Long run changes in the body mass index of adults in Canada *

John Cranfield
Professor
Department of Food, Agricultural
& Resource Economics
University of Guelph
Guelph, ON N1G 2W1
jcranfie@uoguelph.ca

Kris Inwood
Professor
Department of Economics &
Department of History
University of Guelph
Guelph, ON N1G 2W1
kinwood@uoguelph.ca

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Abstract

We use data from South African War and World War I attestation papers, and population health surveys to explore the long-run trend in the body mass index (BMI) of Canadians throughout the 20th Century. Our main focus in this preliminary analysis is documenting whether contemporary changes in BMI are a recent phenomenon or reflect a long-run trend. As well, we explore age and gender based differences in BMI of adults aged 20 to 49 years in Canada. Adult males in Canada have had systematically higher BMI values than females. Moreover, the BMI for adult males experienced larger increases (both in absolute and relative terms) than the BMI for adult females. A changing pattern of gain in BMI across age-group is also present during the 20th Century. This changing pattern is characterized by larger increases in BMI for adult males aged 25 to 39 years of age compared to younger and older male age-groups. For females, the pattern of change is characterized by larger gains in BMI in the 25 to 39 year old age group, while BMI *declines* for females aged 45 to 49 since the 1950s.

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Introduction

Use of anthropometric measures as a gauge of long-run welfare has increased in recent years. In large measure, this anthropometric based literature has focused on analysis of secular trends in heights of a defined population (e.g. those born in a particular country) and also amongst subgroups of a population. The use of stature has advantages over other economic measures of welfare/well-being. Stature is an encompassing measure reflecting the impact of both economic and non-economic factors. As such, stature reflects both the economic status of a population, and broader issues such as population health, exposure to chronic disease, availability of food and adequate nutrition. The encompassing nature of stature frees the economist from only using aggregate monetary measures of economic welfare. However, other anthropometric measures are available.

Body mass index (BMI) is one such measure. Since BMI is a two dimensional anthropometric measure (i.e. weight in kilograms divided by height in metres squared), its use offers a somewhat deeper glimpse into overall well-being. Indeed, a growing number of anthropometric analyses have explored changes in BMI in developed (Katzmarzyk 2002a,b; Tremblay et al 2002; Cutler et al. 2003; Helmchen and Henderson 2004; Komlos and Baur 2004; Mujahid et al. 2005; Sunder 2005; Contoyannis and Wildman 2007; Phuong Do et al 2007), transitioning (Koziel et al. 2004; Huffman and Rizov 2007; Knai et al 2007) and developing countries (Cameron 2003; Dinda et al. 2006). However, most of the anthropometric analysis using BMI has focused on contemporary changes or changes in BMI in the 19th century (e.g. Cuff 1993; Carson 2007). And while the rising tide of overweight and obesity is a significant public health concern in contemporary times, it is also true that understanding the long-run trends in BMI complements existing knowledge related to stature.

Moreover, while it is true that many developed countries have experienced considerable economic growth, contemporary increases in BMI and rising rates of overweight/obese are

not necessarily consistent with the notion of rising welfare. In this respect, a bit of a puzzle exists: generally rising rates of stature point to enhanced long-run well-being, while rising rates of obesity and overweight point to potential reductions in long-run well-being. While some research has been undertaken to juxtapose heights, weights and BMI (e.g. Costa 1993; Komlos and Baur 2004) significant research gaps remain.

This is particularly true in Canada where health professionals have raised alarm over rapidly rising rates of obesity and overweight (Katzmarzyk 2002a; Tremblay et al. 2002; Belanger-Ducharme and Tremblay 2005; Katzmarzyk and Mason 2006). While a considerable body of research has been undertaken to explore contemporary changes in the BMI of Canadians (Contoyannis and Wildman 2007; Cranfield 2008), little systematic analysis has been undertaken to explore the historic, long-run trend in BMI in Canada. Indeed, Katzmarzyk (2002b) provides analysis one of the few, if only, historical studies of weight and BMI of Canadians. He notes that between 1953 to 1998 weight-for-height increased by 5.1 and 4.9 percent for males and females, respectively, while rates of overweight and obesity increased by 25 and 53 percent, respectively, from 1970/72 to 1998. Moreover, Katzmaryk (2002b) corroborates trends evident in earlier studies of weight-for-height and BMI in Canada (see, e.g. Pett 1955; Pett and Ogilvie 1958; Jetté 1980; Torrance et al. 2002). What is not clear, however, is whether increases in average BMI occurred from the mid-1950s, or whether they reflect a longer-run trend.

Following on the work of Cranfield and Inwood (2007), the aim of this research is to understand better the long-run trend in BMI of the Canadian population, trends in BMI for demographically identifiable sub-groups of the Canadian population (e.g. males versus females), and the relationship between any changes in BMI/obesity and Canada's long-run economic growth. The importance of understanding such phenomena is underscored by the social and economic changes witnessed in Canada's post-World War II economy. Such changes include changing structure of the work force (i.e. women working out of the home,

adoption of labour saving technologies, and a shift from a resource and manufacturing based economy to a more service-oriented economy), and changes in diet in nutrition since the 1950s.

The latter may be particularly relevant given evidence in the United States linking increased calories in snacks to rising rates of obesity. In particular, Cutler et al (2003) note that between 1977-1978 and 1994-1996 calories per meal consumed in the U.S. did not change dramatically. However, their evidence indicates that the average calories consumed from snacking during the day increased 90 and 112 percent for males and females, respectively (Cutler et al. 2003 p.101, Table 2). They further note that the number of snacks per day that has risen, not the caloric content of a snack *per se*. Moreover, Cutler et al. (2003) note that increased rates of obesity are correlated with access to new food technologies and to processed foods. (Cutler et al. 2003, p.94).

