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Research

Cancer incidence attributable to inadequate physical activity in Alberta in 2012

Darren R. Brenner PhD, Abbey E. Poirier MSc, Anne Grundy PhD, Farah Khandwala MSc, Alison McFadden BSc, Christine M. Friedenreich PhD

Abstract

Background: Physical inactivity has been consistently associated with increased risk of colorectal, endometrial, breast (in postmenopausal women), prostate, lung and ovarian cancers. The objective of the current analysis was to estimate the proportion and absolute number of site-specific cancer cases attributable to inadequate physical activity in Alberta in 2012.

Methods: We used population attributable risks to estimate the proportion of each site-specific cancer attributable to inactivity. Relative risk estimates were obtained from the epidemiological literature, and prevalence estimates were calculated with the use of data from the Canadian Community Health Survey cycle 2.1 (2003). Respondents who acquired 1.5–2.9 kcal/kg per day and less than 1.5 kcal/kg per day of physical activity were classified as moderately active and inactive, respectively, and both levels were considered inadequate for mitigating cancer risks. We obtained age-, sex- and site-specific cancer incidence data from the Alberta Cancer Registry for 2012.

Results: About 59%–75% of men and 69%–78% of women did not engage in adequate physical activity. Overall, 13.8% of cancers across all associated cancers were estimated to be attributable to inadequate physical activity, representing 7.2% of all cancers diagnosed in Alberta in 2012. Suboptimal levels of physical activity had a greater impact among women: the proportion of all associated cancers attributable to inadequate physical activity was 18.3% for women and 9.9% for men.

Interpretation: A substantial proportion of cancer cases diagnosed in Alberta were estimated to be attributable to inadequate physical activity. With the high prevalence of physical inactivity among adults in the province, developing strategies to increase physical activity levels could have a notable impact on reducing future cancer burden in Alberta.

In 2010, the World Health Organization identified physical inactivity as the fourth-leading cause of global mortality.[1] In Canada, levels of physical inactivity remained high and relatively stable between 2003 and 2014.[2] Based on the 2007–2008 Canadian Community Health Survey (CCHS), the Public Health Agency of Canada estimated that 53.1% of women and 49.2% of men in this country are classified as physically inactive, as measured by leisure time energy expenditure.[3] Colley and colleagues[4] reported in 2011 that 85% of Canadian adults did not meet Canada's physical activity recommendation of at least 150 minutes per week of moderate to vigorous physical activity, accumulated in bouts lasting at least 10 minutes using accelerometry-based measurement.

One of the major implications of increasing levels of physical inactivity is the potential impact on the incidence of several common cancers. The World Cancer Research Fund concluded in its 2007 report that the evidence associating higher levels of physical activity and lowered cancer risk was "convincing" for colon cancer and "probable" for breast cancer in postmenopausal women and endometrial cancer.[5] It has been estimated that 21%–25% of the burden of breast and colon cancer is attributable to physical inactivity.[1] In addition, there is strong evidence that the risk of development of lung,[6] ovarian[7] and prostate cancer[8,9] is linked to physical activity levels. In Alberta in 2012, there were 8215 incident cases of cancer at sites shown to be associated with inadequate physical activity.[10]

Studies of population attributable risk in the United Kingdom and Australia have estimated that 3275 and 1814 incident cancer cases, respectively, could be attributable to inadequate

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Correspondence to: Darren Brenner, Darren.Brenner@albertahealthservices.ca

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levels of physical activity.[11,12] However, these studies considered only colon, breast and endometrial cancers. We previously estimated that, in Canada, 5.8% and 10.2% of cancers in men and women, respectively, could be attributed to inadequate physical activity (energy expenditure < 3 kcal/kg per day).[13] The objective of this analysis was to estimate the proportion and absolute number of site-specific cancer cases attributable to inadequate physical activity in Alberta in 2012.

