et al.* 2006, Rashad 2006, Rashad *et al.* 2006 and Phuong Do *et al.* 2007). Some investigators parse their data by race and examine them separately (Komlos and Baur 2004, Mujahid *et al.* 2005, Rashad 2006 and Ver

Ploeg *et al.* 2007). Previous analysis with Canadian data shows off-reserve aboriginals and whites having higher BMI scores than other race groups (Belanger-Ducharme and Tremblay 2005 and Tremblay *et al.* 2005).

Changes in BMI across age groups have also received considerable attention. Many studies have focused on the young because of rising obesity in children (Tremblay and Willms 2000, 2003, Willms *et al.* 2003, Zellner *et al.* 1996, 2004 and Phipps *et al.* 2006). Some studies specify some polynomial of age as a covariate in BMI regression models (Chou *et al.* 2004, Costa-Font and Gil 2005, Rashad 2006 and Rashad *et al.* 2006, Carson 2007, Huffman and Rizov 2007, Phuong Do *et al.* 2007 and Ver Ploeg *et al.* 2007), while others specify age-group effects as categorical variables (Kimhi 2003 and Komlos and Baur 2004) or parse their data into finer age-based sub-sets (Cutler *et al.* 2003 and Kaushal 2007). The empirical evidence generally suggests an inverse-quadratic relationship between BMI and age.

Economic inequality is also often cited as a factor explaining the distribution of obesity (Vigerova *et al.* 2004, Drewnowski and Specter 2004, Godoy *et al.* 2005 and Drewnowski and Darmon 2005). BMI (or obesity) has been reported to have a quadratic (Chou *et al.* 2004, Costa-Font and Gil 2005, Rashad 2006 and Rashad *et al.* 2006) or inverse (Heineck 2006 and Ver Ploeg 2007) relationship with income or education (Cutler *et al.* 2003, Chou *et al.* 2004, Rashad *et al.* 2006 and Kaushal 2007), while other results are more mixed (Komlos and Baur 2004, Heineck 2006, Rashad 2006, Huffman and Rizov 2007 and Phuong Do *et al.* 2007). Occupation and social status have been included to control for inequality (Komlos and Kriwy 2002, Heineck 2006 and Carson 2007). Food security appears to play a role as well, with some recognizing the connection between BMI and income and relative prices (Chou *et al.* 2004, Drewnowski and Specter 2004 and Drewnowski and Darmon 2005).

A smaller literature examines trends and differences in BMI while taking account of behavioural aspects. There is some evidence of an inverse relationship between intensity of physical activity and BMI (Costa-Font and Gil 2005 and Tremblay *et al.* 2005). Consumption behaviour also contributes to observed patterns of BMI. We might expect to see a positive relationship between BMI, caloric intake and foods with particular characteristics since BMI increases if the energy balance equation is positive. Huffman and Rizov (2007) report a positive relationship between BMI and (i) calories consumed and (ii) percent of calories from fat and protein. Some evidence links time discounting with BMI (Komlos *et al.* 2004, Smith *et al.* 2005 and Borghans and Golsteyn 2006). Smoking has been reported to have a negative relationship with BMI (Kahn *et al.* 1997, Costa-Font and Gil 2005, Rashad 2006 and Huffman and Rizov 2007), a result attributed to increased metabolism and suppression of appetite amongst smokers (Huffman and Rizov 2007). The relationship between alcohol consumption and BMI is less clear (Costa-Font and Gil 2005, Prentice 1995 and Kahn *et al.* 1997).

The existence of so many influences on BMI implies that the analysis of long-term change is going to be rather complex. Nevertheless, a first step is to acquire some clarity about the changing average level of BMI and the long-term experience of groups with particular characteristics.

3.0 Data Sources

The sources used in this paper are reported in some detail in the *Data Appendix* below. By way of an overview, however, we utilize World War One records for all three countries (Cranfield and Inwood 2005, 2015, Cranfield, Inwood and Ross 2015 and Inwood, Oxley and Roberts 2010), World War Two records for Canada and New Zealand and a series of New Zealand prison records 1840-1975 (Inwood, Oxley and Roberts 2015). More recent cohorts are described by a number of nationally representative surveys of Canadians undertaken by Statistics Canada, the Australian 1977, 1983, 1989, 1995, 2001, 2004 and 2008 National Health Surveys and New Zealand Ministry of Health anonymized health survey data (CURFs) 1997, 1989, 1997, 2003, 2007, 2009 and 2011.

4.0 Long Run Trends

The main focus of the paper is on *comparisons of long-term trends* in the BMI of males and females in particular age groups (here we concentrate on those 20-49 years old) *in Australia, Canada and New Zealand*. We review briefly the long term trends in each country separately in order to motivate the subsequent comparisons, sections 4.1 to 4.3.

4.1 Australia

Table A1.0 presents some summary measures from the Australian data (see *Data Appendix* for details). Some points to identify here are, the increase in BMI for males (3.81) from WWI to 2008M (both are based upon independently measured BMI) and the relative flatness of the increase from 1995-2008M for females.

Table A1.0: BMI of Adults (20-49 Years of Age) in Australia

	Males			Females		
	N	BMI	Δ(1995=0)	N	BMI	Δ(1995=0)
World War I	22,078	23.03	-2.74	-	-	-
1995	4,404	25.77	0	4,529	25.19	0
2001	1,721	26.32	0.55	2,147	25.90	0.71
2005	4,650	26.64	0.87	5,003	24.96	-0.23
2008	2,622	26.47	0.7	2,638	25.21	0.02
2008M	2,622	26.84	1.07	2,638	25.81	0.62

M refers to 'measured' BMI.
N refers to 'number of observations'.

