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Long-Run Health Effects of Sports And Exercise In Canada*

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Abstract

Even though insufficient participation in physical activity is shown to be one of the major contributors to chronic diseases, and poor health, participation in physical activity still remains to be substantially low in developed countries including Canada. In this paper, we examine the long-run health effects of participation in sports and exercise among inactive Canadian adults. Based on informative Canadian panel data and semiparametric matching estimation, we show that participation in sports and exercise generally improves physical health and mental well-being of individuals. While this effect is statistically significant and persistent for men, we do not find a similar effect for women. Our results also indicate that positive health effects are only achieved with a level of physical activity that is larger than the current national and international health organizations' guidelines for the minimum level of activity.

JEL Classification: I12, I18, Z28, Z29, L83, C21, C23

Keywords: physical activity, sports, exercise, subjective health, mental health, treatment effect

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1 Introduction

Although insufficient participation in physical activity has been consistently emphasized as one of the main contributors to major chronic diseases, participation in physical activity remains to be substantially low in Canada, USA, and many European countries. In order to promote a healthy lifestyle, international and national agencies such as the World Health Organization (WHO), the Canadian Society for Exercise Physiology (CSEP), the Centers for Disease Control and Prevention (CDC) have issued guidelines suggesting that regular participation in moderate-intensity physical activity for a minimum of 30 minutes on five days each week is needed in order to derive health benefits of physical activity (CSEP 2013; U.S. Department of Health and Human Services 1996, 2010; WHO 2010). Even though this has been emphasized on a regular basis, a large proportion of adults did not achieve these levels during the last two decades. Among Canadian adults less than half of the population meets the minimum recommendations (Sari 2010; Sari 2014).

In an effort to pin down the impact of sports and exercise, which is the main driver of physical activity in developed countries, on various health and labor market outcomes, there has been a small but growing literature within economics and health sciences. Studies show that participation in sports and exercise improves labor market outcomes (Lechner 2009; Lechner and Sari 2015; Barron, Ewing and Waddell 2000; Cabane 2010; Long and Caudill 1991)[1]. For instance, Lechner and Sari (2015) confirm the previous findings of positive long-run income effects of participation in sports and exercise (e.g., Lechner, 2009), but they also suggest that an activity level above the current recommendation of the WHO for minimum physical activity is required to reap in the long-run benefits. Other studies focusing on the impact on health and healthcare utilization also suggest that participation in sports and exercise improves the overall health status and decreases

[1]For a more extensive survey of this literature see Cabane and Lechner (2015) and Lechner (2015).

the likelihood of using any healthcare services. A large body of literature studying the impact of sports and exercise on healthcare utilization concludes that a sufficient level of sports and exercise participation significantly lowers the hospital stays and physician visits (Baun et al. 1986; Leigh and Fries 1992; Bowne et al. 1984; Shephard et al. 1982; Shephard et al. 1983; Shephard 1996; Keeler et al. 1989; Sari 2009; Sari 2010; Sari 2014). Another stream of research that focused on health effects of sports and exercise examines its effects using various dimensions of health such as general health and body weight (Wicker, Coates, Breuer 2015; Colman and Dave 2013), mental well-being and cognitive functioning (Hillman, Erickson, Kramer 2008; Reiner et al. 2013; Rees and Sabia 2010), and the likelihood of developing chronic diseases (Ruseski and Humphreys 2011; Humphreys, McLeod, Ruseski 2014). The results from these studies also indicate that participation in sports and exercise improves health and well-being of the individuals, and that it also has positive effects on cognitive functioning with broad and specific cognitive effects such as scheduling, planning, working memory, multi-tasking and dealing with ambiguity.

To the best of our knowledge, there are only limited studies in the literature examining *long-term* consequences of sports and exercise participation. These studies primarily focus on its effects on labor market outcomes (i.e. Lechner 2009; Lechner and Sari 2015). Other studies investigating the impact of sports and exercise on health and healthcare services mentioned above primarily examine short term consequences. There are a few exceptions that provide long-term causal implications of physical activity for health outcomes. For instance, Lee et al. (2014) examine the long-term effects of running on mortality using a 15-year follow-up study for adults aged 18 and older. They find that runners compared with non-runners had 30% lower adjusted risks of all-cause mortality or 45% lower cardiovascular mortality. This long-term effect on mortality that is similar to the one estimated by Blair et al. (1989), is non-negligible, but these results may suffer from potentially severe self-selection bias. In another study, Colman and Dave (2013) provide long-term health effects of physical activity using the first National Health and Nutrition Examination Survey and its follow-up study (the NHANES I Epidemiologic Follow-up Study) conducted 8 to 10 years after the NHANES I. Their results indicate that participation in leisure time physical activity improves health outcomes measured by the BMI, as well as chronic conditions including diabetes, hypertension, and heart disease. Although, their data provides detailed information on health outcomes, the information regarding physical activity is limited, and not comparable to what we have in our data set.[2]

Our objective in this paper is to fill this gap in the literature by providing estimates for long-term effects of physical activity on various dimensions of health. We focus on estimating the impact of sports and exercise on physical and mental health for those people whose level of sports and exercise is below the recommended level of physical activity. We will use alternative measures for health such as self-reported health, variables related to body weight and chronic diseases, as well as other variables measuring stress, depression and cognitive functioning.

The data used is a biennial panel survey for Canadian adults conducted in the period 1994-2008. This household survey, called the National Population Health Survey (NPHS), is representative for Canadians in 1994 with a rich set of information on health outcomes as well as on participation in sports and exercise. Different from many other national surveys, the NPHS includes detailed information for the types and intensity of sports and exercise.

Our research design which aims at identifying causal effects of sports and exercise on health primarily takes advantage of a rich set of descriptors and the panel structure of the data. Our

[2] There is only one question about leisure time physical activity in their survey that offers the following possible responses to the survey participants: "much exercise", "moderate exercise", and "little or no exercise" ("Do you get much exercise in the things you do for recreation (sports, or hiking, or anything like that), or hardly any exercise, or in between?").

approach is the same as in Lechner and Sari (2015) who use the same data. It includes three steps: First we divide the periods into a baseline (1994), a treatment (intervention) stage (1996), and a post-treatment stage (1998-2008). Second, using the baseline data, we stratify the sample based on gender and physical activity level. Then, in this paper, we restrict our analysis to those individuals who are physically inactive (i.e. individuals who are not meeting the recommended physical activity level) in the baseline period. We focus on this sub-group because of its high level of physical inactivity which makes it particularly relevant for public health policy in Canada, as well as in many other countries. Thus, we end up with two strata, one for men and one for women who were inactive in 1994. Third, within each stratum we use propensity score matching in order to identify stratum specific effects.

The remaining part of the paper is organized as follows: Next, we present the data used and related measurement issues. In Section 3, we discuss descriptive statistics on participation in sports and exercise as well as how selected health outcomes changes over time in Canada. Section 4 shows the details of our research design followed by the presentation of the results in Section 5. The final section of the paper summarizes and concludes. An online Appendix contains additional information about the data, and effects for further outcome variables that were not considered in the main body of the text.

2 Data sources and sports & exercise variables

2.1 The National Population Health Survey and the study sample

In this paper, we use the *National Population Health Survey (NPHS)*, which is a biennial longitudinal survey started in 1994. It is available for 8 cycles covering the period of 1994-2008. This survey is particularly rich with its detailed information on health, health behavior, socio-economic, demographic characteristics and information on individuals' participation in sports and exercise.

We restrict our study sample to the physically inactive adult population aged 20 to 45 in 1994. In addition, we drop the survey participants if they did not respond to the survey, or had physical mobility problems during the first two cycles of the survey. With these restrictions, the sample size decreases to 3589. We also exclude additional 21 individuals due to missing information for their participations in sports and exercise in 1996. As a result, the final sample includes 3568 individuals. Given that we employ a propensity score matching using a probit specification as described in Section 4.2, we also drop any respondents with missing observation in any of their covariates used in the probit specifications. This leads to a final sample of 2830 individuals in our analysis.

2.2 Sports and exercise variables in the NPHS

Unlike many other national health surveys, the NPHS includes a specific physical activity module that includes detailed questions related to all leisure time physical activities (LTPAs), administered for all participants 12 years and older. In each cycle of the survey, there are series of questions concerning the duration and frequency of participation in 20 to 23 types of LTPAs during the last 3 months. The survey participants were also given the opportunity to name 3 additional LTPAs that were not explicitly listed in the survey. The participants have been asked whether they have participated in each activity during the last 3 months. For those individuals who have participated to the corresponding LTPA, there are follow-up questions related to the frequency (episode) and the typical duration time in each episode during the last 3 months prior to the interview.

Using this detailed information, a summary variable for total daily energy expenditure from all

LTPAs was computed and included with the survey. This variable was calculated by multiplying hours of daily activity by the equivalent energy expenditure from the corresponding physical activity expressed as daily kilocalories (kcal) per kilogram (kg) of individual's body weight.[3] Then the daily energy expenditure from each LTPA is summed over all LTPAs to obtain the summary measure for participation in sports and exercise.

In reference to the recommended level of physical activity[4] by the WHO, CSEP, and the US Surgeon General (CSEP 2013; U.S. Department of Health and Human Services 1996, 2010; WHO 2010), the survey participants were categorized into three physical activity groups based on their total daily energy expenditure from all LTPAs. The first group (*physically inactive*) includes individuals whose daily energy expenditure falls below the benchmark energy expenditure of 1.5 kilocalories per kilogram of body weight (kcal/kg). The second group (*moderately active*) includes participants who meet the benchmark daily energy expenditure of at least 1.5 kcal/kg but fall short to be considered as physically active[5]. The third group (*physically active*) consists of individuals with daily energy expenditure from all LTPAs exceeds three kcal/kg from all LTPAs. In our study, we use this definition which also used in subsequent Canadian studies to classify the individuals

[3]The equivalent energy expenditure from the corresponding activity is calculated using the corresponding metabolic rate (MET) for each activity type. The METs are multiples of the resting rates of oxygen consumption during the activity. For instance, one MET represents the approximate rate of oxygen consumption of a body at rest, and the equivalent energy expenditure of 1 MET is 1 kilocalories in an hour per kilogram of individual's body weight (kcal.hr^{-1}.kg^{-1}).

[4]The Centers for Disease Control and Prevention (CDC), and the American College of Sports Medicine (ACSM) organized an expert panel to determine the recommended physical activity level. The panel recommended that the individuals should "accumulate 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week" (Pate et al. 1995: p.404). As a recent update and clarification on 1995 recommendations, Haskell et al (2007) state that all adults aged 18 to 65 need "moderate-intensity aerobic physical activity for a minimum of 30 min on five days each week" (Haskell et al. 2007: p. 1083). This is the current guidelines adopted by the World Health Organization, the Canadian Society for Exercise Physiology (CSEP), and the US Surgeon General (CSEP 2011; U.S. Department of Health and Human Services 2010; WHO 2010). This recommended level of physical activity corresponds to daily energy expenditure of at least 1.5 kilocalories per kilogram of body weight (kcal.kg-1) from all LTPAs.

