Cancers in Australia in 2010 attributable to insufficient physical activity

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Abstract

Objectives: To estimate the proportion and numbers of cancers occurring in Australia in 2010 attributable to insufficient levels of physical activity.

Methods: We estimated the population attributable fraction (PAF) of cancers causally associated with insufficient physical activity (colon, post-menopausal breast and endometrium) using standard formulae incorporating prevalence of insufficient physical activity (<60 minutes at least 5 days/week), relative risks associated with physical activity and cancer incidence. We also estimated the proportion change in cancer incidence (potential impact fraction [PIF]) that may have occurred assuming that everyone with insufficient activity levels increased their exercise by 30 minutes/week.

Results: An estimated 1,814 cases of colon, post-menopausal breast and endometrial cancer were attributable to insufficient levels of physical activity: 707 (6.5%) colon; 971 (7.8%) post-menopausal breast; and 136 (6.0%) endometrial cancers. If those exercising below the recommended level had increased their activity level by 30 minutes/week, we estimate 314 fewer cancers (17% of those attributable to insufficient physical activity) would have occurred in 2010.

Conclusions: More than 1,500 cancers were attributable to insufficient levels of physical activity in the Australian population.

Implications: Increasing the proportion of Australians who exercise could reduce the incidence of several common cancers.

Key words: population attributable fraction, cancer, risk factor, exercise, potential impact fraction

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Regular physical activity is important for optimal health and significant benefits occur from even modest amounts of physical activity, including lower cancer rates.1 There is consistent evidence from a systematic review and meta-analysis of cohort studies that physical activity is associated with a reduced risk of colon cancer.2 Research has also consistently demonstrated links between physical activity and reduced risk of post-menopausal breast cancer4 and endometrial cancer.3 The World Cancer Research Fund (WCRF) has concluded that there is “convincing” or “probable” evidence that insufficient physical activity causes cancers of the colon, post-menopausal breast and endometrium.6

The most recent Australian guidelines for physical activity and sedentary behaviour were released in February 2014.7 They recommend that adults perform at least 150 minutes of moderate intensity physical activity or 75 minutes of vigorous intensity physical activity per week to help improve blood pressure, cholesterol, heart health and muscle and bone strength. This should be increased to 300 minutes of moderate intensity physical activity or 150 minutes of vigorous intensity physical activity per week to reap greater health benefits and help to prevent cancer and unhealthy weight gain.7

The National Guidelines defines 60 minutes of moderate intensity physical activity on most days of the week (assumed 5 days) as a sufficient level to help prevent cancer. We aimed to estimate the fraction and number of cancers of the colon, post-menopausal breast and endometrium arising in the Australian population in 2010 that were attributable to failing to meet this target. We assumed that lower levels of physical activity conferred some benefit, but less than optimum.

Methods

Physical activities are often categorised by domain, e.g. occupational or recreational, as well as by type, frequency, duration and intensity. Different types of activity are commonly equated through metabolic equivalents (METs). One MET is considered to represent resting energy expenditure, about 3.5 mL O2/kg/min when measured in terms of oxygen consumption. Because any form of activity requires increased oxygen consumption, activities can be quantified in terms of multiples of this resting oxygen consumption (e.g. an activity that requires four times the oxygen consumption of rest would be defined as 4 METS). Moderate activity consumes about 3–6 METS, depending upon fitness level.8

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the approach of a UK PAF project and assumed, conservatively, that moderate activity is equivalent to 6 METS. It follows that exercise of moderate intensity of 60 minutes duration consumes 6 MET-hours. Complying with the National Guidelines equates to 300 minutes or 30 MET-hours per week.

Relative risk estimates

For colon cancer and post-menopausal breast cancer, we used relative risks reported in the WCRF Continuous Update for Colorectal Cancer and the WCRF Second Expert Panel Report, respectively. Because the WCRF did not publish a dose-response summary relative risk for endometrial cancer, we sourced the summary relative risk from a dose-response meta-analysis of three cohort studies undertaken by Keum and colleagues (Table 1).

The increase in risk for a decrease of 1 MET-hour of recreational physical activity per week was estimated by assuming a log-linear relationship between exposure and risk, so that:

\[
\text{Risk per 1 MET-hour per week} = \frac{\ln(1/RR_x)}{x} \times \text{exposure level (in MET-hours per week)}\]

where \(x\) is the exposure level (in MET-hours per week) and \(RR_x\) the relative risk for \(x\) MET-hours per week.