4.2 Canada

Table C1.0 presents some summary statistics of the Canadian data. Some points to note here are; the increase in BMI for males 4.7 from WWI to 2005 and the increase of 2.37 from 1953-2005 for females. Furthermore, not the apparent slight fall in BMI for males WWI-WWII.

Table C1.0: BMI of Adults (20-49 Years of Age) in Canada

	Males			Females		
	N	BMI	Δ(1996=0)	N	BMI	Δ(1996=0)
World War I	38,576	22.57	-3.98	-	-	-
World War II	10,286	22.21	-4.34	-	-	-
1953	~22,000	24.89	-1.66	~22,000	23.72	-1.3
1978	1,094	25.32	-1.23	1,359	24.19	-0.83
1985	2,654	25.38	-1.17	3,054	23.92	-1.1
1996	14,899	26.55	0	14,993	25.02	0
2005	18,276	27.27	0.72	19,039	26.09	1.07

4.3 New Zealand

Table NZ1.0 presents some summary measures for the New Zealand data. Some points to note here are, the increase in BMI for males of 5.16 from WWI to 2011 (with an increase between the Wars of 0.34) and the increase of 3.57 from 1977-2011 for females. Furthermore, the increase for females is much steeper than for males, and to now effectively represent parity between the sexes, on average, in the 20-49 year age range.

Table NZ 1.0: BMI of Adults (20-49 Years of Age) in New Zealand

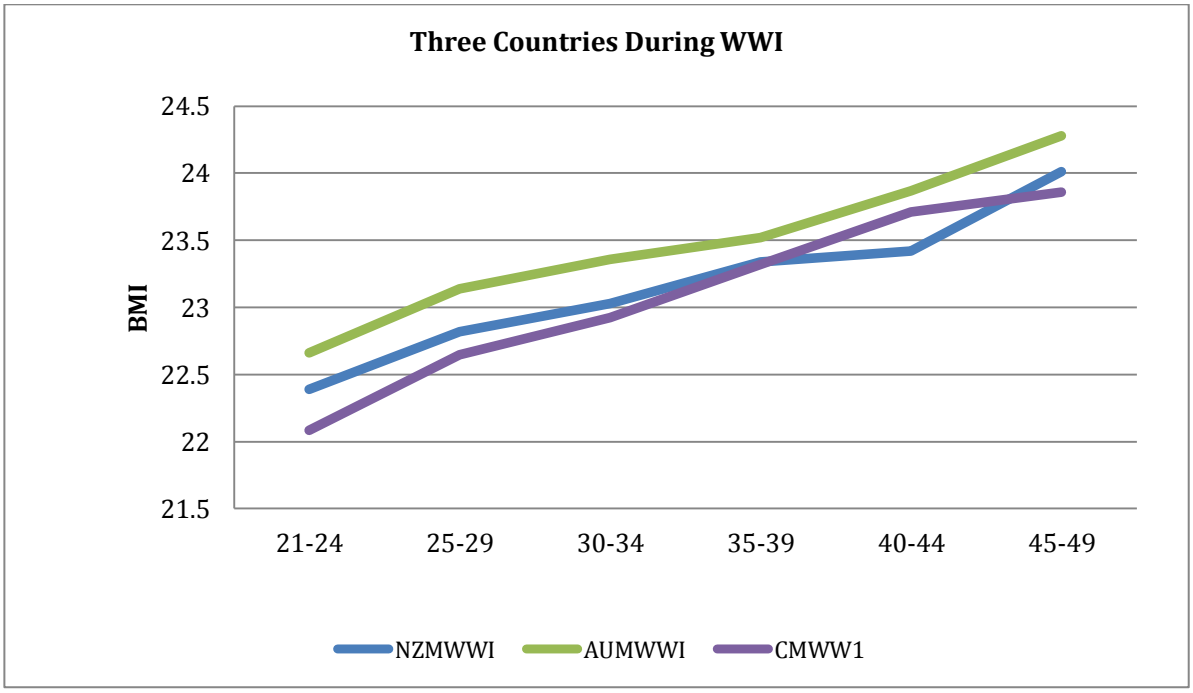
	Males			Females		
	N	BMI	Δ(1997=0)	N	BMI	Δ(1997=0)
World War I	14,349	22.69	-3.41	-	-	-
World War II	10,245	23.03	-3.07	-	-	-
1977	704	25.34	-0.76	742	24.14	-1.84
1989C	1,617	25.44	-0.66	1,797	23.90	-2.08
1997	1,016	26.10	0	1,459	25.98	0
2003	2,404	26.85	0.75	3,897	26.19	0.21
2008	828	27.56	1.46	1,011	27.58	1.6
2011	2,138	27.85	1.75	3,032	27.71	1.73