[5]Individuals can achieve this goal of being at least moderately active with various combinations of sports and exercise types and duration. By choosing high intensity exercises (running as opposed to walking), individuals can meet this recommendation with less exercise time. Some examples are daily walking for 30 minutes with a speed of 2.5 miles per hour on a firm surface, or 3-times a week running for 25 minutes with a speed of 5 miles per hour (for other examples see Ainsworth et al. 2000).

based on their activity status (i.e. Humphreys, McLeod, and Ruseski 2014; Liu et al. 2008; Sari 2010, 2009)

3 Participation in sports & exercise and health outcomes

This section presents the pattern of selected health outcomes and participation in sports and exercise for the Canadian population aged 20 to 59 during the period of 1994-2008. We use multiple data sets for the figures presented in the next two subsections. Given that there are no cross sectional national health surveys conducted in Canada until 2001, for the earlier period we use data from corresponding cycles of the NPHS, which are representative for 1994. In interpreting the data shown for the 1996-2000 period one should keep this potential shortcoming in mind. For the remaining years after 2000, we use the Canadian Community Health Surveys, which are nationally representative for the corresponding year. The values are linearly interpolated for years for which no information is available from either source.

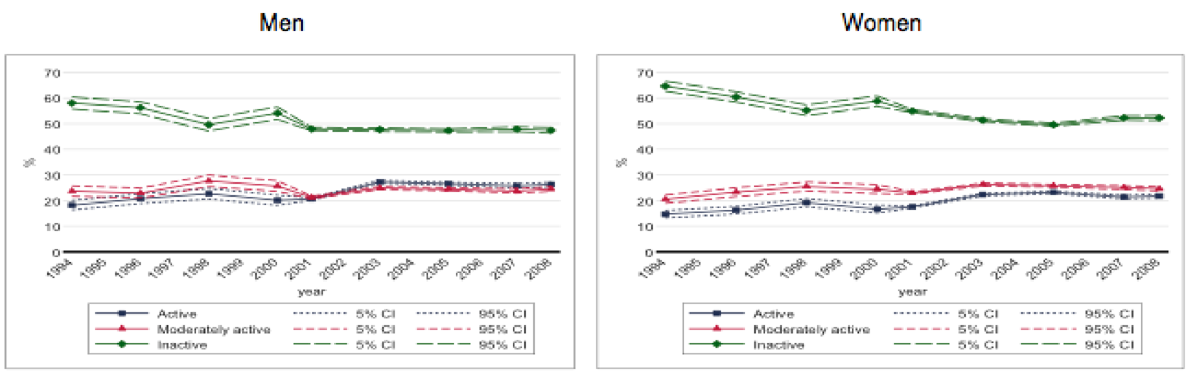
3.1 Participation in sports & exercise

Using the three types of physical activity state defined in the previous section, we illustrate the participation in sports and exercise by activity state in Canada for the period of 1994-2008. The participation pattern in sports and exercise is displayed for the Canadian adult population aged 20 to 59 for men (dashed-dot lines) and women (solid lines) in Figure 1. The vertical axis in the figures indicates the percentage of people who are physically active (dark navy line with square), moderately active (red line with triangle), or inactive (green with diamond) while the horizontal axis shows the corresponding year.

Figure 1 presents the percentage of active, moderately active and inactive Canadian men and women in a given year. As shown in the figure, proportion of physically inactive people shows a decrease in 1990s but after 2002 it fluctuates at around 50% with smaller variation from year to year for the adult population. For active and moderately active subgroups, we observe an increase in 1990s followed by a smaller fluctuation around the participation rate of 25%.

The figure below shows that there are variations between men and women in terms of their participation in sports and exercise. As displayed for the adult population, and also consistently shown in the literature, men are more active than women.

Figure 1: Participation in LTPA for Canadian adult population



Note: Mean values and 90% confidence interval of mean. Own calculations using the NPHS for the years 1994, 1996, 1998, and 2000, and the Canadian Community Health Surveys for the years 2001, 2003, 2005, 2007, and 2008. Values for the other years are linearly interpolated. Population is 20 to 59 years old in any given year.

For the overall adult population of age 20 to 59, more than 60% are physical inactive in 1994 with some gender differences. As shown in Figure 1, 65% of women are inactive in 1994, while it is only 58% for men. For both groups, we observe a decline in physical inactivity over time which plateau at around 47% for men and 52% for women after 2002 onwards. Similarly the same gender difference is observed for the proportion of those who are physically active. For both groups, it increases over time until 2002, and stabilizes after 2002 at around 22% for women and 26% for men.

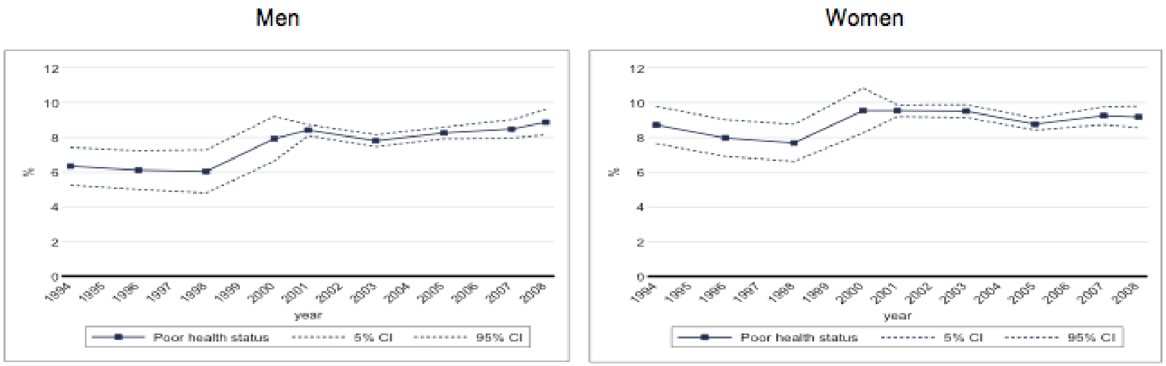
In order to have deeper insight about the gender differences in participation in sports and exercise, we uncover the participation in different types of sports and exercise by activity states for men and women. We do this for a general population as well as for our study sample in Lechner and Sari (2015). The general conclusion from the data presented in our companion paper is that walking for exercise is the top activity both for men and women. This is followed by yard work, home exercises, and weight training. Team sports such as basketball, volleyball, soccer or even hockey are activities with participation rate of less than 1 to 2 percent.

3.2 Dynamics of selected health outcomes

Using a selected set of outcome measures, we present health outcomes for the Canadian population aged 20 to 59. In each figure below, on the horizontal axis we show the percentage of men and women with the corresponding health outcome, while on the vertical axis we show the year when these outcomes are measured.

Figure 2 presents the percentage of those who reports their health status to be poor or fair (on a five point scale). As indicated in the figure, men report somewhat less poor health than women. Throughout the study period, about 8-10 percent of women report that their health status is poor or fair, while fewer men report a poor/fair health status. The gender difference, however, disappears over time.

Figure 2: Self-rated poor/fair health for the Canadian population

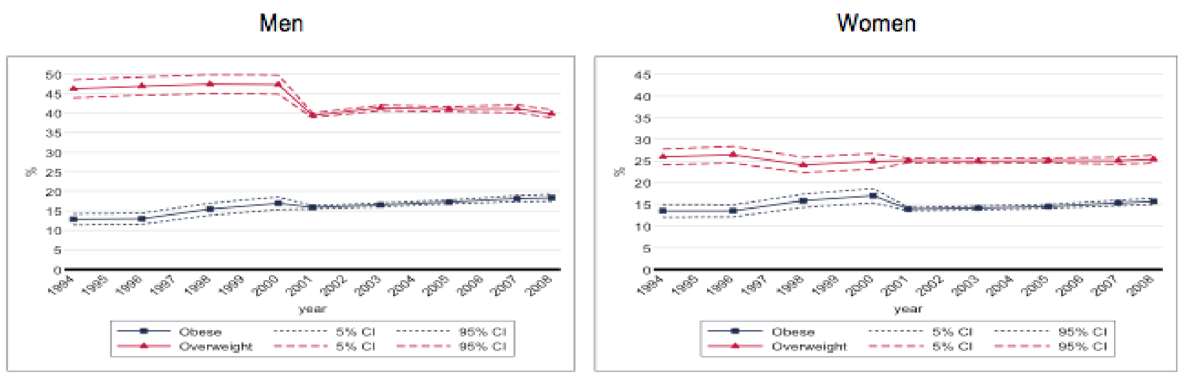


Note: Mean values and 90% confidence interval of mean. Own calculations using the NPHS for the years 1994, 1996, 1998, and 2000, and the Canadian Community Health Surveys for the years 2001, 2003, 2005, 2007, and 2008. Values for the other years are linearly interpolated. Population is 20 to 59 years old in any given year.

Figure 3 shows the share of men and women who are obese or overweight. The rate of obesity among men and women is quite similar prior to 2000, but it changes during the last decade. As the obesity rate is around 13% for men and women aged 20 to 59 in 1994, it increases to about 18% for men and about 16% for women in 2008. The gap between men and women is much larger for overweight than for obesity. From the beginning of the study period to its end, a greater proportion of men have overweight problems compared to women. In 1994, 26% of women are overweight while the corresponding share for men is 46%. In the 1994-2008 period, the rates of overweight or obesity among women have not changed much, but there was a substantial change for men. While the proportion of men who are overweight decreased by 6-percentage points from 1994 to 2008, we observe almost an identical increase in the rate of obesity. Given an almost identical shift from overweight to obesity for men, and no change among women, the total proportion of men and women with body weights above normal body weight has stayed stable at around 60% for men and 40% for women.

As additional health outcome measures, we use the proportion of people with various types of chronic conditions. In Figure 4, we present changes in the health outcomes measured by the presence of any or five specific chronic diseases. In computing the proportion of people with any chronic conditions, we restrict the conditions considered to 14 major conditions that are consistently measured during the study period in the NPHS and the CCHS[6]. For the five specific conditions, we focus on diseases consistently shown in the literature to be correlated with a lack of physical activity. These five conditions are diabetes, hypertension, cancer, heart disease, and stroke.

Figure 3: Obesity and overweight for the Canadian population



Note: Mean values and 90% confidence interval of mean. Own calculations using the NPHS for the years 1994, 1996, 1998, and 2000, and the Canadian Community Health Surveys for the years 2001, 2003, 2005, 2007, and 2008. Values for the other years are linearly interpolated. Population is 20 to 59 years old in any given year. Obesity is defined using the BMI of 30 or higher while overweight is defined as the BMI from 25 to 30.