The increases in risk for a decrease of 1 MET-hour of recreational physical activity per week for colon cancer, post-menopausal breast cancer and endometrial cancer were 4.04, 1.6 and 3.35 respectively.

Exposure prevalence estimates

The latent period between physical inactivity and onset of cancer is not known. In the WCRF systematic review of colon cancer, follow-up periods in cohort studies that reported dose-response MET-hours, ranged from 1.6 years to 16 years, with an average of 9.2 years. For post-menopausal breast cancer, follow-up periods ranged from 4.7 years to 7.3 years, with an average follow-up of 5.7 years; and for endometrial cancer, there was an average follow-up of 8.8 years (ranging from 6.6 years to 11.0 years). We used prevalence data from 2001 and cancer incidence data from 2010 to give a nominal latent period of about 10 years. To account for population ageing with time since exposure and the latent period, we used prevalence data for the age category that was 10 years younger than the corresponding cancer incidence age category (for example, cancer incidence in the 25–34 years age group in 2010 was attributed to insufficient physical activity in the 15–24 years age group in 2001).

We used data from the 2001 National Health Survey Confidentialised Unit Record Files to estimate the deficit in physical activity against the recommended guidelines for cancer prevention (300 minutes of moderate activity or about 30 MET-hours per week), by sex and age categories.

The National Health Survey did not directly report the proportion of people undertaking different amounts of activity by age and sex; however, data reported in the National Health Survey Confidentialised Unit Record Files included:

- the mean number of minutes individuals who reported walking, moderate or vigorous exercise spent participating in that activity for the whole population
- the proportion of people (by age and sex categories) doing different combinations of types of exercise (no exercise, walking only, moderate exercise only, vigorous exercise only, walking and moderate, walking and vigorous, moderate and vigorous, walking plus moderate and vigorous).

To estimate the proportion of people exercising at different levels, we first estimated the average total minutes of activity for each combination spent exercising per week (online supplementary file: Table S1). To do this, we assumed that people who reported two types of activity performed each for half the average duration for each activity and that those who reported all three types of activity performed each for one-third of the average duration. In sensitivity analyses, we assumed that people who performed multiple types of activity in a week spent the average time on each activity type. For example, for people reporting the exercise combination of walking and moderate activity, we simply summed the national average durations for each activity.

We applied a weighting (\(x^2\)) to vigorous activity to account for the higher intensity level of metabolic activity. The estimated average total minutes of activity for each combination was then converted to MET-hours per week on the assumption that 60 minutes of moderate activity constitutes 6 MET-hours. We conducted a sensitivity analysis assuming that 60 minutes of moderate activity constitutes 3 MET-hours rather than 6 MET-hours.

For each age, sex and exercise type category, we calculated the deficit from the recommended 30 MET-hours per week (hereafter described as ‘insufficient physical activity’) and categorised this as no deficit, >0-<6 MET-hour deficit, 6-<12 MET-hour deficit, 12-<24 MET-hour deficit, and 24-30 MET-hour deficit. For each sex and age category, the proportion of people in each MET-hour deficit category was then totalled (Table 2). Relative risks were calculated for each Met-hour deficit category for each age group using the following formula:

\[
\text{Relative Risk} = \exp(\text{Increase in log risk per MET-hour deficit per week} \times \text{deficit in MET-hours per week})
\]

where the deficit in MET-hours per week is the mid-point of the MET-hour deficit categories.

Statistical analysis

The population attributable fraction (PAF) was calculated using the standard formula:

\[
\text{PAF} = \frac{\sum(p_x \times \text{ERR}_x)}{1 + \sum(p_x \times \text{ERR}_x)}
\]

where \(p_x\) is the proportion of the population in each exercise category \(x\) and \(\text{ERR}_x\) is the excess relative risk (RR-1) for each exercise category \(x\).

To obtain the number of cancers attributable to a deficit in physical activity levels, the PAF was multiplied by the number of incident cancers at each site in 2010 for each age and sex category. The number of colon, post-menopausal breast and endometrial cancers attributable to a deficit in physical activity levels was then summed and expressed as a percentage of the total number of all incident cancers (excluding basal cell and squamous cell skin cancers).
cell carcinoma of the skin) recorded among adults aged 25 and over in Australia in 2010.