Indeed, the rise of the modern food industry in Canada is one possible factor underlying changes in the BMI of Canadians. Specifically, the food processing, distribution and retailing industries began to undergo significant change in the 1950s. Such changes are characterized by changes in the product form (e.g. advent of prepared, ready-to-eat, and ready-to-heat foods and more generally foods which offer enhanced preparatory convenience), adoption of technologies embodying economies of scale which led to more-centralized and consolidated production and processing of food products, development of distribution systems which were national in scope, and the rise of supermarkets and centralized (and larger) retailing outlets. While such changes were evident throughout the 20th Century (Connor et al 1985; Connor and Schiek 1997), these innovations were particularly prominent after the 1940s. The premise that structural changes in the Canadian food industry led to changes in BMI is not explicitly tested in this paper, but it is used to motivate interest in examining BMIs of Canadians prior to the 1950s.

In this respect, the long-run trend in BMI will be identified utilizing both contemporary

and historical sources. Contemporary sources of BMI measures will include a variety of population health surveys undertaken at period intervals within Canada . Historical sources include Attestation papers from the Canadian Expeditionary Forces in World War I and the South African War. Analysis focuses on understanding whether the contemporary (rising) trend in the BMI of Canadians was evident in earlier periods of Canada's history and if not, when and how such trends began to arise. Results from this analysis will be juxtaposed to those for stature with the aim of trying to understand better the evolution in long-run well-being of Canadians.

Previous Research

The BMI-related anthropometric literature has generally followed two streams: studies which seek to understand the evolution of and differences in BMI within a given population; and studies which use BMI as a covariate to explain particular economic or health outcomes.[1] Considerable effort has been undertaken to document and explore changes in BMI both globally and regionally (e.g. James et al. 2001; Cole 2003). A broad conclusion is that throughout the 20th Century BMIs (and rates of obesity/overweight) have risen in some regions of the world (e.g. Zellner et al. 1996; Floud 1998; Zellner et al. 2004). While some evidence points to regional changes in BMIs in the early half of the 20th Century (e.g. Whitehall and Nicholas 2001; Carson 2007), most changes have been noted to have occurred in the last 25 years of the 20th Century (e.g. Gyenis and Joubert 2004; Helmchen and Henderson 2004; Komlos and Baur 2004; Zagorsky 2005; Ruhm 2007).

Important in understanding whether BMI within different populations has changed over-time is the decomposition of any trend in BMI across identifiable socio-demographic and

[1]Examples of the latter include analysis of BMI effects on employment, wealth or earnings (Baum and Ford 2004; Zagorsky 2005; Paraponaris et al. 2005; Dinda et al. 2006; Brunello and DHombres 2007), longevity and mortality risk (Costa 1993; Henderson 2005; Linares and Su 2005; Sunder 2005), birth weights (Voigt et al. 2004; Mironov 2007) and early puberty (Hulanicka et al. 2007).

economic factors. In this respect, gender is often an important dimension, with many studies reporting higher BMI for males than females (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; Ver Ploeg et al. 2007). However, gender based differences can mask ethnic effects. Indeed, several studies report lower BMI for African-American males than females, but higher BMI measures for white and Mexican-American men (Komlos and Baur 2004; Mujahid et al. 2005; Phuong Do et al. 2007). Note too, that some have observed a gender catch-up, with female BMI increasing at a faster pace than male BMI (Borghans and Golsteyn 2006).

Changes in BMI across age-groups has also received considerable attention. Given the sensitivity of children to rising rates of overweight and obesity, many studies have focused only on younger age cohorts (e.g. Tremblay and Willms 2000, 2003; Willms et al. 2003; Zellner et al. 1996, 2004; Phipps et al. 2006). Nevertheless, studies of adult BMI have included a polynomial of age as a covariate in BMI regression models (Chou et al. 2004; Costa-Font and Gil 2005; Rashad 2006; Rashad et al. 2006; Carson 2007; Huffman and Rizov 2007; Phuong Do et al. 2007; Ver Ploeg et al. 2007), while others include age-group effects via categorical dichotomous variables (Kimhi 2003; Komlos and Baur 2004) or parsed their data into finer age-based sub-sets (Cutler et al. 2003; Kaushal 2007). Regardless, the empirical evidence suggests an inverse-quadratic relationship between BMI and age.

Economic inequality is often cited as a factor explaining obesity (Vigerova et al. 2004; Drewnowski and Specter 2004; Godoy et al. 2005; 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; Rashad et al. 2006) or inverse (Heineck 2006; Ver Ploeg 2007) relationship with income or education (used as a different means to capture economic inequality) (Cutler et al. 2003; Chou et al. 2004; Rashad et al. 2006; Kaushal 2007), while others report

mixed effects associated with education (Komlos and Baur 2004; Heineck 2006; Rashad 2006; Huffman and Rizov 2007; Phuong Do et al. 2007). Occupation and social status have also been included to control for inequality (Komlos and Kriwy 2002; Heineck 2006; Carson 2007). Food security appears to play a role as well, with some recognizing the connection between BMI and income and relative price (Chou et al. 2004; Drewnowski and Specter 2004; Drewnowski and Darmon 2005).

Regional differences in BMI have been noted for Canada (Shields and Tjepkema 2006; Tjepkema 2006), Germany (Komlos and Kriwy 2002; Heineck 2006), and Russia (Huffman and Rizov 2007). Within Canada, Shields and Tjepkema (2006) note that in 2004 the prevalence of obesity (i.e. BMI$\geq$30) in Saskatchewan, Manitoba, New Brunswick and Newfoundland and Labrador was statistically significant and higher than the national average, while the prevalence of obesity in British Columbia was statistically significant but lower than the national average. Moreover, Shields and Tjepkema (2006) show that adult Canadians living in Census Metropolitan Areas (i.e. cities with an urban core of 100,000 people or more) were less likely to be obese than adult Canadians residing in non-CMA locales.

Differences in BMI have been associated with race (Chou et al. 2006; Rashad 2006; Rashad et al. 2006; Phuong Do et al. 2007), while some parse their data based on race and analyze these sub-sets of data (Komlos and Baur 2004; Mujahid et al. 2005; Rashad 2006; Ver Ploeg et al. 2007). Previous analysis with Canadian data show off-reserve aboriginals and whites having higher BMI scores than other race groups (Belanger-Ducharme and Tremblay 2005; Tremblay et al. 2005). As well, immigrants to Canada have been reported to have lower BMI scores than non-immigrants (Tremblay et al. 2005; Belanger-Ducharme and Tremblay 2005), while evidence on differences in BMI across immigrant and non-immigrant populations in the U.S. is mixed (e.g. Danubio et al. 2005 and Kaushal 2007). Nevertheless, note that immigrant BMI scores in Canadian appear to be converging with those of Canadian birth (Tremblay et al. 2005). Differences in BMI across marital status have been reported, with

higher BMI scores reported for married individuals (Cutler et al. 2003; Costa-Font and Gil 2005; Rashad et al. 2006; Kaushal 2007; Phuong Do et al. 2007).