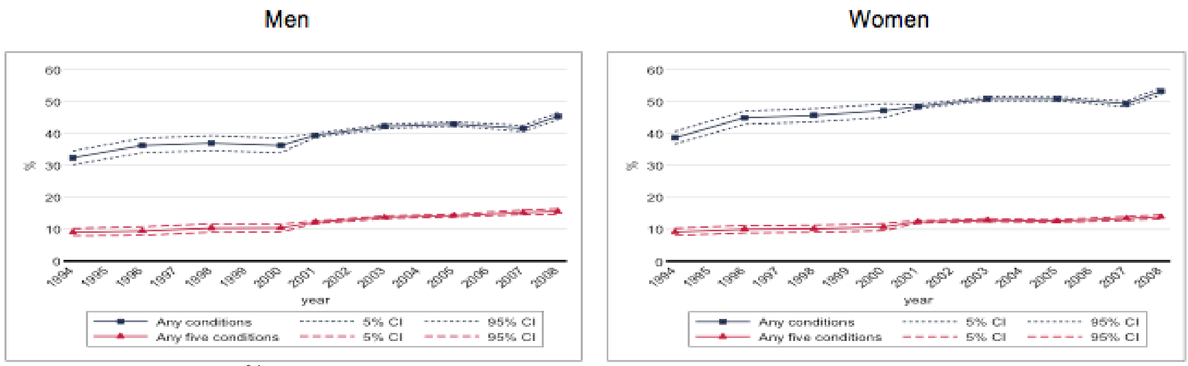
Figure 4 presents the change in the proportion of people with chronic diseases from 1994 to 2008 in Canada. The figure implies several observations regarding the proportion of people with chronic diseases over time. First, the proportion of people with any chronic condition has increased over time for men and women. The share of women with any condition has increased from 39% in 1994 to 53% in 2008. During the same period, it increased by 13 percentage point for men, from 32% in 1994. Second, a similar upward trend is also observed for the likelihood of having any one of the five specific conditions, but the rate of change was higher for men than for women. For both groups, the share of people with one of these conditions in 1994 was about 9% and increased

[6]These chronic conditions include asthma, arthritis, back problem, high blood pressure, migraine, COPD, diabetes, heart disease, cancer, ulcer, bowel disorder, stroke, urinary incontinence, and Alzheimer's disease.

to 14% for women and 15.5% for men. Third, while women are more likely to have any chronic condition, men are more likely to have one of five specific conditions, especially during the last decade. When we compare both groups during the last decade by specific conditions, we conclude that men are more likely to have diabetes, hypertension (see Figure 5), or heart disease while women are more likely to have cancer with a less than 1 percentage point difference. Given that the proportion of people with stroke is less than 0.5% for both groups, the difference in having a stroke is negligible between men and women. In the literature, these gender based differences in chronic conditions have been explained by behavioral differences (i.e. cigarette smoking, heavy alcohol use, eating more red meat and fewer fruits and vegetables, and exposure to physical hazards), as well as differences in physiology between men and women. As stated, for example, in Barrett-Connor (1997) the differences in unhealthy behavior partially explain the increased risk of heart disease in men with the remaining risk explained by the differences in physiology.

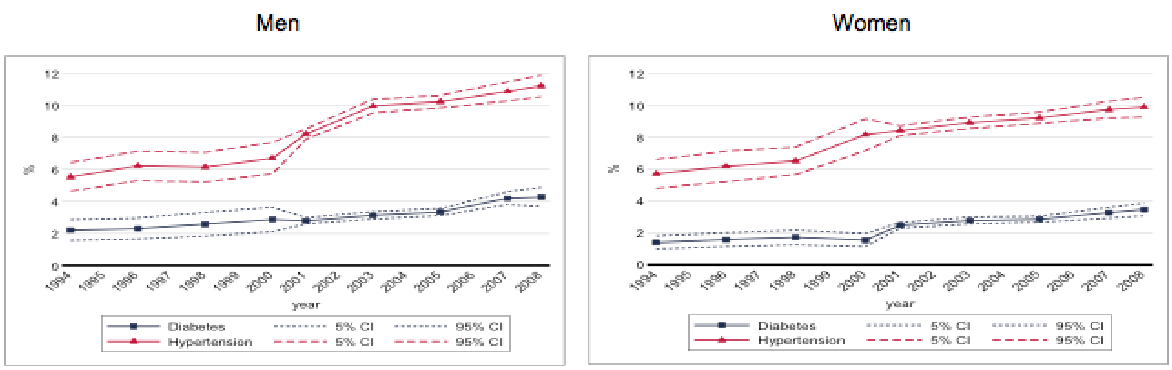
As outlined in this subsection, there are gender based differences in health outcomes among the Canadian adult population. In terms of self-reported health status, men reported better subjective health while they are more likely to have poorer health outcomes based on a chronic-conditions-based definition of health. For instance, a higher proportion of men had weight problems, diabetes, hypertension, or heart disease. Owing to this variation in health outcomes as well as differences in participation in sports and exercise, we stratify our study sample by sex in the empirical analysis below. The following section will describe our empirical strategy, followed by the results discussed in Section 5.

Figure 4: Chronic diseases for the Canadian population



Note: Mean values and 90% confidence interval of mean. Own calculations using the NPHS for the years 1994, 1996, 1998, and 2000, and the Canadian Community Health Surveys for the years 2001, 2003, 2005, 2007, and 2008. Values for the other years are linearly interpolated. Population is 20 to 59 years old in any given year. *Any conditions* include asthma, arthritis, back problem, high blood pressure, migraine, COPD, diabetes, heart disease, cancer, ulcer, bowel disorder, stroke, urinary incontinence, and Alzheimer's disease. *Any five conditions* include diabetes, hypertension, stroke, cancer, heart disease.

Figure 5: Diabetes and hypertension for the Canadian population



Note: Mean values and 90% confidence interval of mean. Own calculations using the NPHS for the years 1994, 1996, 1998, and 2000, and the Canadian Community Health Surveys for the years 2001, 2003, 2005, 2007, and 2008. Values for the other years are linearly interpolated. Population is 20 to 59 years old in any given year.

4 Empirical strategy for the research design

4.1 General empirical framework

We use a research design described below to estimate the causal effects of sports participation in Canada without using instrumental variables. Given that we do not have valid and strong enough instruments, our approach provides an alternative way to estimate a casual association of sports and exercise participation and the selected health outcomes. The basic idea of the approach is to take out a substantial part of any unobserved and confounding heterogeneity, i.e. factors that jointly influence the activity level and the health outcomes, by focusing the analysis on a population that is already homogeneous in a base period, here 1994. Since we are interested in the population of inactive individuals, we focus on this group. Furthermore, as the previous descriptive section documented substantial differences between men and women (see also the evidence in this respect provided by Andersen 1995; Cabane and Lechner 2014; Pate et al. 1995; Sari 2011), we split this group again by considering men and women separately. Within the gender specific strata, we perform a matching analysis, i.e. we control for (many) observable differences between the groups of individuals with the three different activity levels in the treatment period 1996. By including also baseline health variables among the confounders, and by using the homogeneous strata, it may be conjectured that this is a flexible way for dealing with unobserved confounders that have a time constant impact, similar to, but more flexible than a fixed effects model.[7]

Within each of the two strata, we estimate a probit model for each 'treatment' (i.e. active or moderately active or inactive) as determined by the individual activity level in 1996. Therefore, there are a total of 4 probit models (2 for each stratum by comparing active versus inactive, and moderately active versus inactive) estimated in our approach. Further details regarding the probit models, and the confounders included in these estimations are explained in the next section.

[7] Note that technically, this approach is motivated by Lechner (2009) and identical to the one used in Lechner and Sari (2015).

4.2 Determinants of physical activity and the propensity score matching

4.2.1 Determinants of physical activity, and the variables in the probit models

The determinants of physical activity have received substantial attention in academic and policy circles. We briefly summarize this literature below in order to use it as a guide to determine the set of confounders that are included in the four probit models.

The literature on the determinants of sports and exercise participation has focused on factors related to socio-economic characteristics, family composition, other health behaviors (e.g. smoking, diet), peer, family and community influences, and environmental determinants (for a recent review see Cabane and Lechner 2015). A large body of literature shows a consistent association between physical activity and age, sex, income, education, family characteristics, and occupational status (i.e. Sallis et al., 1999; Trost et al., 1996; Trost et al., 1997; Pate et al., 1997). The direction of the association is not necessarily the same across studies. Although many studies emphasize age as an important determinant in participation in sports and exercise, the direction of the association varies (e.g. Eberth and Smith, 2010; Garca, Lera-López, and Suárez, 2011; Humphreys and Ruseski, 2010; Stamatakis and Chaudhury, 2008). Several studies point out the gender differences, and suggest that men are more likely to participate in physical activity than women (e.g. Downward, 2007; Breuer and Wicker, 2008). The same is true for higher levels of education (e.g. Fridberg, 2010; Hovemann and Wicker, 2009), as well as higher income (Downward and Rasciute, 2010; Humphreys and Ruseski, 2010; Lechner, 2009). It has been indicated in many of the studies mentioned above that being an immigrant or a member of minority group is negatively associated with sports and exercise participation.

Household characteristics have also been associated with participation in sports and exercise. For instance the presence of young children in the household is negatively associated with the participation in physical activity for women (Eberth and Smith, 2010; Garcìa, Lera-López, and Suárez, 2011), but is essentially zero for men. Studies indicate the association between marital status and sports and exercise participation with, again, no agreement in terms of the direction of the relationship. Some studies report a positive association (i.e. Kaplan et al., 2001) while others report a weak or no association between marital status and physical activity (i.e. Trost et al., 2002). In relation to labor market participation, Downward (2004) finds a limited association of working hours with participation while Meltzer and Jena (2010) show that the intensity of exercise is positively associated with wage rates. Of course, one possible explanation for the diverging results across studies is the fact that the included control variables vary substantially across studies.

Bauman, Sallis, Dzewaltowski, and Owen (2002) provide further insights for additional factors affecting the participation decision in physical activity. They indicate that indicators for health status such as psychological, cognitive, and emotional factors are associated with sports and exercise participation. In addition, health behaviors (i.e. diet and smoking), social and cultural factors have been suggested as additional contributors for participation in sports and exercise. The association between physical activity and other health behaviors such as dietary habits and smoking is consistent across a large majority of studies. The literature also emphasizes the role of the previous activity state, and shows that past exercise behavior is a good predictor of current activity status (see Kohl and Hobbs, 1998; Trost et al., 2002; Dishman et al., 1985 for an extensive review).

4.2.2 Baseline comparisons, and probit estimations for matching

As described in Section 4.1, we divide the sample of individuals with the same baseline activity status into two gender specific strata. This initial stratification removes most of the heterogeneity among different treatment groups within each stratum. It is, however, likely that we may still have remaining differences among different treatment groups in relation to their characteristics affecting the decision to participate in sports and exercises, and their health outcomes. Therefore, we control the confounding factors in probit models in order to reach a causal interpretation of the results outlined in Section 5. To determine the relevant factors for the probit models, we follow the literature briefly described above. A full list of these control variables is listed in Appendix Table A.1., and a subset of variables with their descriptive statistics by treatment groups is presented in Table 1.