5.0 The Three Countries Compared

5.1 WWI and WWII: Males Only

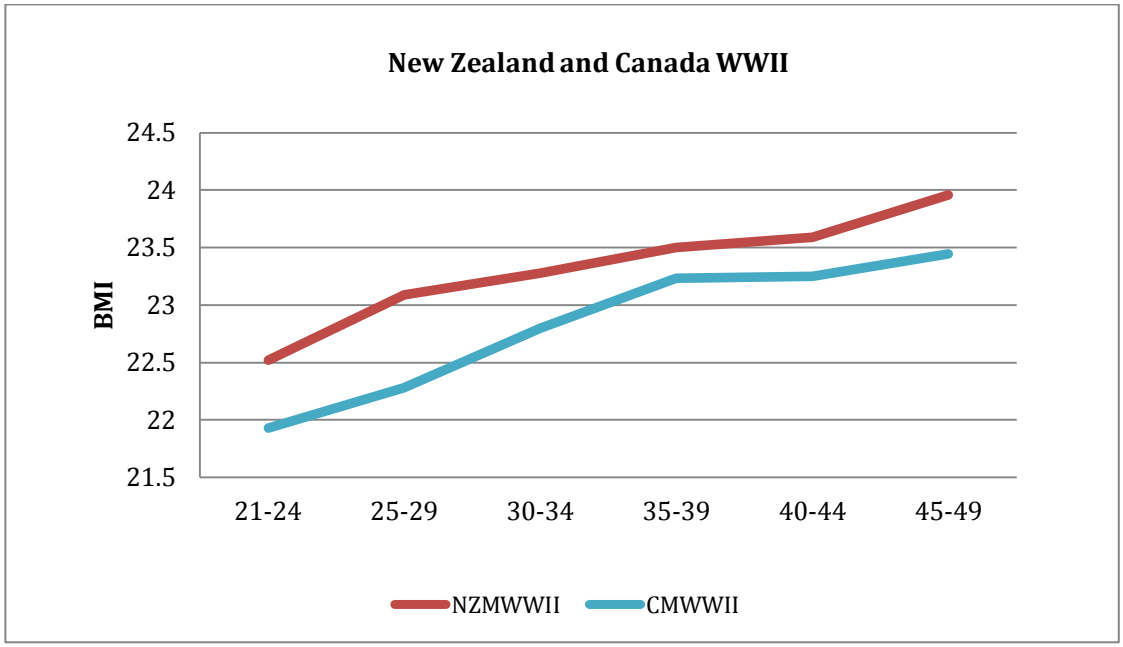
The World War samples are restricted to males on the basis of available sample sizes, and set an opening benchmark for the long term three country comparisons. For WWI we can see (Figure 1) that across all the age groups considered, Australian men have the highest BMI, with New Zealand and Canadian men showing a similar (but lower) upward trend in BMI with age (over this range).

Figure 1: BMI (Males) Australia (AU); Canada (C) and New Zealand (NZ)



For the WWII samples, we have access only to the New Zealand and Canadian attestation data (Figure 2). The point to note here is the uniform gap that has emerged (across all age groups) between New Zealand and Canada and from Table C1.0 above we know there is an absolute decline in BMI in the case of Canada between the wars. Although not pursued further here, this may well reflect the differing economic growth experiences of the two countries with New Zealand experiencing rapid and sustained growth during the mid-1930s (see Greasley and Oxley 2002 whereas Canada's closer proximity to the US and the effects of the Great Depression, may be forces at work here.

Figure 2. BMI (Males) Canada (C) and New Zealand (NZ)



5.2 Modern Periods

Using data from the relevant modern health (and related) surveys (see *Data Appendix for details*), first consider the 1990s. For males (in all three countries) BMI continues to grow, but comparatively, Canada and New Zealand are ahead of Australia, consistently for age groups >30, see Figure 3.1. For females in the 1990s, there is a different pattern, see Figure 3.2. New Zealand women have a higher BMI for all age groups than Canada and Australia, although Canadian women appear to have a slightly higher BMI than in Australia (again for all age groups).

For the 2000s males, there seems to be a sharp increase in BMI in all three countries as age increases (to the mid 30s) and for the older men in this sample, where New Zealanders have a higher BMI (a full BMI point for the 35-39 age group NZ-Australia), see Figure 3.3. These comparative results reflect the convergence of BMI across the sexes in New Zealand and the smaller increase in BMI in Australia. New Zealand women (see Figure 3.4) appear to have a much higher BMI than either Canadian or Australian counterparts across all age groups. This significant result merits further investigation, in particular the effect of ethnic differences (Maori and Pacific Island women have, on average, across all age groups a much higher BMI than the population (weighted) average presented here). Furthermore, the issue of measured versus self-assessed (all NZ samples are based upon independently measured heights and weights), is an issue for further investigation.