In addition to these socio-demographic and economic factors, some have examined trends and differences in BMI while taking account of behavioural aspects. For instance, evidence suggests an inverse relationship between intensity of physical activity and BMI (Costa-Font and Gil 2005; Tremblay et al. 2005). In addition to energy expenditure, modes of consumptive behaviour are also important factors shaping BMI. One would expect a positive relationship between BMI, caloric intake and foods with particular characteristics (ceteris paribus). The notion here is that BMI increases if the energy balance equation is positive. Indeed, Huffman and Rizov (2007) report a positive and significant relationship between BMI and calories consumed, and percent of calories from fat and protein. Some evidence also links time discounting with BMI (Komlos et al. 2004; Smith et al 2005; 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; Huffman and Rizov 2007), a result attributed to increased metabolism and suppression of appetite amongst smokers (Huffman and Rizov 2007). While results are some what mixed concerning the relationship between alcohol consumption and BMI (Prentice 1995; Kahn et al. 1997), Costa-Font and Gil (2005) reported an inverse relationship between BMI and daily alcohol consumption.

Nevertheless, some clear trends and differences have emerged. Generally speak, the extant literature points to rising BMI scores during the latter half of the 20th Century. Within in these broader trends are differences in BMI across gender, age, economic inequality (i.e. income level, education and food security), and ethnicity . At the same time, differences in BMI across locality (i.e. region of residence and urban-rural differences), marital status, and net energy balance related behaviours (i.e. food consumption and physical activity) are also evident. In this preliminary analysis of the Canadian context we undertake examination of the long-run trend of the BMI amongst adult Canadians and focus on differences in gender

and age. As will be seen, differences in the relationship between BMI and age play an important role in understanding changes in the long-run trend in BMI in Canada.

Data Sources

This analysis uses six data sources spanning the latter 19th Century to early 21st Century. BMIs for the late 19th and early 20th Centuries are calculated using data from Attestation records for the Canadian military in the South African (SA) War and World War I (WWI). These data were previously used to explore stature amongst Canadians (see Cranfield and Inwood 2007). The SA War records included both height and weight, while the WWI records used by Cranfield and Inwood (2007) included only height. However, the hard-copy of the archival record for the Canadian military in WWI included weight (Cranfield and Inwood 2007 relied on digital records which excluded weights) and so a sub-sample of the Cranfield and Inwood data was drawn and weights obtained from the printed records.

BMIs in the mid-1950s is approximated using summary information in the 1953 Canadian Weight-Height Survey. These data were collected using similar methods to the Dominion Bureau of Statistics' *Labour Force Survey*. The sample frame included children attending school, employees in businesses with 15 employees or more and individuals in private residences (to capture pre-school children, people working in the home and small business employees), but excluded those who were bedridden, pregnant women, those confined to an institution and members of the armed forces. In total, 59 measurement units were constructed to represent both metropolitan, urban, rural farm and rural non-farm localities in Canada, with a target sample of 0.1 percent of the population in each area. Trained nurses were then dispatched to measure height, weight and skin fold of randomly selected individuals within each area (weights were measured to the nearest 1/2 pound and heights to the nearest 1/4 inch). Based on this information, mean values of weight and height, by gender and age-group, were

developed (see Pett and Ogilvie 1958). We use the gender-age differentiated mean weights and heights to calculate an approximation to BMI for the mid-20th Century; in particular for each gender-age group combination we divide mean weight (in kilograms) by the square of mean height (in metres). We recognize this is only an approximation, but note a trade-off between some approximation error and the absence of a mid-century measures of BMI.

Measures of BMI for the latter portion of the 20th Century are drawn from a number of nationally-representative surveys of Canadians undertaken by Statistics Canada, specifically: the 1985 General Social Survey (GSS); the 1996 National Population Health Survey (NPHS); and the 2001, 2003 and 2005 Canadian Community Health Surveys (CCHS). The 1985 GSS was designed to gather information on health status, a number of health related behaviours, as well as self-declared weights and heights of 15 to 69 year old Canadians.[2] And while a health component was included in the 1991 GSS (which was the last GSS to include a health component), its small sample size limits its use in our analysis and so was not used in this analysis. The NPHS, which was first undertaken in 1994, includes a variety of questions designed to enhance the information available for health care providers and policy makers. Different versions of the NPHS targeted individuals within households, those residing in health care institutions for a period longer than six months, and Canadians in Northern communities (i.e. Yukon and the Northwest Territories). The NPHS core health component survey for individuals in households targets about 17,000 observations, although different versions of the NPHS have expanded this sample size to allow for supplemental questions provided by various provinces. Because the 1996 NPHS included an expanded sample size we use data from it in our analysis. The CCHS, which was initiated in 2001, is intended to provide information about determinants of Canadians health, as well as information about health system utilization. The CCHS data reflects in-depth interviews with one randomly

[2]The GSS has been undertaken in almost every year since 1985, with different themed surveys being undertaken in each year

selected subject per interviewed household (households are randomly selected).

Long run trend

Figure 1 shows the long-run trend in BMI for male and female adults, 20-49 years of age, in Canada, while Table 1 shows the gender specific means for each sample and corresponding sample size. Average BMI for adult males in Canada shows an increasing trend, growing from 23.55 in the late 1800s/early 1900s to 26.7 in the early part of the 21st Century. While limited by the temporal coverage of the data, average adult BMI for females in Canada also appears to follow an upward trend from the early 1950s. Note, however, that the measure for average female BMI in 1985 (from the 1985 GSS) includes pregnant females. Consequently this observation reflects an unusually high value. Nevertheless, ignoring the observation for females in 1985 does not change our conclusion that between 1953 and the late 1990s and early 21st Century, the BMI of adult females in Canada grew. Based on the data presented in Figure 1 and Table 1 we also conclude that the the upward trend in BMI is a recent phenomenon; up to the 1990s the upward trend in BMI appears relatively modest, only to increase markedly during the 1990s.