Methods

This paper is part of a series of exposure-specific manuscripts concerning the proportion of cancer cases attributable to modifiable lifestyle and environmental risk factors in the general population of Alberta. The methodologic framework for the series' methods has been previously described.[14]

Latency period

The cancer risk associated with inadequate physical activity is understood to be the result of past exposure to inadequate physical activity. Thus, we identified a 7- to 10-year latency period based on previous literature.[13] As has been previously described,[14] we considered the theoretical latency period to be the time between initiation of exposure and cancer diagnosis, and the measured latency period to be the time between exposure measurement and cancer diagnosis. We used data from CCHS cycle 2.1 (2003) to estimate the prevalence of physical inactivity among Alberta adults as this cycle corresponded to the midpoint of the latency period suggested by cohort studies for the cancer sites of interest.[15–19]

Prevalence of exposure

The CCHS collected information on the nature, frequency and duration of leisure-time physical activity. The survey is considered representative of the general Canadian population excluding full-time members of the Canadian Armed Forces, people living on reserves or other Aboriginal settlements, and people living in institutions. Details of the methods used for the CCHS were published previously.[20]

In the CCHS, physical activity levels were based on leisure time physical activity only. The derived daily energy expenditure variable was based on the number of times a respondent engaged in a given activity each day multiplied by the average duration of the activity. This product was then multiplied by the energy cost (kilocalories per kilogram of body weight per hour) of the activity. Questions on leisure time physical activity from the 2003 CCHS and the method for estimating daily energy expenditure can be found in Appendix 1, Supplementary Table 1 (available at www.cmajopen.ca/content/5/2/E338/suppl/DC1). Respondents were classified as physically active (energy expenditure ≥ 3.0 kcal/kg per day), moderately active (1.5–2.9 kcal/kg per day) or inactive (< 1.5 kcal/kg per day). The "physically active" category generally reflects a level of regular, daily activity for at least 30 minutes a day. In terms of cancer prevention, being in the moderately active group is suboptimal;[21] thus, this category is referred to as "moderately inactive" in this analysis. Moderate inactivity and inactivity were both considered as inadequate physical activity levels, and we analyzed these 2 categories independently and as a combined variable in order to determine the population attributable risks of cancer due to inadequate physical activity.

Risk estimates

The cancer sites with the most consistent evidence of association with inadequate physical activity include the colon, endometrium, breast, prostate, lung and ovary.[22] We took risk estimates used for estimating population attributable risks of cancers of these sites from recent reviews and meta-analyses[5–9,23–28] (Table 1). Detailed information on the studies from which we abstracted the relative risks (RRs) is presented in Appendix 1, Supplementary Table 2. The same RRs were

Table 1: Risk estimates for risk associated with inadequate physical activity by cancer site of interest

		Activity level; relative risk			Activity level; excess relative risk	
Cancer site	Sex	Active*	Moderately active†	Source	Moderately inactive†	Inactive§
Lung	Both	0.70	0.84	Tardon et al.[6] 2005	1.20	1.43
Colorectum	Both	0.76	0.87	Wolin et al.[23] 2009 and Wolin et al.[27] 2011	1.15	1.32
Prostate	Men	0.95	0.98	Liu et al.[9] 2011, Leitzmann[8] 2011	1.03	1.05
Breast¶	Women	0.75	0.87	Friedenreich et al.[24] 2008, Lynch et al.[28] 2011	1.16	1.33
Ovary	Women	0.81	0.90	Olsen et al.[5] 2007	1.11	1.24
Endometrium	Women	0.70	0.84	Cust et al.[26] 2011	1.20	1.43

*Protective effects associated with engaging in 3.0 kcal/kg per day or more of physical activity during leisure time.
†Protective effects associated with engaging in 1.5–2.9 kcal/kg per day of physical activity during leisure time.
‡Increased risk estimates associated with engaging in 1.5–2.9 kcal/kg per day physical activity during leisure time.
§Increased risk estimates associated with engaging in less than 1.5 kcal/kg per day of physical activity during leisure time.
¶In postmenopausal women only.

also used in our previous paper on the attributable risks of cancer due to physical inactivity in the Canadian population.[13] We abstracted and further screened relevant RRs, and those applicable to our prevalence data were selected for estimation of population attributable risk. To quantify the effect of physical inactivity, we estimated the increased risk associated with being physically inactive as (1 / RR) – 1.