Figure 3

Figure 3.1

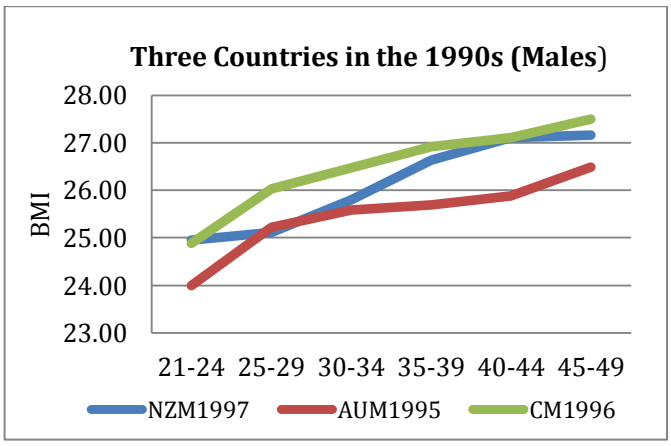


Figure 3.2

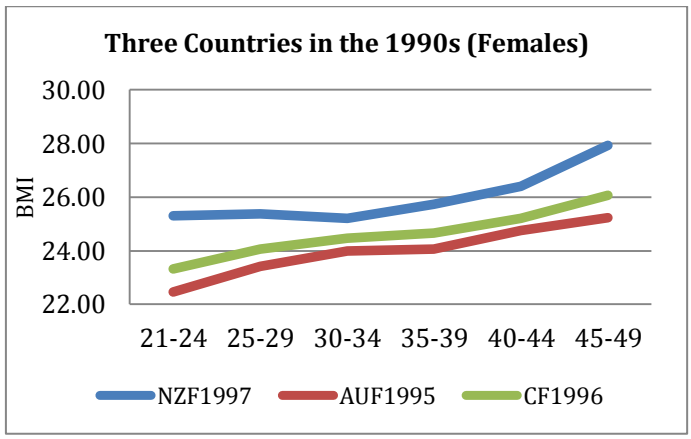


Figure 3.3

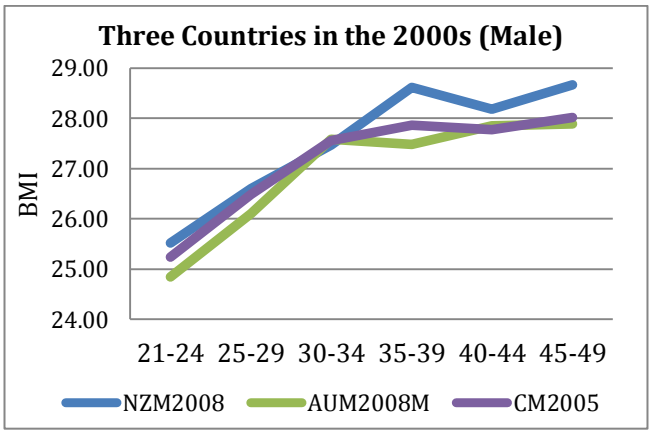
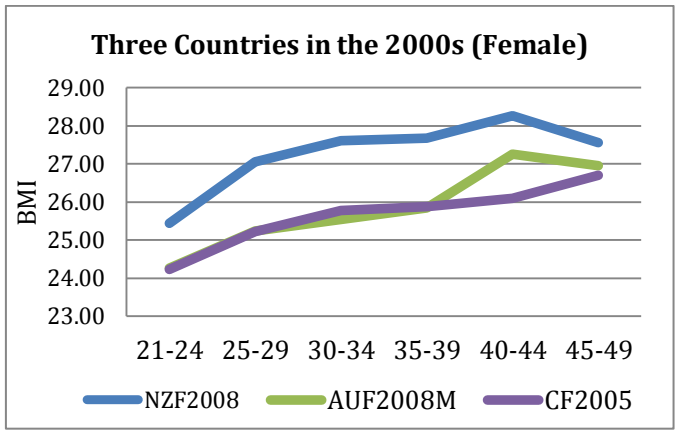


Figure 3.2

Figure 3.4



5.3 Long Term Trends

Figures 4 and 5 below describe the long term trends, absolute and relative changes of BMI in males and females in the 20 to 49 years age group in Australia, Canada and New Zealand. Perhaps the first thing to note is the general concordance in the trend BMI growth of males for these three, ex-Dominion, food abundant countries. Although we have no data relating to Australia during WWII (and Canadian but not New Zealand BMI appears to have fallen between the wars), we see a similar pattern emerging with relatively rapid increases in BMI in the late 20th century, with Australia perhaps peeking earlier (and lower) than in New Zealand.

The question of when BMI first began to increase has different answers for the three countries. A 1953 height-weight survey uniquely available for Canada makes clear that male BMI by that point was already increasing. The points at which we confirm the beginning of increase for New Zealand and Australia are 1978 and 1995. This is driven by the availability of data. It is entirely possible, and indeed the broad similarity of male BMI in the three countries, that we would see an earlier onset to BMI increase in New Zealand and Australia if appropriate data were available.

Figure 4.