Nevertheless, the rate of change in BMI was different across the genders. To see this, Table 1 also includes the difference in each data set′s average BMI from the average BMI in 1953. From 1953 onwards, the change in BMI was larger for adult males than adult females. Moreover, the percent change in adult male BMI between 1953 and 1996 was 7.4 percent, but 10.9 percent between 1953 and 2005. For females these percent changes equalled 2.3 and 7.4 percent, respectively. One conclusion we draw is that adult male BMIs have increased at a more rapid pace than for adult females, but that the rate of change in adult female BMI is increasing.

Figure 1. Average BMI of adults aged 20-49 years of age in Canada.

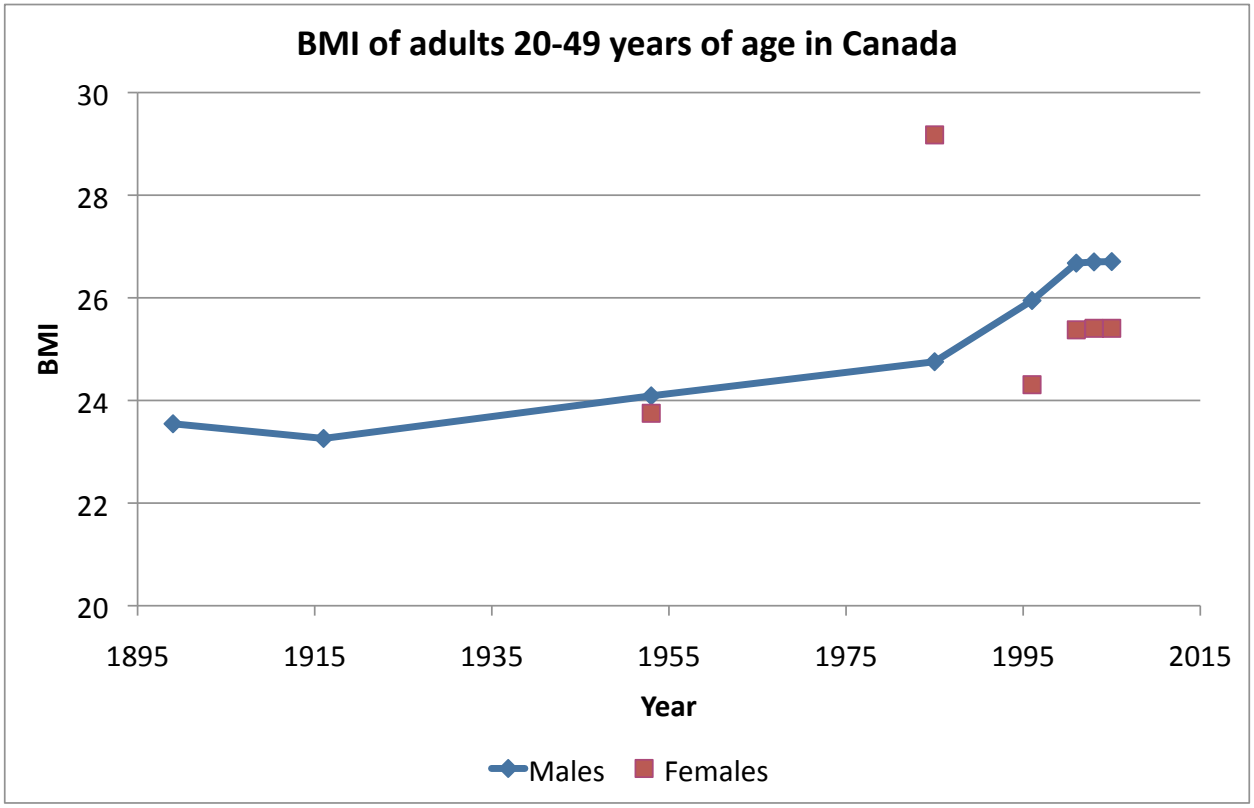


Table 1. BMI of adults (20-49 years of age) in Canada

	Males			Females		
	N	Avg. BMI	Δ(1953=0)	N	Avg. BMI	Δ(1953=0)
South Africa	2,107	23.55	-0.54			
World War 1	2,266	23.26	-0.83			
1953 CWHS	≈22,000	24.09	0.00	≈22,000	23.75	0.00
1985 GSS	2,293	24.76	0.67	2,641	29.18	5.43
1996 NPHS	19,534	25.95	1.86	20,006	24.31	0.56
2001 CCHS	33,714	26.68	2.59	37,935	25.38	1.63
2003 CCHS	21,839	26.70	2.61	23,451	25.41	1.66
2005 CCHS	27,366	26.71	2.62	29,472	25.50	1.75

In addition to differences in BMI across gender, the extant literature also reports differences in BMI across age-groups. In particular, BMI typically follows an inverted U across age or age-groups. Figure 2 shows the profile of BMI across age-groups, by data set, while Table 2 shows the corresponding data. While an inverted U is not evident, this reflects

our truncation of age-groups at 49. Indeed, analysis of more contemporary Canada data shows an inverted U pattern is evident when age-groups beyond 49 years of age are included (see Cranfield 2008). Nevertheless, two points emerge. The average BMI of adult males in Canada increased at a decreasing rate across age-groups, with larger gains in BMI occurring during young adult years compared to older years. Secondly, when compared across the different data sets, the age-group profile of BMI appears to have shifted up overtime. While such a shift reflects the broader secular trend in BMI, it may reflect a change in the profile itself. We explore this possibility below.

Figure 2. Average BMI of adults males in Canada by age-group.