This table compares the socio-economic and demographic characteristics, labor market outcomes as well as health behavior and health outcomes across three activity status determined in 1996 (see Table A.1 in Appendix A for a more comprehensive list of variables). It shows the differences in selected baseline characteristics by treatment status for each stratum. Given that we restricted the sample to a relatively young cohort in 1994, the average age in 1994 is about 33 years. The table shows some differences between men and women with smaller variation within each stratum. For instance, while men are more likely to be regular smokers or alcohol drinkers, women are more likely to have a higher value on the depression scale. When we compare both groups based on physical health indicators, we observe that women are less likely to have any chronic conditions, but they report lower self-rated health. We also observe gender specific differences for the BMI, obesity and overweight measures. For all these measures, women in each activity level have lower BMI or are less likely to be obese or overweight. For other indicators, both groups have somewhat similar characteristics.

Table 1: Descriptive statistics for the study sample in 1994 by activity state in 1996

Variable	Men			Women		
Activity status in 1996	Active	Mod.	Inactive	Active	Mod.	Inactive
Health indicators						
Self-rated health (1: worst; 5: best)	2.93	2.95	2.84	2.94	2.92	2.8
Self-rated health (good/very good)	75	70	67	71	71	64
Health utility index (HUI)	0.88	0.9	0.89	0.91	0.91	0.88
Any chronic conditions	27	26	27	35	34	35
Any of five chronic conditions	-	6	5	-	5	6
BMI	26	26	26	24	24	25
Obese	15	16	13	11	12	14
Overweight or Obese	61	57	55	38	37	37
Cognitive problems	34	31	30	27	26	31
Depression scale	0.35	0.27	0.36	0.58	0.61	0.76
Distress scale	3.87	3.13	3.38	3.81	3.83	4.22
Health behavior						
Total energy expenditure from sports & exercise	0.77	0.71	0.5	0.75	0.7	0.51
Avg. daily number of alcoholic drinks (last week)	0.84	0.67	0.77	0.33	0.24	0.2
Regular smoker	41	35	40	34	32	33
Socio-economic characteristics						
Age	32	32	34	31	32	33
Married	61	60	60	64	58	66
Number of children younger than 12	65	66	66	100	83	90
Immigrant	10	10	12	14	9	14
University or college graduate	30	35	35	30	38	36
Secondary (high) school graduate	50	48	44	53	49	47
Lower than high school graduate	20	17	21	17	14	17
Home owned by household	61	68	66	61	62	61
Total annual household income in 1000 CAD	41	44	42	40	42	39
Employed	81	85	86	67	73	70
Living in a central metropolitan area (CMA)	52	53	52	61	57	55
# of observations in stratum	150	284	1099	156	407	1472

Note: Sample means (for indicator variables x 100) in the strata shown. Due to small cell size as determined by Statistics Canada, the percent of people with one of the five chronic conditions cannot be reported for actives. Any chronic conditions show the percentage of people with any of 14 chronic conditions (asthma, arthritis, back problem, hypertension, migraine, COPD, diabetes, heart disease, cancer, ulcer, bowel disorder, stroke, urinary incontinence, and Alzheimer's disease)

While differences between men and women are relevant, those by treatment status within each stratum are limited. This implies that a simple stratification eliminates most of the heterogeneity among treatment groups. In order to remove any remaining heterogeneity, we control for confounding factors in probit models. For instance, we use multiple dimensions of socioeconomic characteristics through several variables such as age, sex, and marital status, presence of young children in the household, immigration status, income, and education. In addition, we use proxy indicators for wealth measured by house ownership as well as size of the house (number of bedrooms). Following the literature mentioned above, we also control for baseline health outcomes using multiple dimensions of health such as self-rated and functional health measures, chronic conditions as well as mental health measures using depression and stress scales.

In order to capture behavioral aspects which would affect the health outcome and sports and exercise participation, we include variables measuring alcohol consumption, smoking behavior, and dietary concerns. Given that there will be variations within the inactive stratum in terms of intensity of participation in sports and exercise, we include total energy expenditure from LTPAs. Furthermore, non-leisure time physical activities during daily life are also used as additional confounding factors.

To control for labor market characteristics, we use several indicators such as employment status, particular features of their current job. We also include regional indicators. Those directly included in the analysis capture the type of region in terms of population size and density, as well as the regional average education and unemployment levels.

Using the full list of confounding factors listed in Appendix Table A.1, we estimate four probit models that are presented in Appendix B. One needs to keep in mind that these probit models are merely a technical tool to flexibly capture and remove the confounding influence of the covariates on the comparison of the treatment states. In our context, the purpose of the probit models is not to describe the selection into treatment in any causal manner.

4.2.3 Matching strategy and implementation of research design

The previous section showed that due to the informative data set used for this study there are little remaining concerns about unobservable confounding variables. Thus, an empirical approach taking into account these variables as control variables, like regression or matching type estimators do, should lead to causal conclusions even when only a cross-section is used. For this to hold, these variables should not be influenced by the treatment ('exogenous' in this particular sense)[8]. However, it is very likely that several, if not most, of the variables are influenced by past sports participation. This effect could occur contemporarily and/or after some time. Due to the stratification in our empirical design, individuals who are more or less active in 1996 share the same activity level (and sex) in 1994, therefore, within a stratum covariates measured in 1994 cannot be affected by different activity levels. As a result, this endogeneity problem is mitigated by using 1994 measurements of covariates together with stratification. Of course, the price to pay is that we miss if some of them changes between 1994 and 1996 prior to the corresponding change of the activity level.

As in the companion paper by Lechner and Sari (2015), propensity score matching using the estimator proposed by Lechner, Miquel, and Wunsch (2011) is applied. Such semi-parametric estimators provide advantages by allowing for effect heterogeneity without specific functional form assumptions for the relationship of the outcome variables with the treatment and confounders (see Lechner and Sari (2015) for further details and references to the respective econometric literature).

The price to pay due to using a base period and one treatment period only is that the meaning of the treatment may be somewhat different than in a standard non-dynamic or a fully dynamic setting.

[8]See Lechner (2010) for the necessary conditions in a non-parametric causal setting.

The reason is that, formally speaking, we estimate a short-term causal effect of sports activity: In the base period individuals are identical with respect to their activity level, and essentially the effect of a change in that level is identified and estimated with this approach. However, as shown in Lechner and Sari (2015), the current activity level has long lasting effects on future activity levels. Therefore, the effects to be presented capture more than contemporary, short term changes in activity levels.

5 Results

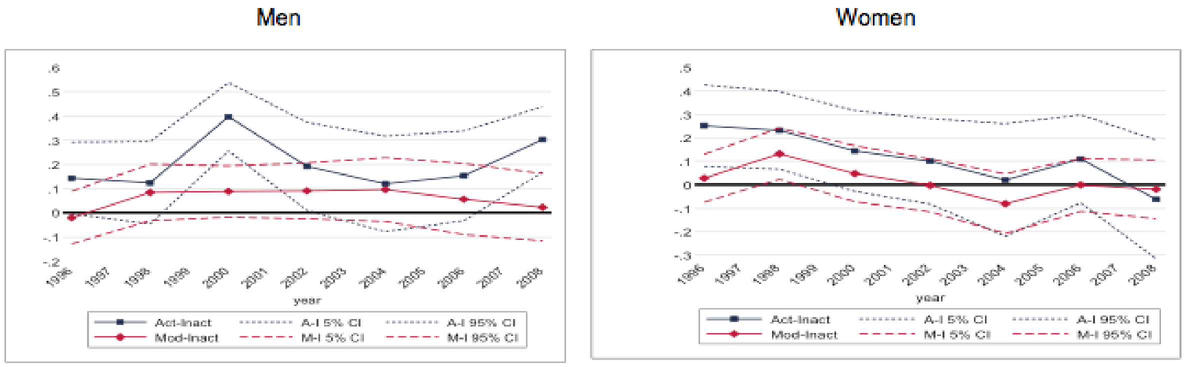
In this section, we discuss the effects of an increase in sports and exercise participation on a series of self-reported health and mental health indicators, body weight management, and chronic diseases. The average effects for women and men are presented in this section with additional results provided in Appendix C. In each figure we present the effect for the corresponding measure within one to 12 years after the 'intervention' of increased activity. The horizontal axis indicates the year while the vertical axis measures the average treatment effect (ATE) in the corresponding year.

5.1 Self-reported general health

In this subsection, we report the results for the self-reported health indicators. Figure 6 shows the results for self-rated health on a five scale while Figure 7 shows the results for a binary indicator measuring self-rated health reported as *good* or *very good*.

The left column of Figure 6 presents the impact of sports and exercise on self-rated health for men while the right column shows the same information for women. Self-rated health measures the health status of the participants on a rating scale of 1 to 5 with 1 is the worst (poor) and 5 is the best (very good) health state.

Figure 6: Self-rated health



Note: Self-rated health measures the health status of the participants on a rating scale of 1 to 5 with 1 is the worst (poor) and 5 is the best (very good) health state.

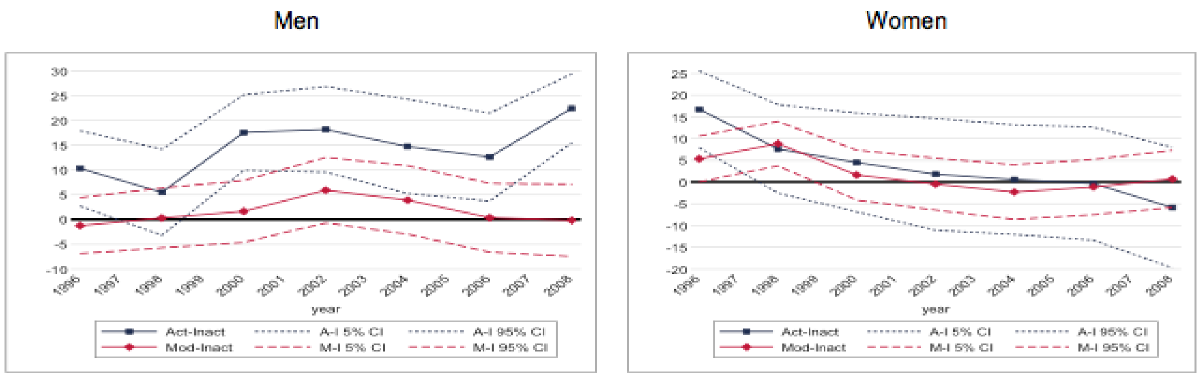
Among men, the results show that there are positive effects of activity on self-rated health. An increase in LTPA participation from inactive to only a moderate activity level generates a weak positive health effect, which is not statistically significant over the course of the study period. The figure, however, suggests that an activity level increased from inactive to active creates long-lasting positive health effects for men. This positive impact is not negligible. The effect generated from an activity level increased from inactive to active varies between 0.1 and 0.4, which corresponds to 3.4 to 13.7 percent of baseline average health status for inactive men. This is somewhat similar to the results estimated in the literature for short term effects of physical activity.[9]

In order to better assess the size of the effect presented in Figure 6 above, we create a binary indicator for good or very good self-rated health. As indicated in Figure 7, except for 1998, there is a persistent health effect from increasing the activity level from inactive to active level for men. The effect suggests that increasing the activity status to the active level compared to the inactive level increases the probability of reporting 'good' or 'very good' health by about 15 to 20 percentage points. This effect stays statistically significant throughout the study period. If the activity level

[9]For instance, Wicker, Coates, and Breuer (2014) conclude that a four-week fitness program creates significantly positive effect on subjective well-being and health of the participants to the program. The effect corresponds to 14% reported satisfaction with one's health.

only increased to a moderate level, as also indicated earlier, that does not generate substantial health effects as measured by this indicator.