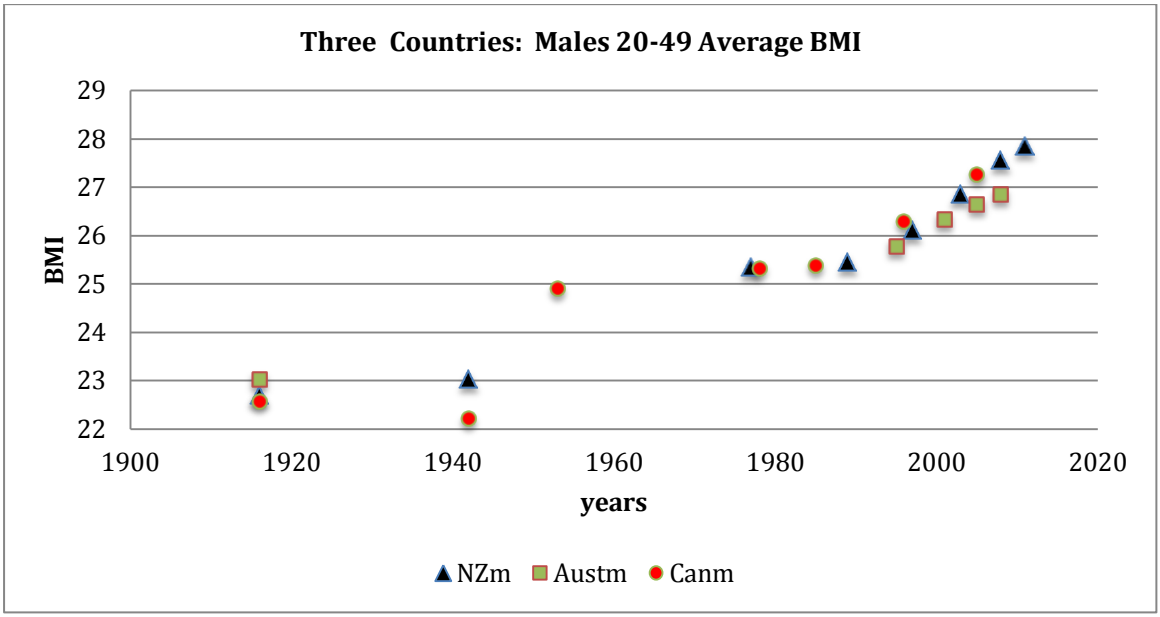
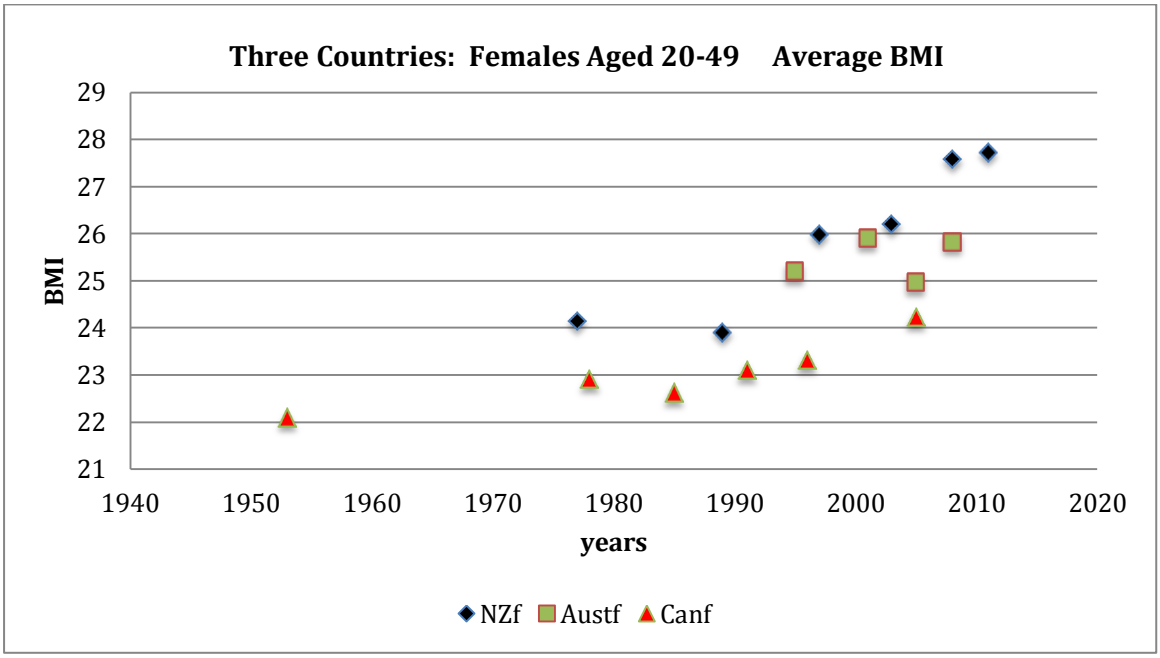


Figure 5.



The story for females, however, is different and more complicated. As we lack sufficient data to track women's BMI from the early 20th century, we are constrained to consider mid-late 20th century trends. There seems to be much less of a tendency for women's BMI in the three countries to converge – if anything quite the opposite. Figure 5 shows that for most of the sample, New Zealand female BMI was highest and Australian the lowest (with Canada consistently between the two. However, the size of the gap between Australian and New Zealand women's BMI appears (not yet) to have stabilized.

There may be some measurement difference between countries, or ethnic composition may differ, however, the former is unlikely to change over time and the latter would change slowly if at all. Further work on women's BMI is needed and may offer more unexpected perspectives.

7.0 Conclusions

The aim of this research is to understand better the long-run trend in BMI of the populations of Australia, Canada and New Zealand using data drawn from both the two World Wars (male soldiers), other sources where available and a range of modern health surveys. Two within country patterns of gender difference emerge: in Canada and Australia the gap between males (leading) and female BMIs remains large with some increases in the gap in the 35-39 year age group, but narrowing in the 45-49 range especially in Australia. In contrast, the BMI of both sexes has effectively converged for most age ranges (although it has been similar for the 45-49 age range since 1977. In New Zealand women exceeded the BMI of same aged females in Australia and Canada from the 1980s. The data further suggest that New Zealand female BMI has continued to grow while that of Australia may be leveling off. Male BMI followed a remarkably similar trajectory in the three countries although the absolute differences between leading BMI countries has changed over time culminating in New Zealand being the 'top ranked' obese country for males in the 20-49 age group.

Canadian BMI appears to have begun its secular increase earlier than might be expected considering the hypotheses that are typically used to explain rising obesity in the second half of the 20th century. Whether or not this is true also for New Zealand and Australia awaits further research.