Estimation of population attributable risk

We used the method applied by Parkin[11] to estimate population attributable risks associated with being either moderately inactive or inactive, using the following equation:

$$\text{Population attributable risk} = [(pe_1 \times ERR_1) + (pe_2 \times ERR_2)] / 1 + [(pe_1 \times ERR_1) + (pe_2 \times ERR_2)]$$

where pe_1 is the prevalence of moderate inactivity, pe_2 is the prevalence of inactivity, and ERR_1 and ERR_2 denote the excess RRs associated with moderate inactivity and inactivity, respectively.

We then multiplied the population attributable risks by the number of incident cancer cases of interest in Alberta in 2012, obtained from the Alberta Cancer Registry, to determine the excess attributable cases for each cancer site. For breast cancer in postmenopausal women, only breast cancers diagnosed after 55 years of age were included, as the median age at menmenopause is 50–51 years among North American women.[29,30] We estimated the total proportion of cancer cases estimated to be attributable to inadequate physical activity at each individual cancer site as the total number of excess attributable cases for that cancer across all age groups divided by the total number of observed cancers at that site for both men and women individually and combined.

All analyses were conducted with the use of RStudio version 0.98.1080 (R Studio, Inc.).

Ethics approval

Ethics approval was obtained from the Conjoint Health Research Ethics Board, University of Calgary.

Results

Prevalence

Prevalence estimates of moderate inactivity and inactivity among men and women in Alberta are presented in Table 2. Overall, 41.2% (95% confidence interval [CI] 38.6–43.8) to 53.0% (95% CI 50.0–56.0) of adults were physically inactive, and 21.8% (95% CI 19.3–24.2) to 28.6% (95% CI 25.8–31.4) were moderately inactive. Higher proportions of adults in older than in younger age groups were physically inactive; however, the differences were not significant for all age groups. The prevalence of inactivity appeared to be slightly higher among women than men. Cancer-site-specific population attributable risk

The numbers and proportions of cancer cases for specific cancer sites attributable to moderate inactivity and inactivity combined are presented in Table 3. Specific cancer incidence estimates attributable to moderate inactivity and inactivity are presented separately in Appendix 1, Supplementary Tables 3 and 4. Among different cancer sites, the attributable proportions of cases were highest for lung cancer (18.1%–21.2%) and endometrial cancer (19.3%–22.0%), across all age groups. In terms of absolute numbers, the sites most affected by inadequate physical activity were the lung (n = 192) and colorectum (n = 175) for men and the breast (n = 221) and lung (n = 210) for women, mainly owing to the greater total incidence for these cancer sites (Figure 1). For prostate cancer, the RR associated with inadequate physical activity was low (Table 1); thus, despite a much higher total incidence, the attributable proportion of cases (n = 69) was much lower than for other high-incidence sites (Figure 1). At the time of exposure, people aged 50 or more were most affected by lack of adequate physical activity (Table 3). This is a result of the greater total incidence of being less active among the older population.

Overall population attributable risk

The total number and proportion of excess attributable cases of cancer for each site are summarized in Table 4. Overall, 13.8% of cancers (n = 1135) across all associated sites were estimated to be attributable to inadequate physical activity. The proportion of attributable cancers was higher for women (697 [18.3%]) than men (436 [9.9%]). This is a result of a greater number of excess attributable cases in women over a smaller number of total observed cases (Table 4). We estimated that, overall, 7.2% of all cancer cases diagnosed in Alberta in 2012 could be attributable to inadequate physical activity; again, this estimate was higher for women (9.1%) than men (5.4%).