**Potential impact of increasing physical activity levels in the Australian population**

We estimated the number of cancers in 2010 that may have been prevented by proposing a hypothetical situation in which all those exercising below the recommended level increased the amount of time they spent exercising at moderate intensity by 30 minutes (3 MET-hours) per week. To do this, we reduced the mid-point of each exercise deficit category by 3 MET-hours (e.g., the mid-point of the 6–<12 MET-hour deficit category was reduced from 9 to 6), and then used the relative risk per MET-hour deficit to estimate the new relative risk for each MET/hr deficit category. We then calculated the potential impact fraction (PIF) using the formula of Barendregt and Veerman:17

\[
PIF = \frac{\sum_{x=1}^{n} p_x R_x - \sum_{x=1}^{n} p_x R_x^*}{\sum_{x=1}^{n} p_x R_x}
\]

where \( p_x \) is the proportion of population in each age and sex category, \( R_x \) is the relative risk for that category and \( R_x^* \) is the new relative risk for each MET/hr deficit category when the mid-point of each category was reduced by 3 MET-hours.

The PIF is the proportional difference between the observed number of cancers and the number expected under the alternative scenario. Finally, we calculated the number of colon, post-menopausal breast and endometrial cancers that would have not occurred among people aged 25 and over in Australia in 2010 under the alternative scenario.

**Results**

The estimated proportion of Australian adults meeting the physical activity guidelines for cancer prevention was only 4% for men and less than 1.0% for women (Table 2).

The proportion of women doing little or no exercise increased steadily with age, ranging from 24% (15–24 years) to 55% (75+ years). A similar pattern was seen for men, although there appeared to be an increase in activity after retirement age. Of note was the large decline in activity levels between the 15–24 and 25–34 year age groups, particularly for men, suggesting this group might be an appropriate target for intervention activities.

Table 2. Estimated proportion (%) of adult men and women in the Australian population performing physical activity at the given level (against the recommended 30 MET-hours per week) (National Health Survey, 2001).a

| Age Group | Men (%) | Women (%) |
|-----------|---------|-----------|
| 15–24 yrs | 24.0 | 55.8 |
| 25–34 yrs | 21.5 | 50.4 |
| 35–44 yrs | 19.8 | 46.6 |
| 45–54 yrs | 18.5 | 43.0 |
| 55–64 yrs | 17.4 | 39.8 |
| 65–74 yrs | 16.3 | 36.6 |
| 75+ yrs | 15.2 | 33.4 |

**Potential impact of increasing physical activity levels in the Australian population**

Reducing the ‘average’ deficit in the activity categories by 3 MET-hours/week would have had a modest impact on cancer incidence. If everyone who did insufficient physical activity had increased their exercise levels by 3 MET-hours/week, about 314 fewer cancers would have been diagnosed (PIF 1.2%). This represents 17% (314/1,814) of all cancers attributable to insufficient physical activity. The proportional impacts were similar across all three cancer types.

**Discussion**

We estimate that 1,814 cases of colon, post-menopausal breast and endometrial cancer that occurred in Australian adults in 2010 could be attributed to insufficient levels of physical activity, corresponding to PAFs of 6.5% for colon cancer, 7.8% post-menopausal breast cancer (6.8% of all breast cancers) and 6.0% for endometrial cancer.

The estimates of PAF were not especially sensitive to the values of energy expenditure used in the calculations of ‘activity deficit’ with the major influence being the high prevalence of physical inactivity (or activity at less than recommended levels) in the population. These attributable fractions are higher than those reported for the UK16 for cancers occurring in 2010 (5.3% for colon, 3.4% for breast and 3.8% for endometrium); however, the UK study considered a sufficient level of activity as 15 MET-hrs/week, the UK Department of Health target,18 which is half the level for cancer prevention recommended by Australian guidelines. Not unexpectedly,
the proportion of Australians meeting these cancer prevention guidelines in 2001 was low; however, our dose–response calculations of the PAF took into account any exercise performed under the recommended level. Another factor that may have contributed to the very low prevalence of Australians meeting the physical activity guidelines for cancer prevention in our analysis is the way in which physical activity data are reported. The National Health Survey Confidentialised Unit Record Files only report the proportion of people by age-group and sex who participate in any given activity, and then report the mean number of minutes spent performing that activity. For the purposes of estimating the PAF, it would be more informative to report the proportions of Australians in categories of time spent in moderate and vigorous activity, respectively (e.g. ‘none’, ‘1–29 mins/week’, ‘30–59 mins/week’, ‘60–89 mins/week’, etc). Ideally, future investigations would have access to more complete data to enable better estimates.