8.0 Future Research

The results to date may raise more questions than answers. We have uncovered trends and patterns of male-female BMI convergence (or otherwise) that differ between countries. The effects of self-assessed versus independently measured BMI measures clearly warrants attention before any radical conclusions are drawn on cross-country comparisons. A hunt for additional mid-20th century sources in New Zealand and Australia would be useful. The drivers of differences (and similarities) between country, gender and cohort remain to be uncovered. They are likely to include ethnic differences (across and within countries), changing occupational mixes (gender-specific) and potentially differences in economic (eg food prices) and social (for example, urban-rural mix) influences.

The hunt continues!

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Appendix A (Australia)

Table A1: BMI of Adult Males in Australia by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
World War I	22.66	23.14	23.36	23.52	23.87	24.28
1989	23.59	24.48	24.80	25.27	25.66	25.84
1995	23.99	25.22	25.59	25.69	25.88	26.49
2001	24.71	25.32	26.14	26.70	26.59	26.91
2005[1]	24.48[1]	26.07	26.87	27.53	27.53	27.59
2008[1]	24.57[1]	25.79	27.05	27.03	27.50	27.53
2008M[1]	24.85[1]	26.11	27.58	27.48	27.86	27.89

M=measured. [1] 18-24

Table A2: BMI of Adult Females in Australia by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
1989	22.11	22.85	23.11	23.68	24.15	24.71
1995	22.45	23.41	23.98	24.06	24.75	25.24
2001	23.17	23.82	24.93	24.75	25.34	26.06
2005	23.31[1]	24.13	25.36	25.18	25.50	26.06
2008	23.76[1]	24.62	25.01	25.20	26.68	26.22
2008M	24.26[1]	25.24	25.53	25.85	27.26	26.95

M=measured. [1] 18-24

Appendix C (Canada)

Table C1: BMI of Adult Males in Canada by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
WW1	22.08	22.65	22.92	23.32	23.71	23.86
WW2	21.93	22.28	22.80	23.23	23.25	23.45
1953 CWHS	23.49	24.12	25.38	25.76	25.77	25.77
1978 CHS	24.30	24.83	25.46	25.97	25.95	26.31
1985 GSS	24.05	24.89	25.32	26.04	26.08	26.71
1991 GSS	24.74	25.63	26.18	26.71	26.91	27.41
1996 NHPS	24.89	26.03	26.47	26.92	27.11	27.50
2005 CCHS	25.24	26.49	27.56	27.86	27.78	28.02

Table C2: BMI of Adult Females in Canada by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
1953 CWHS	22.09	22.54	23.19	24.36		
1978 CHS	22.91	23.32	23.59	25.00	25.48	26.02
1985 GSS	22.62	23.08	23.48	24.08	24.39	24.68
1991 GSS	23.10	23.63	23.97	24.31	24.90	25.33
1996 NHPS	23.32	24.07	24.46	24.65	25.21	26.06
2005 CCHS	24.22	25.22	25.77	25.87	26.09	26.70

Appendix NZ (New Zealand)

Table NZ1: BMI of Adult Males in New Zealand by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
WW1	22.39	22.82	23.03	23.34	23.42	24.01
WW2	22.52	23.09	23.28	23.5	23.59	23.96
1977	24.24	24.73	25.25	25.89	26.06	25.91
1989C	23.92	25.15	25.35	25.43	25.96	26.34
1997	24.95	25.12	25.80	26.64	27.10	27.15
2008	25.53	26.61	27.47	28.62	28.18	28.66
2011	26.74	26.83	27.67	26.17	29.18	28.24

Table NZ2: BMI of Adult Females in New Zealand by Age Group

	20-24	25-29	30-34	35-39	40-44	45-49
1977	23.27	23.54	23.65	24.32	24.95	26.13
1989C	23.00	23.26	23.59	23.72	24.55	25.03
1997	25.31	25.37	25.22	25.74	26.39	27.94
2008	25.44	27.06	27.61	27.67	28.26	27.57
2011	27.39	27.32	27.80	26.14	27.61	28.12

Data Appendix

New Zealand Data Sources

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S) BMI	Sponsoring Organization and Documentation
PRISONS	83,637 males aged between 21-49 admitted from 1875-1975	**Not weighted**	**Measured weight and height**	NZ Prison Records. See Inwood, Oxley & Roberts (2015)
WW1	14,349 males aged between 20-49	**Weighted by 1911 Census**	**Measured height and weight**	Attestation records of the New Zealand military, see Inwood, Oxley & Roberts (2010)
WW2	10,245 males aged between 20-49	**Weighted by 1936 Census**	**Measured height and weight**	Attestation records of the New Zealand military
1977	1977 **National Diet Survey** based on the 1976 Adult Oral Health sampling units; urban >2000 population, rural otherwise. Sex ratio of total sample (m/f)-0.87; study sample (m/f) 858/1080=0.79. 1976 Census had ratio of 1.0, so excess of women in total sample. ranges. **Usable data: 990 female; 707 male (1776).**	**Not population weighted**; Maori sample under-represented.	**Measured height and weight** Respondent placed against a vertical surface and measured to nearest millimeter with portable measure. Spring weight measures. Light clothing, no shoes nearest 0.1kg. Trained examiners used	National Heart Foundation of New Zealand: National Diet Survey 1977. John A Birkbeck. *New Zealanders and their diet: A report on the National Heart Foundation of New Zealand on the national diet survey,* 1977.