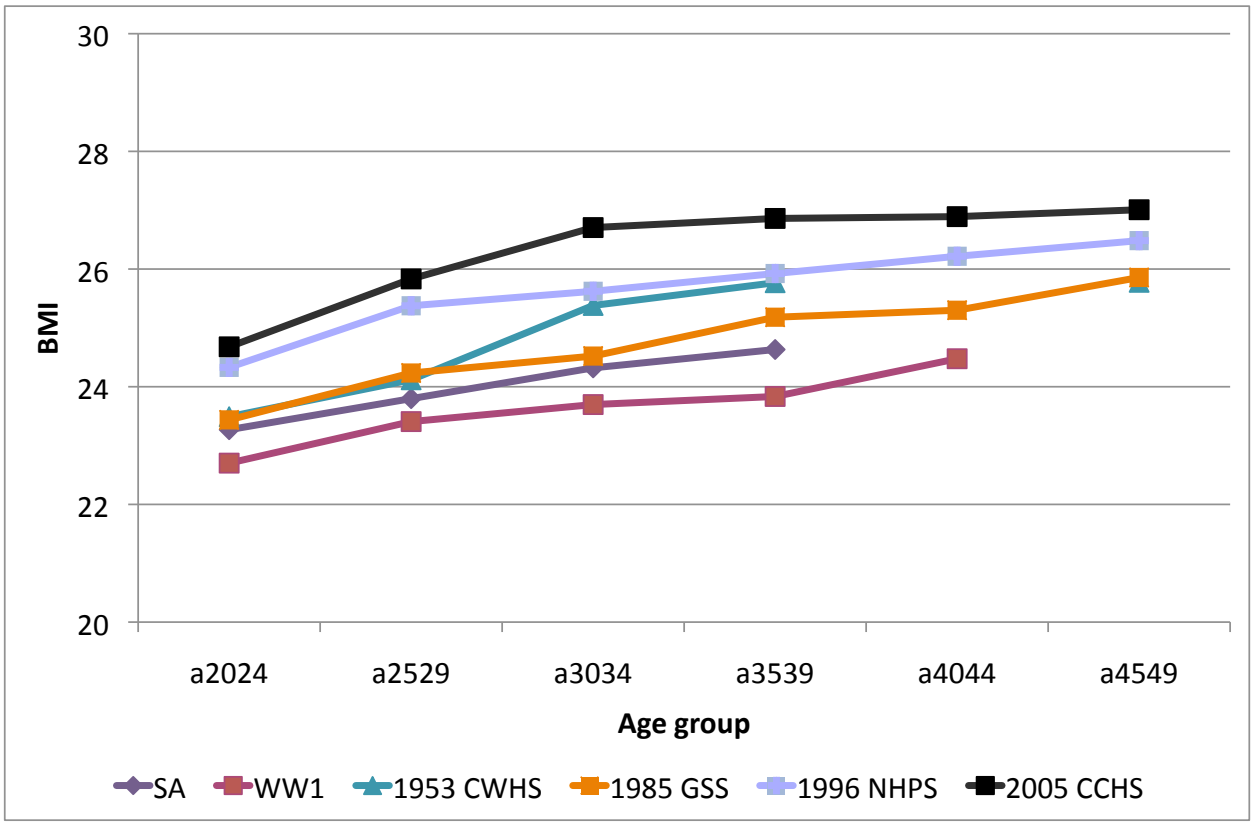


Table 2. BMI of adults males in Canada by age-group

	Age-group					
	20-24	25-29	30-34	35-39	40-44	45-49
SA	23.27	23.80	24.32	24.63	NA	NA
WW1	22.70	23.41	23.70	23.83	24.48	NA
1953 CWHS	23.49	24.12	25.38	25.76		25.77
1996 NHPS	24.33	25.38	25.62	25.92	26.22	26.48
2001 CCHS	24.86	26.17	26.53	26.68	26.76	26.96
2003 CCHS	24.95	26.03	26.79	26.71	26.80	26.85
2005 CCHS	24.68	25.83	26.71	26.86	26.89	27.01

Figure 3 and Table 3 show the age profile of BMI for adult females by data source (given issues related to pregnant females in the 1985 GSS data set, it was dropped from the age-group analysis). As with adult males, the BMI age profile for adult females has shifted up over time, again reflecting the broader secular trend in adult female BMI scores. However, unlike adult males, the average BMI of adult females in Canada increased in the early adult years (i.e. 20 to 29 years of age), plateaued between 30 and 39 years of age and increased again between 40 and 49 years of age. Moreover, a comparison of the the age profile of female BMI from the 1996 NPHS with age profiles from the three CCHS data sets suggests an asymmetric shifts in the age-profile of adult females overtime. To see this, the last row of Table 3 shows the change in average adult female BMI between 1996 and 2005. The upward shift in the age-profile of BMI is greatest for those between 30 and 30 years of age, followed by 25-29 year olds, 20-24 year olds, and is smallest for 45-49 year olds; those in the 25 to 39 year range had larger increases in BMI than other age-groups. Such a change could point to a "catching-up" effect for females in their early adult years to older adult females in Canada.

Figure 3. Average BMI of adults females in Canada by age-group.