Figure 7: Self-rated health (good or very good)



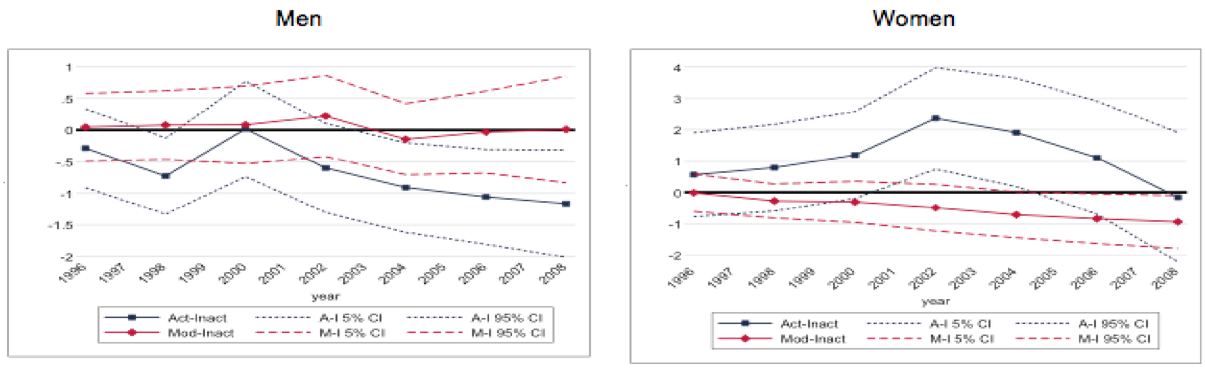
The implication of increased activity is not the same for women, because there appears no long-lasting subjective health effect for women. The results are similar even if we use a binary indicator for reporting 'good' or 'very good' health status.

5.2 Body weight management

In this section, we present the results for the impact of sports and exercise on body weight management. For this purpose, we present the results using the body mass index (BMI) and obesity in the main text, and present the additional results using body weight and an indicator for being overweight in Appendix C.1.

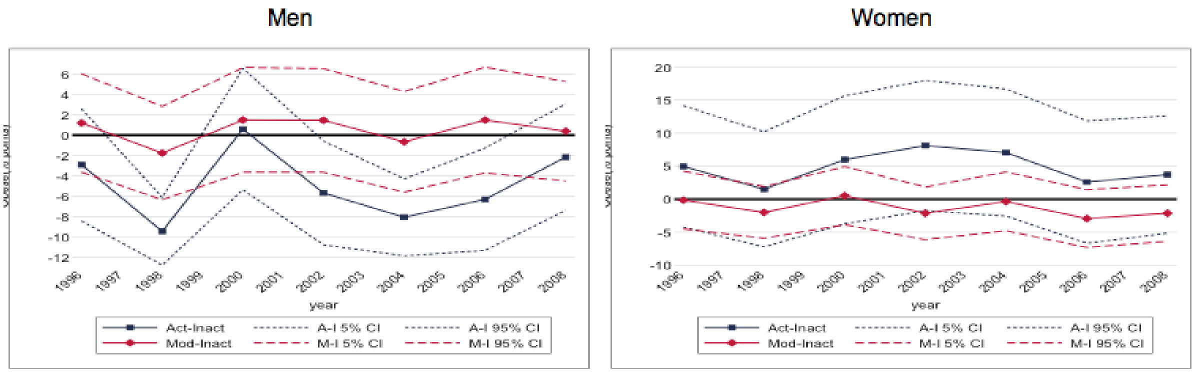
Figure 8 presents the impact of LTPA on the BMI for inactive men and women. The results in the figure illustrate that while increasing the activity status to a moderate level does not generate a clear impact on the BMI neither men nor women, further increases in activity levels beyond the moderate level of exercise decreases the BMI for men (only). For men, a higher level of activity decreases the BMI by about 0.5 to 1.0 points during the period of 2002-2008.

Figure 8: Body mass index



As an additional result, we present the impact of sports and exercise on the likelihood of being obese in Figure 9. The results are qualitatively similar to the ones presented for the BMI. LTPA has no detectable impact on being obese for women but decreases the likelihood of being obese for men. The figure indicates that the effect is not statistically significant at the beginning but it becomes large enough to be significant after 6 years for the inactive/active comparison. The result suggests that an increase in the activity level beyond a moderate level reduces the probability of being obese by 6 to 8 percentage points for men after 6 to 10 years. However, for the last 2 years of the study period the effect becomes insignificant.

Figure 9: Obesity



Although being subject to considerable sampling noise, our results for the BMI are comparable in magnitude to the findings that exist in the literature. For instance, Colman and Dave (2013) find that high levels of recreational activity relative to no or little activity reduce the BMI by about between 0.28 to 0.78 points while our estimates suggest that the BMI for men decreases by about 0.5 to 1.0 points due to a substantial increase in physical activity.

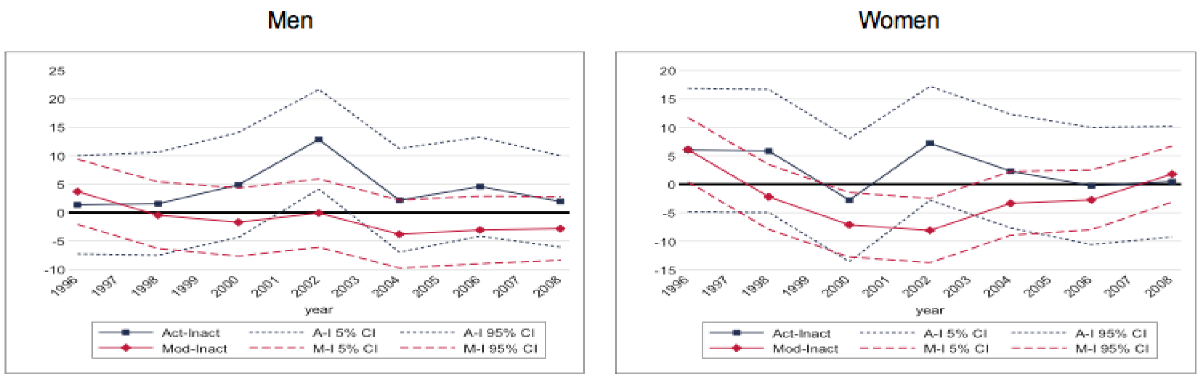
5.3 Chronic Diseases

In this section, we discuss the impact of participation in sports and exercise on developing chronic conditions. For this purpose, we use multiple measures that include whether individuals have any chronic conditions, the number of chronic conditions, and whether individuals have any of five specific chronic conditions that are shown to be associated with lack of physical activity.

We present the results for the impact of activity on having any chronic conditions for men and women in Figure 10. As shown in this figure, there is no detectable impact of LTPA for an increase in activity level from inactive to moderate or active levels. Other than a 5 percentage point impact in 2000-2002 period for women, there is no clear effect that can be detected in our results.

Our finding reported here is also consistent with the results when we use the number of chronic conditions as an alternative measurement for the severity of chronic conditions. These additional results are relegated to Appendix C.2.

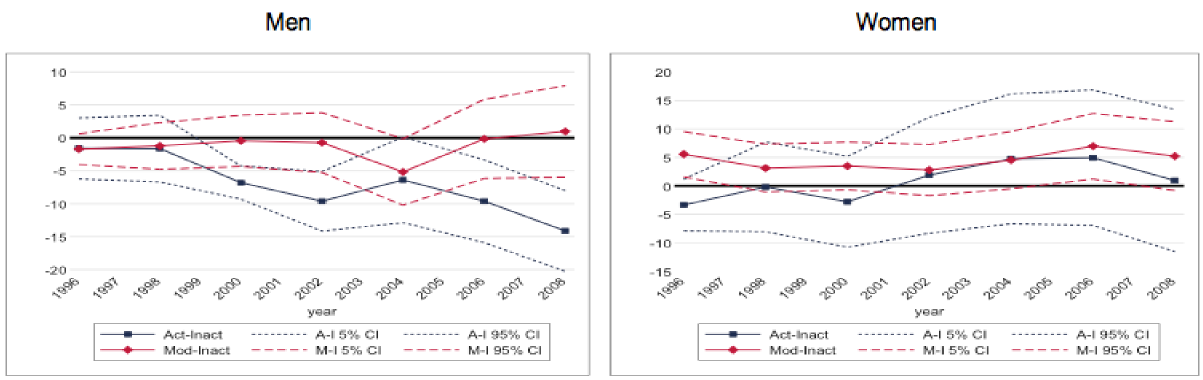
Figure 10: Any chronic conditions



As a next step to uncover potential impact of sports and exercise on chronic conditions, we use alternative measures specific to five chronic conditions (hypertension, diabetes, heart disease, stroke, and cancer). For this purpose, we present the results based on an indicator variable measuring whether an individual has any of these five conditions (Figure 11). In addition, we show additional results in Appendix C.2 that based on the number of conditions specific to these five conditions (Figures C.2.2), and on binary indicators for developing diabetes (Figures C.2.3) or hypertension (Figures C.2.4).

Figure 11 shows the results for the ATE based on an indicator variable which measures whether the individual develops any of the five specific conditions. As before, the effect is different for men and women. Although we detect a clear, long run impact of increasing physical activity for men, we do not see any detectable impact for women. The effect for men is clear-cut and statically significant for the inactive-active comparison as opposed to the inactive-moderately active comparison. For inactive men, starting from year 2000 the long-run effect of increasing physical activity beyond the moderate level of activity is clearly observed. The effects for the inactive-active comparison fluctuate around 5 to 10 percentage points, and even increases to 15 percentage points by the end of study period. In summary, the figure suggests that a higher level of physical activity beyond the moderate level decreases the likelihood of developing any of these five chronic conditions.