New Zealand Data Sources *continued*

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S) BMI	Sponsoring Organization and Documentation
1989/90	**3107 male; 3719 women** 21 years and older **(6826) usable records** (334 <21). Majority of respondents selected from the 1988 general electoral rolls.	**Not weighted**	**Self reported height and weight.** Results created with and without suggested correction to height.	University of Otago, for the Hillary Commission Recreation and Sport; Department of Health. National Nutrition Survey of New Zealand linked to National Health Survey. *Life in New Zealand (**LINZ**) Survey* Life in New Zealand Survey: Executive overview (Russell and Wilson 1991)
1996/97	**4635** adults (including **704** Maori) aged 15 and over interviewed. 15 ethnic groups. **Usable records: 1853 male; 2514 female (4367)**	**Population weighted** Oversampling of Maori and Pacific Islanders, but weights derived from 1991 Census and used in analysis.	**Measured. Height and weight**. Height without shoes using a portable stadiometer. Two measures to nearest 0.1cm and mean used. Weight: Seca digital platform scales (Model 770).	National Nutrition Survey (NNS). *Food comes first: Methodologies for the National Nutrition Survey of New Zealand*. Quigley, R., and Watts, C. (1997). *NZ Food: NZ People* *http://www.moh.govt.nz/notebook/nbbooks.nsf/8b635a98811e8aed85256ca8006d4e51/62c5d9d4c418c4e74c2567d9007186c2/$FILE/nns.pdf*
2002/03	**12,929** respondents (including **4369** Maori) aged 15 and over. **Usable records: 4594 male; 6729 female; (11,323).**	**Weighted** Based on Census 2001 and includes explicit adjustment for non-responses.	**Measured.** Height without shoes using a portable stadiometer. Two measures to nearest 0.1cm and mean used. Weight: Seca digital platform scales (Model 770)	NZ Health Survey. Ministry of Health. *A portrait of health: Key results of the 2002/03 New Zealand Health Survey.* http://www.moh.govt.nz/notebook/nbbooks.nsf/0/1A291BC68D950D60CC25770D007208AE/$file/aportraitofhealth.pdf

New Zealand Data Sources *continued*

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S) BMI	Sponsoring Organization and Documentation
2006/07	**12,488** adults aged 15 years and over surveyed. Actual age and 17 age categories, adults 15 years and over. 5 ethnic groups. **5,121** males. **6,545** females (**11,666 usable records**). 4 ethnic groups (other included with European)	Used '**calibrated weighting'** (Deville and Sarndal 1992) based upon population counts from the 2006 Census, broken down by age, gender, DHB area and ethnic group.	**Measured** by interviewer using professional weighing scales (Tanita HD-351), a portable stadiometer (Seca 214), and a standard anthropometric measure tape (Lufkin W606PM).	NZ Health Survey. Ministry of Health. *A portrait of health: Key results of the 2006/07 New Zealand Health Survey.* http://www.health.govt.nz/publication/portrait-health-key-results-2006-07-new-zealand-health-survey
2008/09	**4721** adults 15 years and older. Usable sample**: 2003** males ; **2500** females; (**4503)**	Used '**calibrated weighting'** (Deville and Sarndal 1992. Weights based on resident population 30 June 2007.	**Measured** using professional weighing scales (Tanita HD-351), a portable stadiometer (Seca 214), and a standard anthropometric measure tape (Lufkin W606PM).	NZ Adult Nutrition Survey. Ministry of Health. *A focus on nutrition: Key findings from the 2008/09 NZ adult nutrition survey.* http://www.health.govt.nz/system/files/documents/publications/a-focus-on-nutrition-v2.pdf
2011/12	**12,370** adults aged 15 years and over**. 10,691** useable records; **4581** male; **6110** female.	**Weighted.** For measurement data (heights, weights and body mass index), survey weights were recalculated to account for item non-response, so that the estimates still represent the total resident adult population.	**Measured** using professional weighing scales (Tanita HD-351), a portable stadiometer (Seca 214), and a standard anthropometric measure tape (Lufkin W606PM).	New Zealand Health Survey. Ministry of Health. *Annual update of key findings 2012/13.* http://www.health.govt.nz/publication/health-new-zealand-adults-2011-12

Australian Data Sources

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S) BMI	Sponsoring Organization and Documentation
WW1	22,078 males aged between 20-49		**Measured height and weight**	Attestation records of the Australian military see Cranfield & Inwood (2015).
1989/90	Age in 5-year bands; truncate at 20-24. **18,187** (female); **17,707** (male) usable records.	Population **weighted**	**Self reported height and weight** (recorded at interview)	1989-90 National Health Survey: *Lifestyle and Health, 1989-90.* Conducted by the ABS (Australian Bureau of Statistics) http://www.ausstats.abs.gov.au/ausstats/free.nsf/0/D17F9B5EDB4DFC26CA257225000495E0/$File/43660_8990.pdf
1995	Age in 5-year bands; truncate at 20-24. **17,173** (female); **17,005** (male) usable records.	Population **weighted**	**Self reported height and weight** (recorded at interview)	National Health Survey (formerly Australian Health Survey) 1995. Conducted by the ABS (Australian Bureau of Statistics) http://www.ausstats.abs.gov.au/ausstats/free.nsf/0/C32B970BCC3E56E0CA257225000495DE/$File/43640_1995.pdf
2001	Age in 5-year bands; truncate at 20-24. **9,124** (female); **8,177** (male) usable records.	Population **weighted**	**Self reported height and weight** (recorded at interview)	National Health Survey 2001. Conducted by the ABS (Australian Bureau of Statistics) http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/90A3222FAD5E3563CA256C5D0001FD9D/$File/43640_2001.pdf