Table 2: Prevalence of inadequate physical activity in Alberta in 2003

	Activity level; prevalence (95% CI)	
Sex; age, yr	Moderately inactive	Inactive
Men		
20–34	21.6 (18.3–24.9)	37.8 (34.1–41.6)
35–49	24.4 (21.1–27.7)	48.8 (44.9–52.6)
50–64	28.7 (24.5–33.0)	46.6 (42.2–51.1)
≥ 65	21.0 (17.3–24.8)	49.4 (44.9–53.9)
Women		
20–34	24.6 (21.7–27.5)	44.7 (41.2–48.3)
35–49	24.6 (21.0–28.0)	44.0 (39.9–48.0)
50–64	28.5 (24.8–32.2)	49.3 (45.1–53.4)
≥ 65	22.4 (19.0–25.7)	56.0 (51.9–60.0)
Total		
20–34	23.1 (20.9–25.3)	41.2 (38.6–43.8)
35–49	24.5 (22.1–36.9)	46.4 (43.6–49.2)
50–64	28.6 (25.8–31.4)	48.0 (44.9–51.0)
≥ 65	21.8 (19.3–24.2)	53.0 (50.0–56.0)

Note: CI = confidence interval.
Source: Canadian Community Health Survey cycle 2.1 (2003).

When we removed lung cancer from the analyses, the proportion of attributable cases for the remaining 5 sites increased slightly, to 14.3%, and the overall proportion of attributable cases was reduced to 5.7% for all cancers (data not shown).

Interpretation

In the current analysis, an estimated 7.2% (n = 1135) of all cancer cases, representing 13.8% of associated cancer cases, diagnosed in Alberta in 2012 were estimated to be attributable to inadequate physical activity. The overall cancer burden due to inadequate physical activity was much greater among women (9.1% of all cancers, n = 697) than men (5.4% of all cancers, n = 436). This sex difference was expected, as 3 of the cancer sites associated with inadequate physical activity are female specific (breast, endometrium and ovary).

The current site-specific estimates for Alberta are comparable to previous Canadian estimates. Brenner[13] estimated that 21.1% of lung or bronchus, 16.8% of colon, 3.1% of prostate, 18.5% of breast (in postmenopausal women), 22.4% of endometrial and 13.8% of ovarian cancers could be attributed to suboptimal leisure time physical activity in Canada in 2007. The corresponding estimates in the current study are 20.6%, 16.1%, 2.9%, 17.4%, 20.5% and 12.7%. Similar risk estimates for colon (19.9%) and breast (11.0%) cancer burdens associated with physical inactivity in Canada were also reported by Katzmarzyk and colleagues.[31] The International Agency for Research on Cancer summarized in its 2002 and 2009 reports that 13%–14% of colon cancer, 11% of breast cancer in postmenopausal women and 30% of endometrial cancer could be attributable to physical inactivity.[32,33] Our use of the method developed by Parkin[11] means that our results can be compared directly to those of Parkin and of other investigators who have used Parkin's method. The estimates in the UK and Australian studies were quite a bit lower than the current estimates: Parkin's[11] estimates for colon, breast and endometrial cancer attributable to inadequate physical exercise ranged from 3.4%–5.3%, and estimates for the same sites in the Australian study ranged from 6.0%–7.8%.[12] However, both Parkin[11] and Olsen and colleagues[12] used minutes of activity per day rather than a comprehensive measure of daily energy expenditure, which reduced the magnitude of the protective effect of physical activity. This was reflected in the RRs used to calculate the population attributable risk and contributed to the lower estimates.

Overall, 13.8% of cases among associated sites and 7.2% of cases among all cancers in Alberta in 2012 could have been

Table 3: Numbers and proportions of incident cancer cases attributable to inadequate physical activity in Alberta in 2012