Figure 11: Any of the five chronic conditions



In Appendix C.2, we present additional results using the number of conditions out of these five specific conditions, or the likelihood of developing diabetes or hypertension. These additional results align well with the one presented in the main body of the text. Other than a small initial effect (about 1 percentage point) based on the binary indicator measuring whether the individual develops diabetes, we do not detect any long-run effect of physical activity for women. However, for men the effect is similar in magnitudes when we use binary indicators for developing diabetes or hypertension. In the post-2000 period, the effect is persistent and statistically significant for both indicators with magnitudes varying between 2 and 6 percentage points for diabetes (Figure C.2.3) or about 5 and 13 percentage points for hypertension (Figure C.2.4). Again this effect for hypertension and diabetes is comparable to the estimated long-run effect in the literature.[10]

5.4 Cognitive functioning and mental health

This section describes the results regarding the impact of participation in sports and exercise on cognitive and mental health. To do this, we use various measures based on information related to cognitive functioning, and mental well-being.

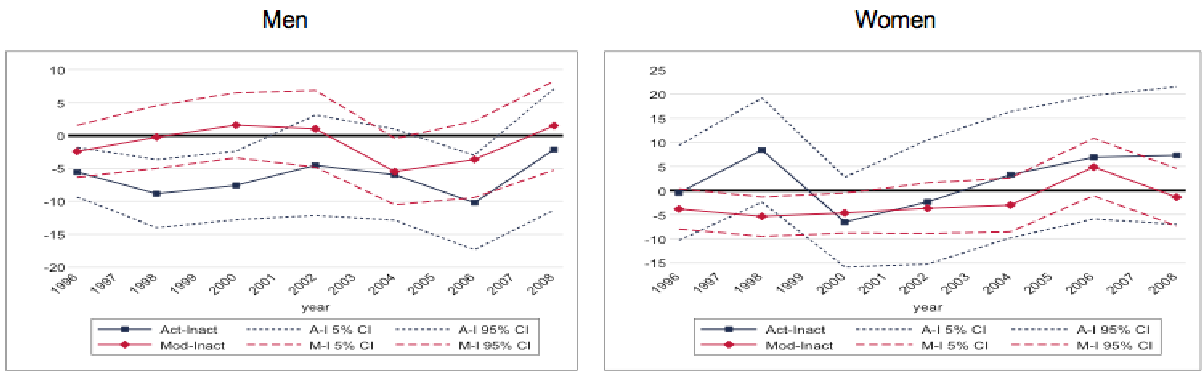
There is a limited but growing literature examining the relationship between physical activity and dementia, particularly Alzheimer's disease. These few existing studies indicate that physically active people are at a lower risk of developing cognitive impairment and have higher cognitive ability scores. There are also few randomized control studies investigating the effects of physical activity and fitness training on different aspects of perception and cognition (for a review see Reiner et al., 2013). Using an indicator variable measuring to identify *whether the individual has any cognitive problems*, we examine this issue, and present the effect of LTPA on cognitive health in Figure 12. The vertical axis in the figure measures the effect for the cognitive problems.

Figure 12 shows that an increase in activity from inactive to moderate level is not sufficient to generate a persistent impact on cognitive ability. In order to generate positive health effects for cognitive functioning, it needs to be increased beyond a moderate level of activity. For women, a moderate level of activity generates a weak effect (about a 5 percentage point lower cognitive problems) at the beginning but the impact disappears after the year 2000. Especially for men, the effect is much more persistent and significant. An activity level raised from inactive to active creates a substantial improvement in cognitive health in which the effect becomes significant following the intervention, and stays significant during most of the study period. As shown in Figure 12, for

[10] As stated in Colman and Dave (2013) a high level of recreational exercise reduces the probability of having high blood pressure by between 2.8 and 8.4 percentage points, and the probability of diabetes by as much as 2 percentage points.

men, cognitive problems are reduced by about 5 to 10 percentage points due to an increase of the activity to the active level in all years except the final one.

Figure 12: Cognitive problems

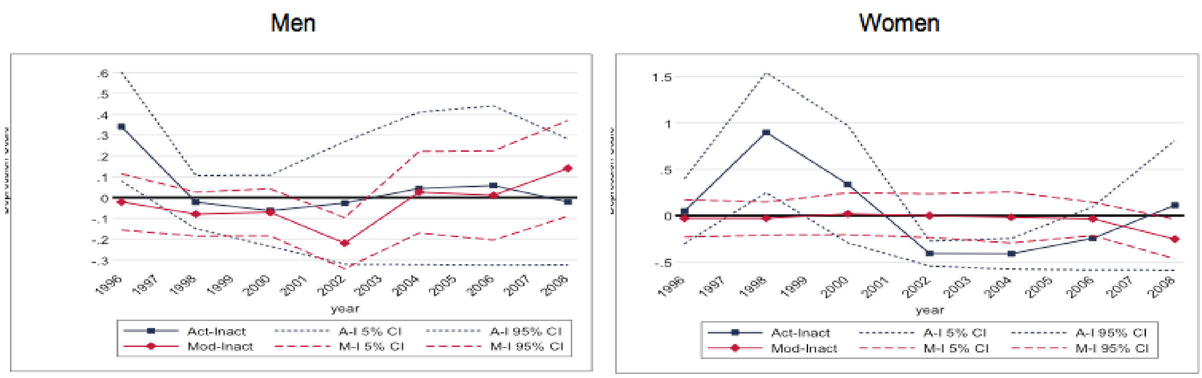


For women, the results suggest that there is a weak impact of participation in sports and exercise, but the effect is sometimes statistically significant. The initial (but only weakly significant) positive effect of increasing the level of activity from inactive to moderate is about 5 percentage points from 1996 to 2004.

In order to examine the effects of LTPA on mental well-being, we use depression and stress scales. The depression scale variable assesses the respondent's depression state based on the work of Kessler and Mroczek (1994). This is a short form score that captures the periods during which the respondent felt sad or depressed or lost interest in everyday life. The scale varies between 0 and 8 (higher values indicate higher level of depression). In Figure 12, we present the results using this depression scale measure for men and women.

As shown in the figure, there appears to be no significant effect of LTPA on the depression scale for men. However, the impact is somewhat different for women: An increase in physical activity reduces depression, and it is significant during the 2002-2004 period for the active-inactive comparison. Although, this positive mental health effect stays insignificant until 2006, it becomes large enough to be significantly negative by the end of the study period for an activity level increased from inactive to moderate. The size of the effect for both comparisons is around -0.25 that is comparable to the baseline depression scale of 0.69 for inactive women. However, it is not persistent during the study period, and potentially it may be just due to random noise.

Figure 12: Depression scale



When we use the numbers of week respondents felt depressed as an alternative measure, the result is somewhat consistent with the one presented above. These results (for details see Appendix C.3) indicate that there is a small and none-persistent effect for both men and women for the active-inactive comparison. The effect is about 0.5 to 1 week, and significant in the period 1998-2002 for men, and 2002-2006 for women (Figures C.3.1).

Our results, which indicate small or zero effects for men and women, are consistent with studies examining the short-run effects of physical activity on depression. For instance, Rees and Sabia (2010) state that their estimated effects of physical activity on depression become small in magnitude or statistically indistinguishable from zero when they control for time invariant unobservables using individual fixed effects.

In an effort to capture alternative dimensions of mental health and well-being, we also use additional indicators based on a distress scale. These variables for stress are based on the K6 scale which was developed to identify individuals with mental health problems that are severe enough to cause moderate to serious impairment in social and daily life functioning. It measures the frequency of each of six symptoms of mental illness or nonspecific psychological distress rather than specific mental illnesses.[11] Based on Kessler and Mroczek (1994), the K6 tool was developed to identify persons with mental health problems that require treatment. The distress scale variable varies between 0 and 24 with higher values indicating a higher stress level. For a detailed discussion and description of the tool see Kessler et al. (2002) and Kessler et al. (2003).

Using the distress scale described above, we present the effect of sports and exercise participation on distress in Figures 13 and 14. While Figure 13 shows the effect using a level variable using the distress scale directly, Figure 14 shows the results using a binary indicator that measures a serious level of psychological distress (distress scores higher than 12).

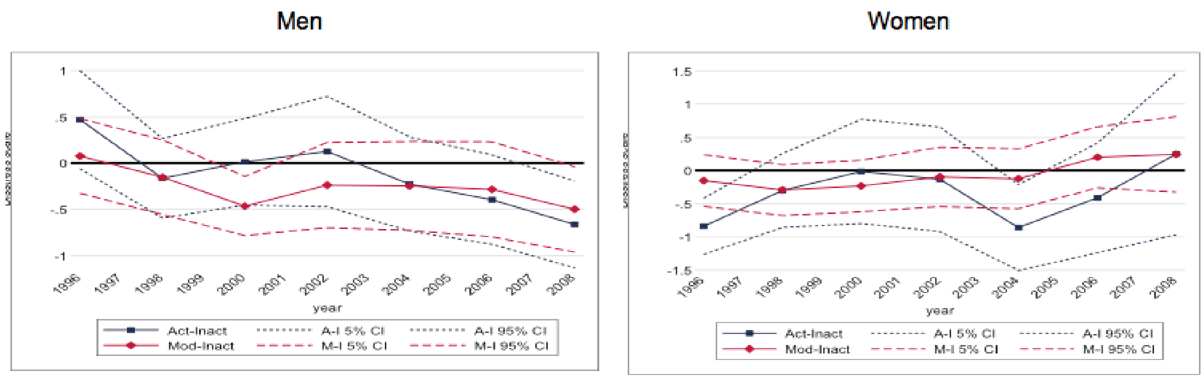
The left panel of Figure 13 indicates that an increase in activity decreases the nonspecific psychological distress level for men. We observe this effect for an activity level increased from inactive to moderate as well as for an increase to active. As shown in the figure there is no immediate gain from increasing the activity level with some evidence suggesting that there might be long term effects of sports and exercise in reducing stress levels. For the inactive to moderate comparisons, the effect becomes negative after 1996 and stays negative for all years. However, the impact becomes statistically significant only by the end of the study period. For increasing the activity level beyond moderate levels of activity, there are positive gains in improving levels of stress that are significant towards the end of the study period. The size of the effect is around 0.5

[11] These symptoms are to feel very sad, nervous; restless or fidgety; hopeless; that everything was an effort; and worthless. The frequency of each feeling is asked to be described with one of the following options: never, a little of time, some of the time, most of the time, all of the time.

for both comparisons that is equivalent to 15% of the baseline distress scale for inactive men.

As shown by the figure in the right panel, an increase in activity does not lead to any clear-cut impact on distress for women. Despite a positive impact of LTPA for men, we observe no health effects for women when we use this distress scale as a measure.