Australian Data Sources *continued*

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S) BMI	Sponsoring Organization and Documentation
2004/05	Age in 5-year bands; truncate at 20-24. **9,074**(female); **8,132** (male) usable records.	Population **weighted**	**Self reported height and weight** (recorded at interview)	National Health Survey 2004/05. Conducted by the ABS (Australian Bureau of Statistics) http://www.ausstats.abs.gov.au/Ausstats/Subscriber.Nsf/0/3b1917236618a042ca25711f00185526/$File/43640_2004-05.pdf
2007/08	Age in 5-year bands; truncate at 20-24. **4,690**(female); **4673** (male) usable records.	Population **weighted**	**Self reported and measured height and weight.** All physical measurements were voluntary, and women who had identified they were pregnant were not measured. Interviewers used digital scales to measure weight (maximum 150kg), a stadiometer to measure height (maximum 210cm), and a metal tape measure (which avoided the risk of the tape stretching) to measure waist circumference.	2007/08 National Health Survey: Users Guide. http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/CC0FB5A08570984ECA25762E0017CF2B/$File/4363055001_2007-08.pdf

Canadian Data Sources

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S)	Sponsoring Organization and Documentation
SA	**2,088** males (ages 20-40)	**Not weighted**	**Measured** height and weight	Attestation records for the Canadian military
WW1	**38,576** males (ages 20-49)	**Not weighted**	**Measured** height and weight	WW1 Attestation records of the Canadian military: heights (Cranfield and Inwood, 2007) supplemented by hard-copy of a subsample to include weight.
WW2	**10,286 males** (ages 20-49)	**Not weighted**	**Measured** height and weight	Obtained from a sample of military records of Canadian servicemen killed in action during the Second World War (WW2) whose surnames began with the letters B, F, S, or M.
1953 Canadian Weight-Height Survey	≈ **22,000** males (ages 20-49); ≈ **22,000** females (ages 20-49);	**Not weighted**	**Measured** height, weight and skinfold (by nurses): weight to nearest ½ pound and height nearest ¼ inch.	Statistics Canada, as published in *The Report on Canadian Average Weights, Heights and Skinfolds*, Canadian Bulletin on Nutrition Vol. 5, No.1 September 1957. See also Pett, L. and G. Ogilvie. 1958. The Canadian weight-height study. Human Biology 25, 177-188. Primary data is not available, so BMI is approximated as ratio of mean weight (in kg) to mean height squared (in cm) for corresponding gender-age cohorts.
1985 General Social Survey (GSS)	15-69 year olds. **2,293** males; (ages 20-49); **2,641** females (ages 20-49);	**Not weighted**	**Self reported** height and weight (recorded at interview)	Statistics Canada http://www.statcan.gc.ca/pub/89f0115x/89f0115x2013001-eng.pdf has details on the GSS, including discussion of topics included in different versions of the GSS

Canadian Data Sources *continued*

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S)	Sponsoring Organization and Documentation
1996 National Population Health Survey (NPHS)	**19,534** males; (ages 20-49); **20,006** females (ages 20-49);	**Not weighted**	**Self reported** height and weight (recorded at interview)	Statistics Canada http://publications.gc.ca/Collection-R/Statcan/82-567-XIB/0009882-567-XIE.pdf Sample frame included residents of Canadian households., excluding thought on First Nations Reserves and Crown Lands, those residing in health institutions, full-time members of the Canadian Forces Bases and some remote areas in Ontario and Quebec.
2001 Canadian Community Health Survey (CCHS)	**33,714** males; (ages 20-49); **37,935** females (ages 20-49);	**Not weighted**	**Self reported** height and weight (recorded at interview)	Canadian Community Health Survey Cycle 1.1 Statistics Canada http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=3359 A cross-section design survey. Sample drawn from Canadian population over 12 years of age, but excludes those on First Nations reserves/settlements, full-time members on the Canadian Forces bases, and those in residing in an institutional setting (e.g. long-term care facility). The CCHS data reflects in-depth interviews with one randomly selected subject per interviewed household (households are randomly selected).

Canadian Data Sources *continued*

	Sample Size and Composition	Weighting	Measured (M) or Self-Reported (S)	Sponsoring Organization and Documentation
2003 Canadian Community Health Survey (CCHS)	**21,839** males; (ages 20-49); **23,451** females (ages 20-49);	**Not weighted**	**Self reported** height and weight (recorded at interview)	Canadian Community Health Survey Cycle 2.1 Statistics Canada http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=4995 A cross-section design survey. Sample drawn from Canadian population over 12 years of age, but excludes those on First Nations reserves/settlements, full-time members on the Canadian Forces bases, and those in residing in an institutional setting (e.g. long-term care facility). The CCHS data reflects in-depth interviews with one randomly selected subject per interviewed household (households are randomly selected) Canadian Community Health Survey Cycle 3.1 Statistics Canada http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=22642
2005 Canadian Community Health Survey (CCHS)	**27,366** males; (ages 20-49); **29,472** females (ages 20-49);	**Not weighted**	**Self reported** height and weight (recorded at interview) A sub-sample of respondents also had their height and weight **measured** by a trained enumerator using calibrated measuring devices.	A cross-section design survey. Sample drawn from Canadian population over 12 years of age, but excludes those on First Nations reserves/settlements, full-time members on the Canadian Forces bases, and those in residing in an institutional setting (e.g. long-term care facility). The CCHS data reflects in-depth interviews with one randomly selected subject per interviewed household (households are randomly selected)