Sex; age at exposure, yr	Age at outcome, yr	Cancer site																		
		Lung			Colorectum			Prostate			Breast			Ovary			Endometrium		
		Obs.*	PAR, %†	EAC‡	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC	Obs.	PAR, %	EAC
Men																				
20–34	30–44	13	16.9	2	37	13.2	5	18	2.4	–										
35–49	45–59	141	20.4	29	276	16.0	44	591	3.0	18										
50–64	60–74	468	20.3	95	454	16.0	73	1240	2.9	37										
≥ 65	≥ 75	331	20.1	67	338	15.8	53	504	2.9	15										
Total		953		192	1105		175	2353		69										
Women																				
20–34	30–44	8	19.3	2	35	15.1	5				–	–	–	15	11.7	2	25	19.3	5	
35–49	45–59	171	19.1	33	193	14.9	29				–	–	–	62	11.5	7	175	19.1	33	
50–64	60–74	479	21.0	101	292	16.5	48				840	17.1	144	64	12.8	8	230	21.0	48	
≥ 65	≥ 75	341	22.0	75	326	17.4	57				427	18.0	77	48	13.5	6	73	22.0	16	
Total		999		210	846		139				1267		221	189		24	503		103	
Total																				
20–34	30–44	21	18.1	4	72	14.1	10	18	2.4	–	–	–	–	15	11.7	2	25	19.3	5	
35–49	45–59	312	19.7	62	469	15.5	73	591	3.0	18	–	–	–	62	11.5	7	175	19.1	33	
50–64	60–74	947	20.6	196	746	16.3	121	1240	2.9	37	840	17.1	144	64	12.8	8	230	21.0	48	
≥ 65	≥ 75	672	21.2	142	664	16.7	111	504	2.9	15	427	18.0	77	48	13.5	6	73	22.0	16	
Total		1952		403	1951		315	2353		69	1267		221	189		24	503		103	

Note: EAC = excess attributable cases due to exposure, Obs. = total number of observed cases per age–sex group, PAR = population attributable risk.
*Cases represent the total number of cases of each cancer type in 2012.
†PAR represents the proportion of cancer cases attributable to inadequate physical activity (moderately inactive and inactive).
‡Excess attributable cases represent the number of cases attributable to inadequate physical activity (moderately inactive and inactive).

preventable with increased physical activity levels. These numbers are similar to those reported by Brenner[13] (14.7% and 7.9%, respectively). Friedenreich and colleagues[34] examined the cancer burden due to physical inactivity in Europe and estimated that about 19% of associated cancers at the same sites could be prevented by increased physical activity.

The effect of physical inactivity on rates of lung cancer may be confounded by smoking or chronic lung disease, as smokers or people with pulmonary disease, who are at increased risk for lung cancer, are more likely to have reduced levels of physical activity.[5] When we removed lung cancer from the analyses, the proportion of attributable cases for the remaining 5 sites increased slightly, to 14.3%, and the overall proportion of attributable cases was reduced to 5.7% for all cancers.

Limitations

Our analyses are limited by several factors. We considered only leisure time physical activity, and therefore physical activity related to occupation or transportation was not included. In addition, although differences in risk and latency period may exist between men and women, we did not account for these differences in our analysis. We abstracted risk estimates from meta-analyses and pooled analyses, which may not reflect the risk for the adult Canadian population, as these estimates are pooled across various populations.

Many studies included in the meta-analyses adjusted for body mass index when estimating the risk associated with physical inactivity.[7,24,26] Thus, physical activity appears to have effects on cancer risk independent of that of body weight. In a separate analysis, we estimated the cancer burden attributable to overweight and obesity.[35] Body weight and physical activity are highly related. As sustained physical inactivity combined with excess energy intake can lead to overweight and obesity, it is likely that there is overlap in the number of attributable cases estimated. Thus, the population attributable risks associated with physical inactivity and excess body weight should not be combined, and the attributable fraction estimates should be interpreted with caution.

The current estimate of cancer burden associated with inadequate physical activity may be an underestimate as the prevalence estimates relied on the use of self-reported data from the CCHS. In our previous study of population attribut-