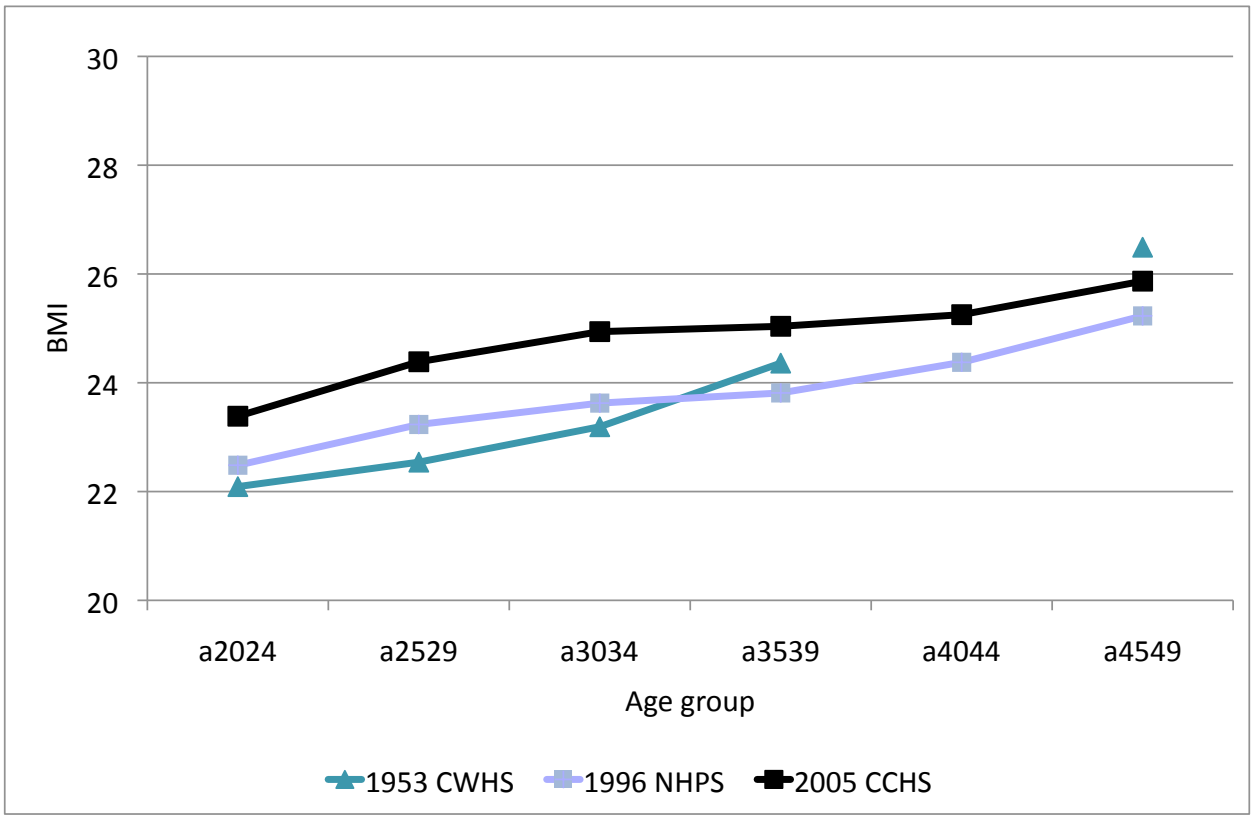


Table 3. BMI of adults females in Canada by age-group

	Age-group					
	20-24	25-29	30-34	35-39	40-44	45-49
SA	NA					
WW1	NA					
1953 CWHS	22.09	22.54	23.19	24.36		26.49
1985 GSS	27.67	28.31	28.90	29.59	30.05	30.54
1996 NHPS	22.48	23.23	23.63	23.81	24.38	25.23
2001 CCHS	23.49	24.56	24.87	24.90	25.24	25.75
2003 CCHS	23.38	24.42	24.98	24.89	25.18	25.58
2005 CCHS	23.39	24.39	24.94	25.04	25.25	25.87
ΔBMI (1996-2005)	0.91	1.16	1.31	1.23	0.87	0.64

Decomposing adult BMIs in Canada

Figure 4 plots the gender specific average BMI (for all ages) and gender specific average BMI for 20 and 24 years of age from all data sets. While average BMI for both male and female 20 to 24 year olds is increasing over time, note that the gap between the average BMI for all males and average BMI for 20 to 24 year old males is widening. However, the gap between average BMI for all females and average BMI for 20 to 24 year old females widens subtly. Nevertheless, the widening gap for males suggests that the changes in BMI of young male adults does not entirely explain the secular trend in BMI for adult males. To explore this widening gap, we calculate the difference in BMI for 20 to 24 year olds and the corresponding BMI for the remaining age groups for each data set. This BMI differential normalizes the age-group specific BMIs from each data set and removes any trend effect associated with 20 to 24 year olds.