Figure 13: Distress scale



As described above, this scale is an index variable with a range of 0 to 24 with higher values indicating higher level of distress. An alternative is to use a binary indicator measuring serious psychological distress. To do this, we follow Kessler et al. (2004), and create a dichotomous variable using distress scores of 12 as a cut-off value. The results based on this variable are presented in Figure 14. This figure indicates that a higher level of activity beyond the moderate level improves the mental well-being of individuals for men as well as for women. However, the impact is not long lasting for women. The initial effect of 1 to 2 percentage points continues for about four years, but then it becomes statistically insignificant for women while becoming stronger for men.

Figure 14: Serious psychological distress

As shown in Figure 14, the effect for men in the active-inactive comparison is significant in all years except the last year of the study period. It fluctuates around 2 percentage points. Towards the end of the study period it becomes smaller and insignificant. When these results are evaluated within the context of the baseline values for this indicator, it is non-negligible. In our study sample the percentage of inactive men and women with serious psychological distress at the baseline is 2.02% and 3.59% respectively. Hence, effects of 1 to 2 percentage points are substantial, and have important consequences for the mental health and well-being of the individuals.

These results are suggestive of long-term mental health effect of physical activity, and are consistent with a body of literature on short-term effects of sports and exercise in which regular exercise is offered as a means of treating depression, anxiety and enhancing self-esteem, improving mood states, and developing resilience to stress (e.g. Fox 1999; Warburton, Nicol, and Bredin 2006; Penedo and Dahn 2005). For instance, Hamer, Stamatakis and Steptoe (2009) use a psychological distress scale derived from a self-reported General Health Questionnaire (GHQ-12), and show that participation in walking and sports of more than once a week has a substantial impact on the stress level. In another study, Sturm and Cohen (2014) use the 5-item mental health inventory (MHI-5) from the Medical Outcomes Study as their outcome variable while they use the proximity to a park as a proxy for the physical activity status. The MHI-5 scale is scored from zero to 100 with higher values indicating better mental health. Their results show that the mental health index decreases by 2 points for individuals living more than 1/4 miles away from a park compared to the ones living closer to the park.[12] Their estimated effect of a 2 points reduction in the mental health scale is consistent and similar in magnitude to our results presented above.

6 Conclusion

We examine the long-run effects of participation in sports and exercise on various aspects of individuals' health. Using a Canadian panel data covering the period of 1994 to 2008, we estimate the effects of leisure time physical activity, i.e. sports and exercise, on health outcomes for inactive men and women. The results indicate that an increase in leisure time physical activity improves individuals' physical health and mental well-being. These effects are stronger and more persistent for men than for women.

The results further suggest that an activity level increased from inactive to active creates long-lasting positive physical health effects for men. For instance, it increases the probability of reporting 'good' or 'very good' self-rated health by about 15 to 20 percentage points; reduces the BMI by about 0.5 to 1.0 points; and decreases the probability of being obese by 6 to 8 percentage points. In addition to these indicators, a higher level of leisure time physical activity also decreases the likelihood of developing any of five chronic conditions. The impact due to additional sports and exercise beyond the moderate level could be as high as 15 percentage points by the end of study period.

[12] They also show that mental health declines by 4.5 points for resident living more than 1/2 miles, but less than 1 mile from a park, compared to residents within 1/4 miles from the park.

Our results also show that an activity level raised from inactive to active creates a substantial improvement in cognitive functioning and mental well-being. While we find that cognitive problems are reduced by about 5 to 10 percentage points for men, we do not find robust statistically significant effects for women. Based on psychological distress indicators, the results show that a higher level of activity beyond the moderate level improves mental well-being of individuals for men as well as for women. However, the impact is not long lasting for women.

This paper has important implications for current physical activity guidelines adopted by the national and international organizations. In order to meet the minimum activity level, the guidelines recommend that adults should accumulate a total of 150 minutes of moderate intensity activities in a given week. However, our study suggests that this is not sufficient for individuals to derive substantial health benefits of physical activity. Instead, individuals need to increase their activity level beyond the recommended moderate level of physical activity.

As indicated above, our study does not offer strong statistically significant effects of long run health benefits of physical activity among women. This could be due to differences in physiology between men and women and the way that women cope with stress and mental health. It is also likely that we do not have enough statistical power in our study to precisely estimate the (probably smaller) effects of physical activity for women. Future research with a special focus on this subgroup is needed to learn more on this. A further open issue that deserves attention in future research concerns the question whether all dimensions of sports and exercise have the same health effects. In this study, we concentrate on the intensity (energy expenditure) dimension of the all activities taken together. However, it may well be that different types of exercise and sports (e.g. team sports vs. running) lead to different (in particular mental) health outcomes.

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Online Appendix A: Additional descriptive statistics

Table A1: Coefficients of probit estimations for active vs. inactive comparison

	Men			Women		
Activity level in 1996	Active	Moderate	Inactive	Active	Moderate	Inactive
Age	32	32	34	31	32	33
Married/have a common law partner	61	60	60	64	58	66
Number of children of age < 12	65	66	66	100	83	90
Immigrant	10	10	12	14	9	14
University / college graduate	30	35	35	30	38	36
Secondary school graduate	50	48	44	53	49	47
Average daily # of alcohol consumption (past week)	0.84	0.67	0.77	0.33	0.24	0.2
2-6 times per week alcohol Drinker (last year)	26	26	26	26	26	26
BMI	26	26	26	24	24	25
Regular smoker	41	35	40	34	32	33
Self-rated health (1: worst; 5: best)	2.93	2.95	2.84	2.94	2.92	2.8
Health utility index (HUI)	0.88	0.9	0.89	0.91	0.91	0.88
Depression scale	0.35	0.27	0.36	0.58	0.61	0.76
Activities prevented by pain	-	6	6	10	7	11
Distress scale	3.87	3.13	3.38	3.81	3.83	4.22
At least one of 5 chronic conditions	-	6	5	-	5	6
Any chronic conditions	35	36	36	51	46	46
Home owned by household	61	68	66	61	62	61
Number of bedrooms in home	2.7	2.7	2.8	2.9	2.8	2.9
Total annual household income in 1000 CAD	41	44	42	40	42	39
Employed	81	85	86	67	73	70
Occupation in management, business, finance, administration, sciences	17	24	25	35	39	40
Usually sit during daily activities	13	23	19	21	20	22
Total energy expenditure from LTPAs	0.77	0.71	0.5	0.75	0.7	0.51
Not biking in non-leisure time	89	92	94	95	96	96
Not walking in non-leisure time	42	44	53	37	37	38
Injuries other than repetitive strain injuries (last year)	25	22	19	17	16	14
Male 25+ unemployment rate	10	10	10	0	10	10
Highest schooling rate 15+ aged: Less than grade 9	13	12	14	12	12	13
Regional density in logarithm	-5.7	-5.6	-5.4	-5.8	-5.9	-5.7
Central metropolitan area	52	53	52	61	57	55
Observations	150	284	1099	156	407	1472

Note: Sample means shown. All variables are measured in 1994. Due to small cell size, we cannot report statistics for the corresponding cells. HUI is a quality adjusted health status indicator which describes an individual's overall functional health with a single numerical value for any possible combination of levels of eight self-reported health attributes (vision, hearing, speech, mobility, dexterity, cognition, emotion, and pain and discomfort). For a detailed explanation see Furlong, Feeny, Torrance (1999).

Online Appendix B: Probit estimations for inactive strata

Table B1: Coefficients of probit estimations for the moderate vs. inactive comparison

	Men		Women	
Variable	Coefficient	p-value (%)	Coefficient	p-value (%)
Age	-0.01	21.1	-0.02	2.1
Married/have a common law partner	0.167	17.2	0.041	76.6
Number of children of age < 12	0.031	60.8	-0.026	64
Immigrant	-0.026	87.7	-0.084	61.7
University / college graduate	-0.258	12.2	-0.18	35.7
Secondary school graduate	-0.049	73.4	-0.015	93.4
Average daily # of alcohol consumption (past week)	-0.06	28.2	0.124	20.3
Daily alcohol drinker (last year)	0.195	48	0.378	53.3
2-6 times per week alcohol drinker (last year)	0.05	71.3	0.055	78.3
BMI	0.001	96.1	-0.018	15.7
Regular smoker	-0.037	75	0.069	57.6
Self-rated health	0.036	60.5	0.047	53.6
Health utility index	-0.178	64.9	0.715	9.8
Depression scale	-0.036	43.2	-0.057	9.8
Activities prevented by pain	0.187	49.6	0.251	21.2
Distress scale	0.032	10.7	0	99.1
At least one of 5 chronic conditions	-0.474	11.9	-0.26	42.8
Other chronic conditions	-0.132	24.5	0.036	76.5
Home owned by household	0.02	89.1	0.056	69.9
Number of bedrooms at home	-0.022	73.6	0.026	71.1
Total annual household income/10000	0.019	45	0.001	98.2
Employed	-0.132	37.7	0.157	58.6
Not in labor force	-	-	0.268	38.8
Occupation in management, business, finance, administration, sciences	-0.216	14.3	-0.092	48.7
Usually sit during daily activities	-0.246	12.4	0.043	76.1
Total energy expenditure from LTPAs	0.694	0	0.712	0
Not biking in non-leisure time	-0.068	73.8	-0.1	69.1
Not walking in non-leisure time	-0.206	5.3	-0.134	24
Injuries other than repetitive Strain injuries (past 12 months)	0.073	56.8	0.223	13.1
Male 25+ unemployment rate	0.921	24	-2.798	0.7
Highest schooling rate 15+ aged: Less than grade 9	-0.733	40.9	-0.261	78
Regional density in logarithm	-0.036	24.1	0.036	30.2
Central metropolitan area	-0.044	75.1	0.117	38.3
Constant term	-1.093	11.5	-1.165	16.5
Efron's Pseudo R^2 in %	8.2		5.8	

All covariates are measured in 1994.Dependent variable is 'active in 1996'. Sample includes active and inactive individuals (1996) for inactive strata as defined in 1994.