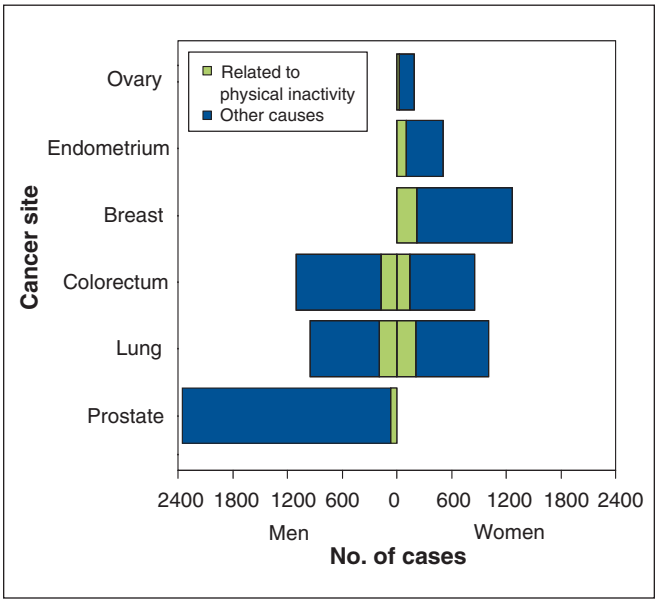

Figure 1: Number of cancer cases attributable to physical inactivity and other causes in Alberta in 2012.

Table 4: Summary of cases and proportions of cancer in Alberta adults in 2012 attributable to inadequate physical activity

	Total			Men			Women		
Cancer site	Observed cases*	Excess attributable cases†	% attributable‡	Observed cases	Excess attributable cases	% attributable	Observed cases	Excess attributable cases	% attributable
Prostate	2353	69	2.9	2353	69	2.9	–	–	–
Breast§	1267	221	17.4	–	–	–	1267	221	17.4
Lung	1952	403	20.6	953	192	20.1	999	210	21.0
Colorectum	1951	315	16.1	1105	175	15.8	846	139	16.4
Endometrium	503	103	20.5	–	–	–	503	103	20.5
Ovary	189	24	12.7	–	–	–	189	24	12.7
All associated cancers¶	8215	1135	13.8	4411	436	9.9	3804	697	18.3
All cancers**	15 836	1135	7.2	8155	436	5.4	7681	697	9.1

*Number of observed cancer cases in Alberta in 2012 at individual cancer sites.
†Number of cancer cases at individual cancer sites attributable to inadequate physical activity.
‡Proportion of cancers at individual cancer sites attributable to inadequate physical activity (calculated as excess attributable cases/observed cases).
§In postmenopausal women breast only (defined as cancers diagnosed at age 55 or more).
¶Represents all cancers with a known association with inadequate physical activity, as listed in table.
**Represents all incident cancers in Alberta in 2012 in all age groups.

able risk, sensitivity analysis of Canadian data from the CCHS showed that, by using bias-adjusted prevalence estimates based on accelerometer data from the 2008 Canadian Health Measures Survey, the total cancer burden attributable to inadequate physical activity increased from 7.9% to 10.7%.[13] In addition, in the current analysis, we excluded cancer sites for which the evidence of association is suggestive but not yet fully developed, such as the pancreas,[5] kidney[36] and liver.[37] Thus, the overall burden of cancer in Alberta associated with physical inactivity is likely to be higher than the estimates reported here. Despite the limitations associated with self-reported data, CCHS data provided provincially representative prevalence estimates, as the survey's sampling frame represents 96%–98% of the Canadian adult population with the exception of a few specific populations (e.g., Aboriginal Canadians living on reserves and people living on Crown land or in military facilities).

Conclusion

We estimated that 1135 cancer cases, equivalent to over 7% of all cancers, diagnosed in Alberta in 2012 were attributable to inadequate physical activity. With a high prevalence (> 70%) of suboptimal physical activity among adults in the province, developing targeted strategies to encourage people, particularly women and adults 50 years of age or older, to engage in sustained adequate physical activity could have great potential in reducing cancer burden in Alberta.

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Affiliations: Department of Cancer Epidemiology and Prevention Research (Brenner, Poirier, Grundy, Khandwala, McFadden, Friedenreich), CancerControl Alberta, Alberta Health Services; Department of Oncology (Brenner, Friedenreich), Cumming School of Medicine, University of Calgary; Department of Community Health Sciences (Brenner, Friedenreich), Cumming School of Medicine, University of Calgary, Calgary, Alta.

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