Figure 4. Change in BMI of young adults (20-24 years old) in Canada

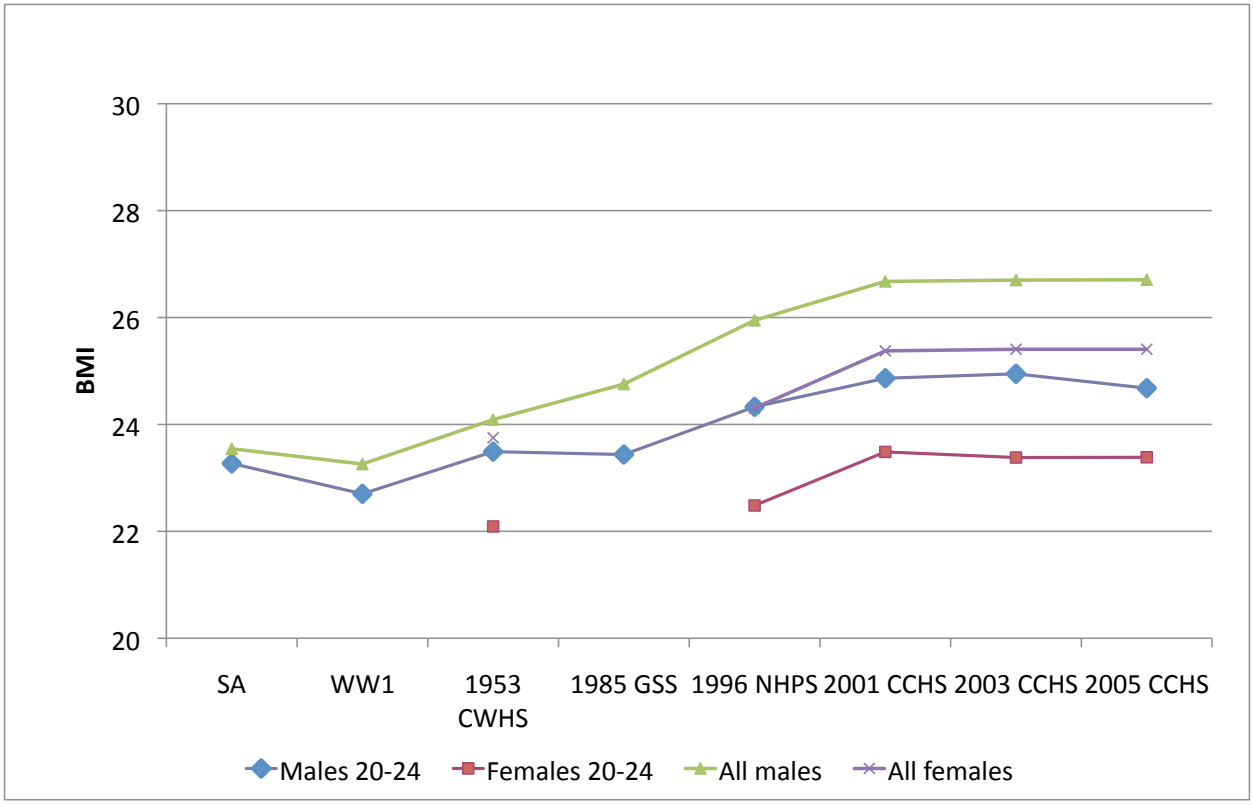
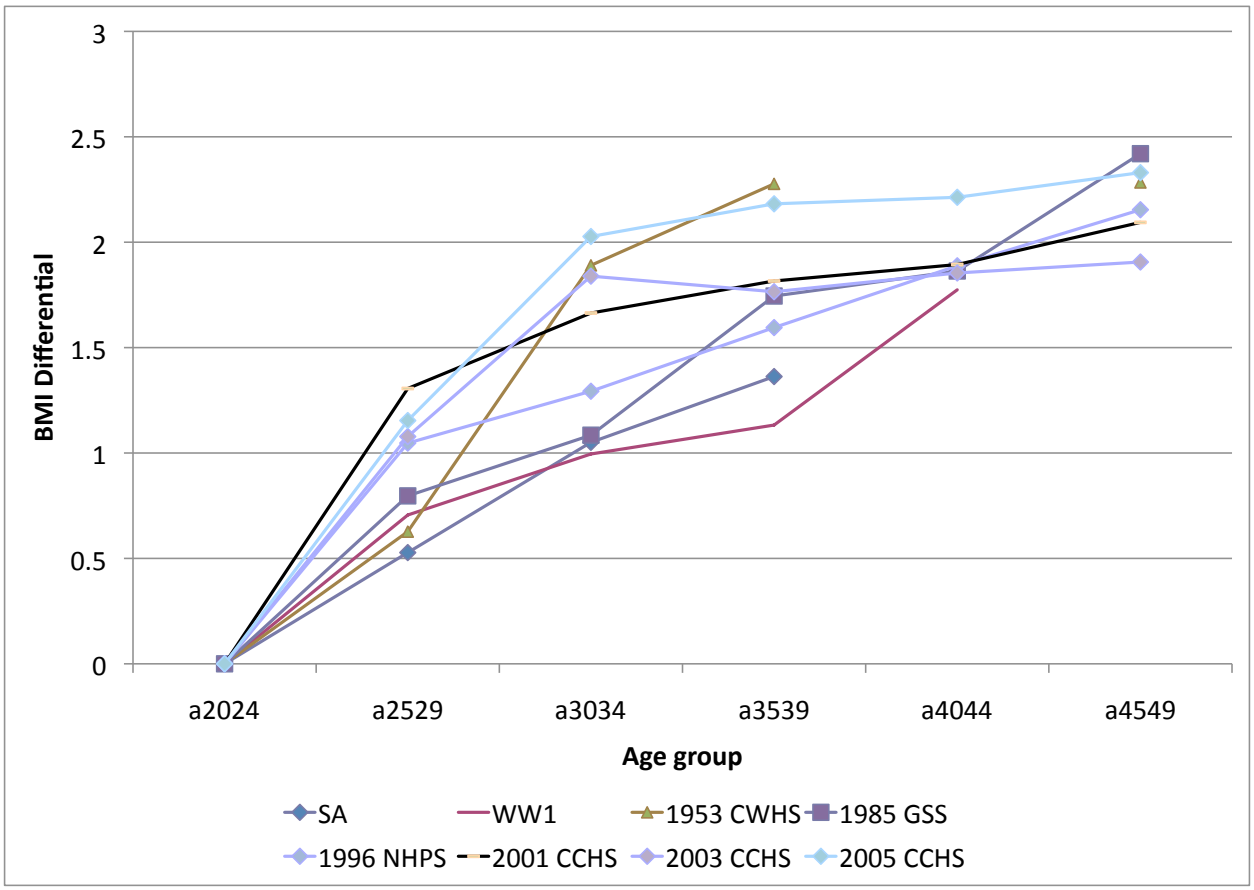


Figure 5 plots these BMI differentials across different age groups and data sets for males in Canada. While considerable noise is present, the BMI differentials widened between the early 20th Century and 21st Century. The plot of the BMI differentials from the South African War and World War I records lies below the plots of the BMI differentials from the other data sets, while the BMI differential from the 2005 CCHS generally lies above the BMI differentials from earlier data sets. Given recent evidence documenting rising stature amongst Canadian borne through the 20th Century (Cranfield and Inwood 2007), the plots in figures 1, 4 and 5 suggest that throughout the 20th Century Canadian males in the same age-group gained weight at a more rapid pace than they gained stature.

In fact, we can say more than this by using the BMIs in Table 1 and stature data in Cranfield and Inwood (2007) to calculate the predicted weight of Canadian males in the early 2000s had adult male BMI not changed from World War I levels. Using BMI from our World War I data set (23.36) and average stature of Canadian born men from the 2002 CCHS (1.75 metres), the BMI held constant *predicted* weight of Canadian men in 2002 is 71.2 kilograms.[3] The actual average weight of adult males in Canada in 2001 was 81.8 kilograms. Compared to Canadian men in World War I, and after accounting for stature effects, Canadian men in the very early 21st Century appear to have gained an extra ten kilograms weight. Based on data in figures 4 and 5, the source of these additional ten kilograms can be partially attributed to weight gain amongst 20 to 24 year olds (i.e. the upward trend in BMI for this age group), but more so from the change in the BMI differential between 20 and 24 year olds and older age-groups.