Other studies that have reported PFAs for different populations have generally undertaken dichotomous comparisons of active vs. inactive adults, however defined, resulting in much higher PFAs. Such estimates are not directly comparable with our findings using dose–response relative risks, which assume that even low levels of physical activity confer some benefits. We contend that this approach generates more plausible estimates of effect than a simple categorical analysis in which it is assumed there is no benefit for failing to meet the guideline, even among people undertaking some physical activity. We also used summary relative risks from cohort studies only, which are less likely to be affected by information biases than risk estimates from case-control studies, but are typically more conservative in their estimates of benefits of physical activity.

These analyses highlight the relative paucity of national data describing durations (as opposed to categories) of different types of physical activity among Australians. We used the available data to estimate the distribution of MET-hours/week of activity within categories of age and sex; however, this required us to make assumptions about certain activity patterns, especially for people engaging in two or more forms of physical activity. Our approach was to reduce their time spent on each separate activity proportionately. It is possible that this approach was overly conservative, and so we performed sensitivity analyses allowing a more liberal summation of activity levels. Even so, this made little substantive difference to the estimates: most Australians perform insufficient activity, and the estimates of the cancer burden changed little regardless of how activity levels were summed.

We were limited to considering recreational physical activity only, and were unable to consider the potential adverse effects of sedentary behaviour separately. Sedentary behaviour may be particularly important for colon, endometrial and breast cancer risk,23,24 with a recent meta-analysis reporting increased risks associated with high levels of total sitting time.25 Notably, our calculations of the fraction of cancers attributable to physical inactivity should be independent of the effects of overweight/obesity. We used relative risk estimates that were adjusted for the potentially confounding effects of other exposures, including overweight/obesity, although it is possible that some residual confounding remains.

To avoid potentially subjective assessments of causality, we restricted our analyses to cancers causally associated with physical activity.

Table 3: Population attributable fraction (PAF) and estimated number of cancers diagnosed in Australia in 2010 attributable to insufficient levels of physical activity.

| Age at outcomea | Colon (C18, C19)b | Breast (post-menopausal) (C50)c | Endometrium (C54, C55)d | All cancersc |
|-----------------|------------------|--------------------------------|-------------------------|-------------|
|                 | PAF Obs. Ex.     | PAF Obs. Ex.                  | PAF Obs. Ex.            | PAF Obs. Ex. |
| Males 25-34 yrs | 5.4 37 2         | 1,042 2                       |                         |              |
| 35-44 yrs       | 6.9 134 9        | 2,214 9                       |                         |              |
| 45-54 yrs       | 7.4 469 35       | 6,632 35                      |                         |              |
| 55-64 yrs       | 7.5 1187 89      | 16,279 89                     |                         |              |
| 65-74 yrs       | 6.0 1,817 109    | 19,513 109                    |                         |              |
| 75-84 yrs       | 4.7 1,557 73     | 14,520 73                     |                         |              |
| 85+             | 6.3 498 32       | 4,968 32                      |                         |              |
| Total           | 5,699 349        | 65,168 349                    |                         |              |
| PAFaw= 6.1     |                  |                                |                         |              |
| Females 25-34 yrs | 7.4 40 3        | 258 6.1 19 1                 | 1,401 4                |              |
| 35-44 yrs       | 7.5 134 10       | 1,420 6.3 103 7              | 3,637 17               |              |
| 45-54 yrs       | 7.8 422 33       | 3,385 84 32 24               | 7,812 341              |              |
| 55-64 yrs       | 7.9 908 72       | 3,893 330 6.6 721 48         | 11,042 450             |              |
| 65-74 yrs       | 6.0 1,346 80     | 2,845 182 5.0 556 28         | 11,073 290             |              |
| 75-84 yrs       | 6.2 1,522 94     | 1,617 107 5.1 355 18         | 9,819 219              |              |
| 85+             | 8.4 794 66       | 756 68 7.0 139 10            | 5,166 144              |              |
| Total           | 5,166 358        | 14,174 971 2,255 136         | 49,950 1,465           |              |
| PAFaw= 6.9     | 6.8b             | 6.0                           | 2.9b                   | 2.9b        |
| Persons 25-34 yrs | 77 5            | 258 19 1                     | 2,443 6                |              |
| 35-44 yrs       | 268 19           | 1,420 103 7                 | 5,851 26               |              |
| 45-54 yrs       | 891 68           | 3,385 284 362 24             | 14,444 376             |              |
| 55-64 yrs       | 2,095 161        | 3,893 330 721 48             | 27,321 539             |              |
| 65-74 yrs       | 3,163 189        | 2,845 182 556 28             | 30,586 399             |              |
| 75-84 yrs       | 3,079 167        | 1,617 107 355 18             | 24,339 292             |              |
| 85+             | 1,292 98         | 756 68 139 10                | 10,134 176             |              |
| Total           | 10,865 707       | 14,174 971 2,255 136         | 115,118 1,814          |              |
| PAFaw= 6.5     | 6.8b             | 6.0                           | 1.6                    | 1.6b        |