Table B2: Descriptive statistics for study sample in 1994 by activity status in 1996

	Men		Women	
	Coefficient	p-value	Coefficient	p-value
Age	-0.005	44	-0.004	51.8
Married	0.043	68	-0.205	4.1
Number of children of age < 12	0.012	82.8	-0.046	31.3
Immigrant	-0.136	32	-0.301	3.2
University / college graduate	-0.083	53	-0.185	17.8
Secondary school graduate	0.066	58.8	0.049	70.1
Average daily # of alcohol consumption (past week)	-0.043	36.1	-0.011	89
2-6 times or daily per week alcohol drinker (last year)	-0.126	27.3	0.19	18.8
BMI	-0.003	73.7	-0.002	78.3
Regular smoker	-0.005	95.5	0.01	91.8
Self-rated health	0.019	74.9	0.013	81.4
Health utility index	0.194	58.5	0.304	39.1
Depression scale	-0.082	7.3	0.009	70.8
Activities prevented by pain	0.392	7.7	-0.158	34.8
Distress scale	0.002	89.9	-0.011	37.7
At least one of 5 chronic conditions	0.028	88.6	-0.226	22.8
Other chronic conditions	0.022	81.5	-0.055	52.3
Home owned by household	0.114	33.5	0.068	51
Number of bedrooms at home	-0.055	30.1	-0.049	31.6
Total annual household income/10000	0.022	30.3	0.048	2.7
Employed	-0.081	52.8	0.201	30.5
Not in labor force	-	-	0.354	9.1
Occupation in management, business, finance, administration, sciences	-0.102	36.1	0.04	68.1
Usually sit during daily activities	0.152	15.7	0	99.7
Total energy expenditure from LTPAs	0.649	0	0.612	0
Not biking in non-leisure time	-0.005	97.4	0.143	48.3
Not walking in non-leisure time	-0.15	8.9	0.021	80.4
Injuries other than repetitive Strain injuries (past 12 months)	0.006	95.9	0.236	3.5
Male 25+ unemployment rate	0.112	88.2	0.328	61.6
Highest schooling rate 15+ aged: Less than grade 9	-1.129	11.3	-0.543	43.8
Regional density in logarithm	-0.042	7.6	-0.046	5
Central metropolitan area	-0.187	8.1	-0.136	16.3
Constant term	-1.021	9.2	-1.626	0.5
Efron's Pseudo R^2 in %	6.5		6.5	

Note: All covariates are measured in 1994.Dependent variable is 'moderately active in 1996'. Sample includes moderately active and inactive individuals (1996) for inactive stratum as defined in 1994.

Online Appendix C: Additional results

Online Appendix C.1: Results for body weight management

Figure C1.1: Body weight

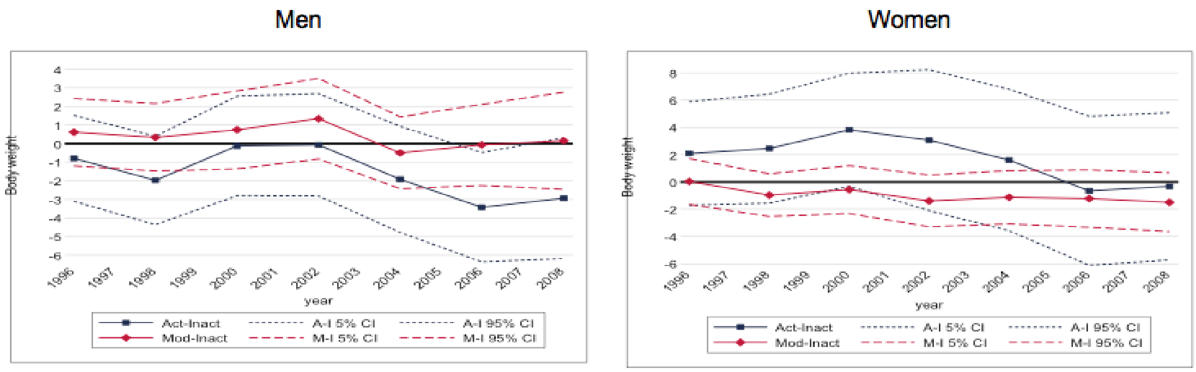
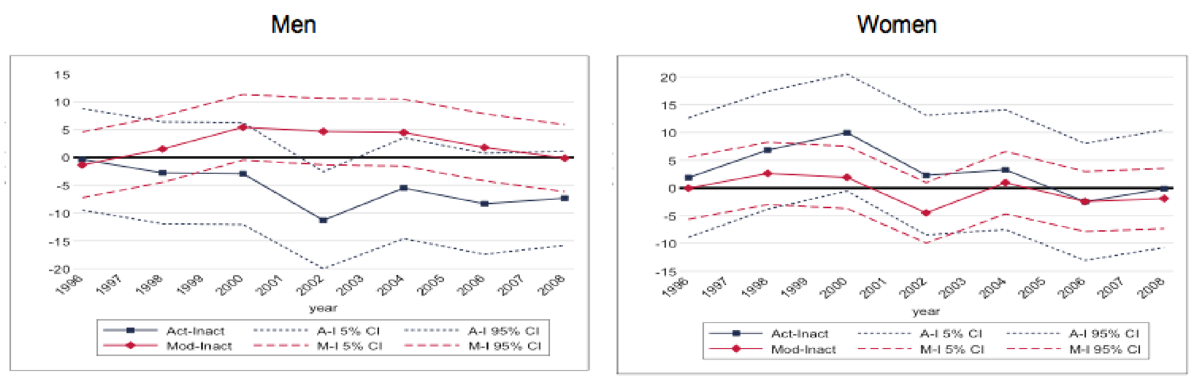


Figure C1.2: Overweight



Online Appendix C.2: Results from alternative chronic condition measures

Figure C2.1: Number of chronic conditions

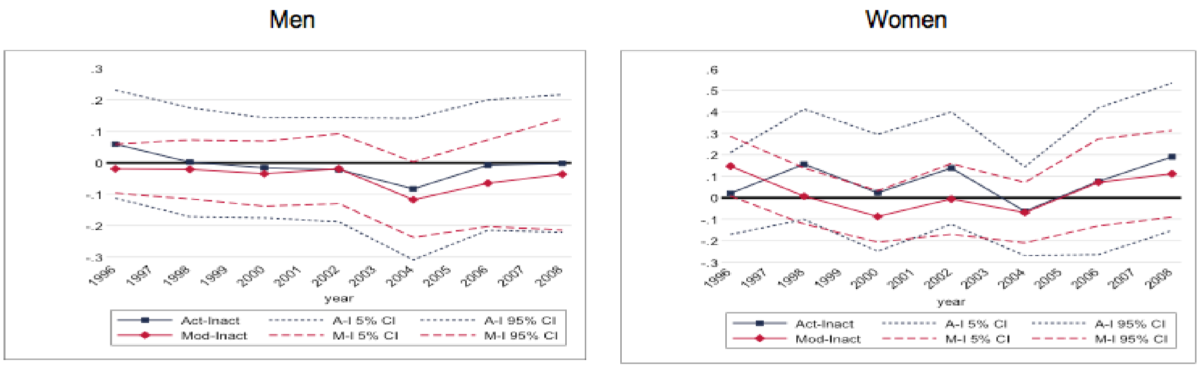


Figure C2.2: Number of chronic conditions for the five specific conditions

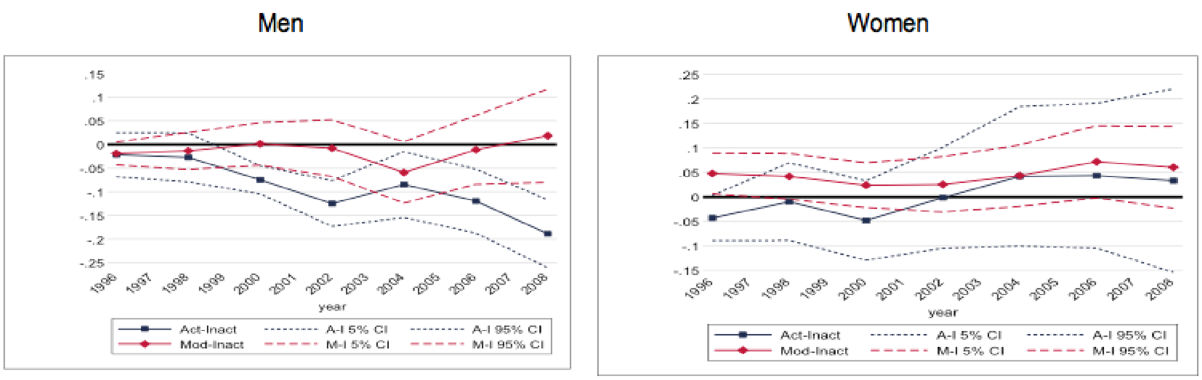


Figure C2.3: Likelihood of developing diabetes

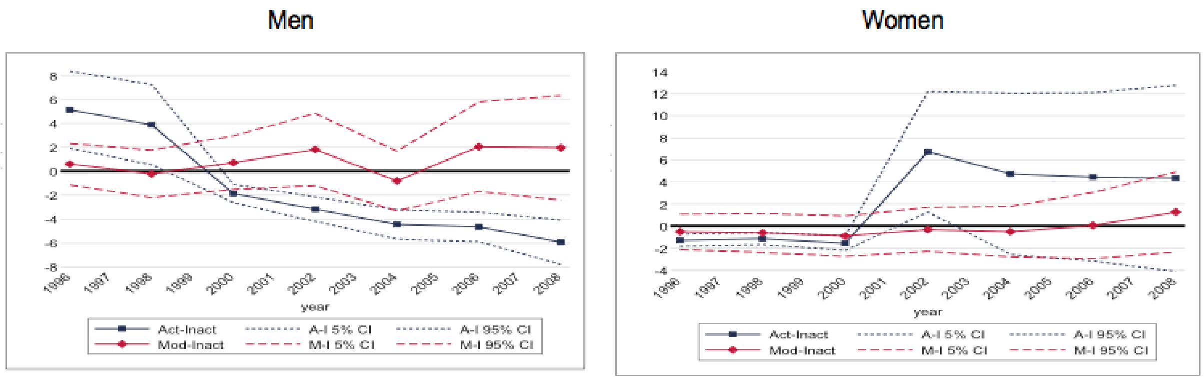
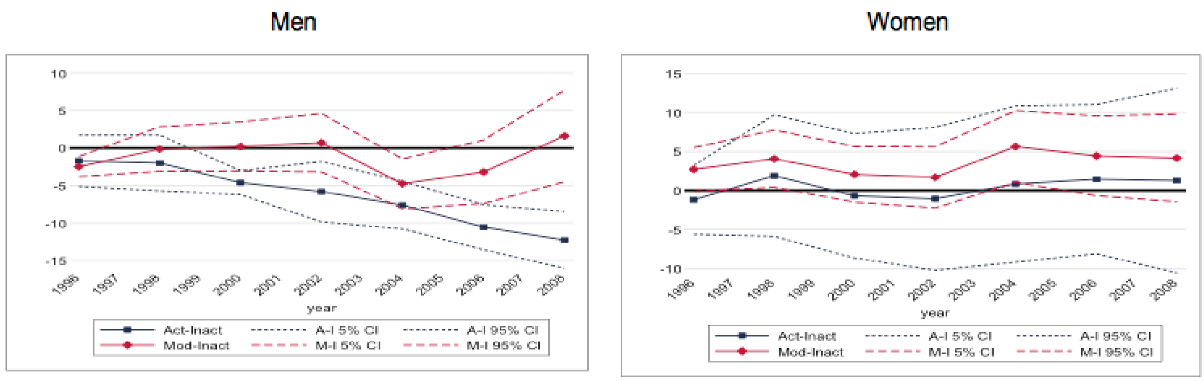


Figure C2.4: Likelihood of developing hypertension



Online Appendix C.3: Results from alternative mental health measures

Figure C3.1: Numbers of week respondent felt depressed