[3]The 2002 CCHS was based on the 2001 CCHS

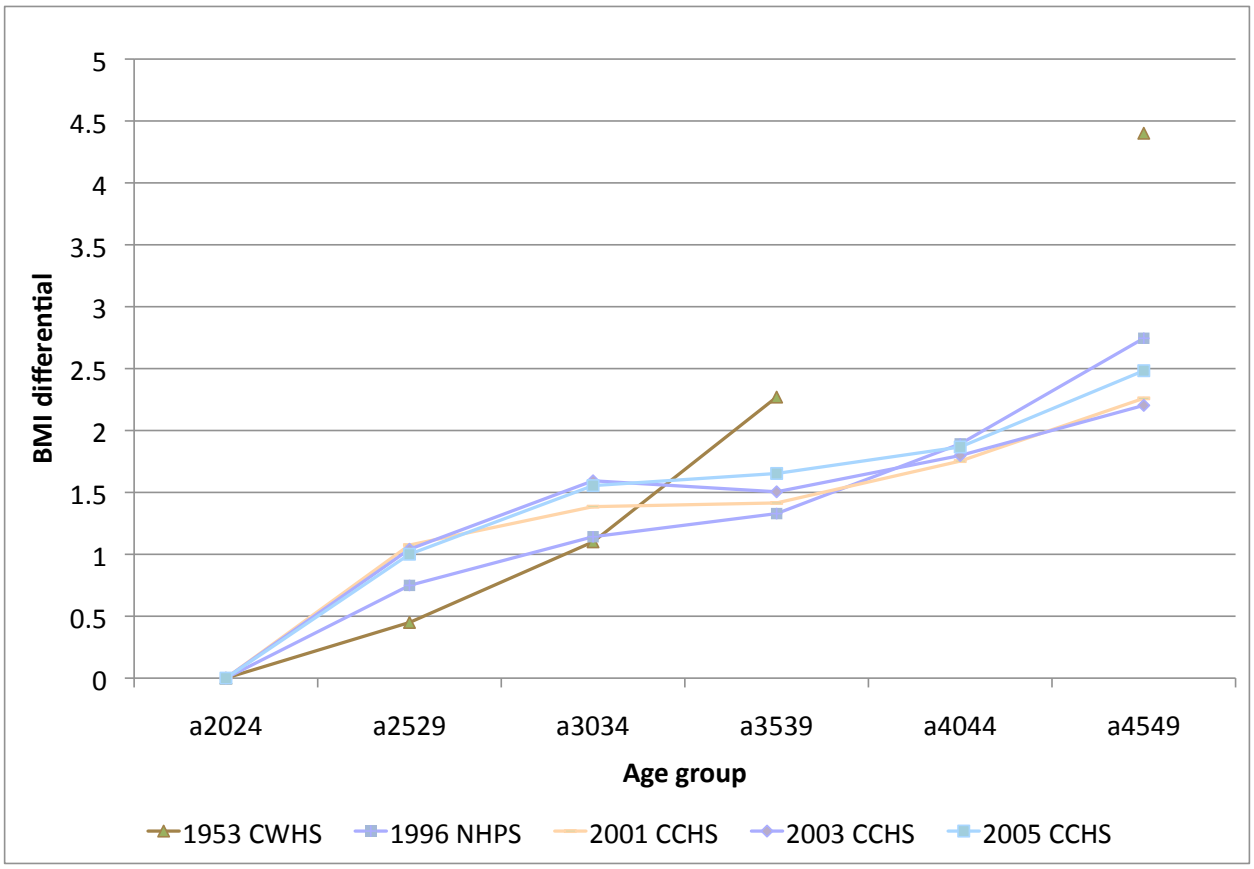
Figure 5. Male BMI differential across age groups inCanada



Differences in the trends of adult female BMI and the BMI for 20 to 24 year old females (see Figure 4) are subtle and do not suggest changes in the BMI of young adult females as a possible source of the overall trend. However, when BMI differentials are calculated for females (see Figure 6) one obvious (and we think important) change is present. The BMI differential based on the 1953 CWHS data set suggests rising BMI levels amongst 25 to 49 year old Canadian females relative to 20 to 24 year old females. However, the BMI differential for females between 25 and 39 years of age widened between 1953 and 2005, while the differential for the 45 to 49 year old age-group shrank between 1953 and the early 21st Century. Such a result suggests that, on average and relative to 20 to 24 year old females, females aged 25 to 39 in Canada experienced more weight gain throughout the latter half of the 20th Century compared to 1953, while those aged 45 to 49 experienced less weight gain.

More broadly, the pattern of the BMI differential for females appears to be changing shape from a convex looking function to one which reflects a diminishing marginal effect over time - a pattern similar to the BMI differentials for males (see Figure 5). Whether changes in the female BMI differentials reflect a convergence of the BMI differentials across gender (or at least a convergence of the pattern) remains to be seen and will require further data and analysis.

Figure 6. Female BMI differential across age groups inCanada



Conclusions

The aim of this research is to understand better the long-run trend in BMI of the Canadian population. To this end we use military attestation documents and data drawn from popu-

lation health surveys to explore average BMI of male and female adults (20 to 49 years old) in Canada. Results show a systematic and positive difference in BMI between adult males and females in Canada. Moreover, the gap between male and female BMI has grown over time; this widening gap comes about from larger rates of BMI gain for males than females. After accounting for stature change throughout the 20th Century, the BMI held constant predicted weight of adult males in Canada was ten kilograms lighter than the actual weight of adult males in Canada in 2001. A changing pattern of gain in BMI across age-group is also present. This changing pattern is characterized by larger increases in BMI for adult males aged 25 to 39 years of age compared to younger and older age-groups. For females the pattern of change is characterized by larger gains in BMI in the 25 to 39 year old age group, but BMI *declines* over time for those aged 45 to 49.

Future work will explore regional differences in BMI and, to the extent possible, rural/urban and ethnic influences. As well, it will be important to understanding the underlying origins of rising BMIs. While rising BMI is indicative of an imbalanced in the net-energy equation, research needs to be undertaken to see the extent to which increase caloric consumption or reduced caloric expenditure is at the core of the trend. At the same time, connections between changing BMI and changes in economic and social dimensions of the Canadian population needs to be explore.

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