Abbreviations: Obs. = observed cancers in 2010; Exc. = excess cancers in 2010 attributable to insufficient physical activity; PAF = population attributable fraction (expressed as a percentage); PAFaw = age-weighted population attributable fraction (expressed as a percentage).

a: Prevalence data age groups are 10 years younger than cancer incidence age groups assuming a 10 year latent period.

b: International Classification of Diseases Code (ICD-10).

c: Excluding basal cell carcinoma and squamous cell carcinoma of the skin.

d: % of all breast cancers.

e: % of post-menopausal breast cancers (45+ years).
inactivity as determined by independent agencies (in this case WCRF) that have undertaken systematic and continual review of the evidence. While we are aware of a growing literature describing possible associations with other cancers (e.g. oesophageal, bladder, gastric, lung, prostate and pancreatic cancer), the evidence to date has not been sufficient for WCRF or IARC to make a causal judgement, and so these cancers were not included in our analyses.

Maintaining a sufficient level of activity potentially offers people an opportunity to reduce their risk of colon, breast and endometrial cancers in addition to the numerous other chronic diseases associated with low physical activity. There are a number of biologically plausible pathways that may underlie a protective effect of higher levels of activity. For colon cancer, postulated mechanisms include decreased gastrointestinal transit time (reducing exposure to carcinogens), changes in serum levels of insulin and insulin-like growth factors (IGFs), and alterations in the level of prostaglandin E2. Regular physical activity significantly lowers insulin levels and enhances insulin sensitivity, independently of body mass index (BMI) - a measure of body fatness calculated as weight in kilograms divided by the square of height in meters (kg/m²) and - insulin increases the bioactivity of insulin-like growth factor I. In laboratory studies and animal models, insulin is a growth factor for colon mucosal cells, and physical activity causes a decrease in prostaglandin E2, which has been shown to stimulate colon cell proliferation in cell culture. Indirect evidence for a role of prostaglandin E2 derives from the observation that aspirin and nonsteroidal anti-inflammatory drugs – inhibitors of prostaglandin synthesis – reduce risk of colon cancer.

Proposed mechanisms for the benefits of physical activity on breast and endometrial cancer development include alterations in endogenous sex hormone levels (oestrogen, progesterone and androgens), insulin-mediated pathways, and maintenance of energy balance. Regular physical activity has been shown to lower the levels of biologically available oestrogens, progesterone, and androgens and to increase levels of circulating sex hormone binding protein. Elevated serum levels of androgens and oestrogens in both pre- and post-menopausal women are associated with increased endometrial cancer risk, and elevated circulating oestrogens in post-menopausal women are associated with increased breast cancer risk. Regular physical activity also helps prevent or reduce obesity with consequent improvement in the metabolic profile (endogenous hormone and growth factor levels), although it can be difficult to disentangle the independent effects of increasing physical activity and weight loss.

Sequential National Health Surveys have indicated that the proportion of Australians who are inactive or undertake only low levels of physical activity has declined from 73% in 2007-08 to 68% in 2011-12. The 2011-12 Survey results indicated that undertaking sufficient levels of physical activity was more likely for people who rated their health as "excellent," who lived in areas of least disadvantage, and who had higher incomes and higher levels of education. It is possible that those Australians who would stand to benefit most by engaging in higher levels of physical activity are not becoming more active, and this could have implications for future levels of cancer (and other chronic diseases) in the Australian community. While evidence on the effectiveness of workplace physical activity interventions is equivocal, community-wide health education campaigns and school-based interventions have been shown to be effective, supporting the role of multi-component interventions to successfully increase physical activity levels.

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PAF Project

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