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Economic evaluation of the direct healthcare cost savings resulting from the use of walking interventions to prevent coronary heart disease in Australia

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Abstract Coronary heart disease (CHD) is the leading cause of death in Australia. Direct healthcare costs of CHD exceed those of any other disease. The purpose of this study was to evaluate the direct healthcare cost savings resulting from walking interventions to prevent CHD in Australia. A meta-analysis was performed to quantify the efficacy of walking interventions in preventing CHD. The etiologic fraction and other mathematical models were applied to quantify the cost savings resulting from walking interventions to prevent CHD. The net direct healthcare cost savings in CHD prevention resulting from 30 min of normal walking a day for 5–7 days a week by the sufficient walking population were estimated at AU$126.73 million in 2004. The cost savings could increase to $419.90 million if all the inactive adult Australians engaged in 1 h of normal walking a day for 5–7 days a week. Given its low injury risk and high adherence, walking should be advocated as a key population-based primary intervention strategy for CHD prevention and healthcare cost reduction.

Keywords Coronary heart disease · Cost savings · Healthcare cost · Physical activity · Walking · Meta-analysis

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Introduction

The health expenditure in Australia more than doubled from $36.99 billion in 1993–1994 to $78.60 billion in 2003–2004 (Australian Institute of Health and Welfare 2005). By 2006–2007, the total expenditure on health goods and services reached $94 billion, or $4,507 person. This was over $7 billion or $286 per person more than the previous year. For the decade from 1996–1997 to 2006–2007, the average annual real growth in health expenditure exceeded that of GDP, resulting in a substantial increase in the health expenditure to gross domestic product (GDP) ratio (Australian Institute of Health and Welfare 2008b). It is projected that the total healthcare expenditure together with residential aged care expenditure will almost triple from $85 billion in 2003 to $246 billion by 2033. This represents an increase from 9.3% of the GDP in 2002–2003 to 12.4% of the GDP in 2032–33 (Goss 2008).

Cardiovascular disease (CVD) is the most expensive disease group in Australia, accounting for 11% of the total health expenditure in 2004–2005. Between 2000–2001 and 2004–2005, inflation adjusted expenditure on cardiovascular diseases increased by 18% (Australian Institute of Health and Welfare 2008a). It is projected that the health expenditure on CVD for treatment plus prevention will surge from $9.3 billion in 2003 to $22.6 billion in 2033, a 143% increase (Goss 2008).

As the most common form of CVD and largest single cause of death in Australia, coronary heart disease (CHD) incurred direct healthcare costs $1.81 billion, or over 30% of the total healthcare expenditure on CVD for 2004–2005 alone, far higher than the direct healthcare costs of any other types of CVD (Australian Institute of Health and Welfare 2008a). It is also by far the most costly single disease with direct healthcare costs exceeding those of any other disease (Australian Institute of Health and Welfare and Mathur 2002).

The magnitude of the impact CHD has on the national health and economy is such that prevention and management of CHD and other cardiovascular diseases has been identified as a national health priority in Australia (Australian Institute of Health and Welfare 2007).

Despite the enormity of the health and economic impact, CHD is largely lifestyle induced and preventable. It is well established that physical inactivity is a major contributing risk factor of CHD (Powell et al. 1989; U.S. Department of Health and Human Services 1996; World Health Organisation 2002). The physically inactive are almost twice as likely to die from CHD as the physically active (Leon et al. 1987; Powell et al. 1987; Johansson et al. 1988; Pate et al. 1995; U.S. Department of Health and Human Services 1996) and physical activity reduces the risk of and prevents the disease (Powell et al. 1987; Berlin and Colditz 1990; U.S. Department of Health and Human Services 1996).

The economic impact of physical activity interventions to prevent CHD, however, remains an under-researched area. Preliminary studies of physical inactivity costs in 2000 and 2007 in Australia (Stephenson et al. 2000; Medibank Private 2007) largely focused on hypothetical cost savings by assuming varying degrees of increase in physical activity participation. A more recent study by (Brown et al. 2008) examined the relationships between physical activity and body mass index (BMI) with healthcare costs in mid-age Australian women. Overall, the studies did not differentiate between different types of physical activity in relation to their efficacy in CHD risk reduction or cost savings despite evidence that intervention effect is task specific (Baker et al. 1994; Tanasescu et al. 2002). Identifying and promoting evidence-based, safe, effective and cost-saving physical activity interventions for disease prevention and reduction in disease burden in the general population is high on the national health agenda (Australian Research Council 2003; Schoppe et al. 2004).

Walking is reportedly the most popular and prevalent form of physical activity (Hatziandreu et al. 1988; Morris and Hardman 1997; Australian Bureau of Statistics 2006), and is an activity with low injury and high adherence rates (Pollock et al. 1991). Walking is accessible to the vast majority of the population irrespective of social groups, ages and religious beliefs (The National Heart Foundation of Australia 2007). Studies conducted in the United States (Jones and Eaton 1994) and Japan (Tsuji et al. 2003) showed that walking generated substantial cost savings from CHD prevention and reduced medical expenditure. However, no study has been undertaken to quantify the economic benefits of walking to prevent CHD in Australia. The purpose of our study was to conduct an economic evaluation of the direct healthcare cost savings resulting from walking interventions to prevent CHD and reduce the financial burden of CHD on the healthcare system in Australia.

Methods

Our economic evaluation was based on the etiologic rationale that the removal of the exposure to a risk factor can affect disease incidence. To quantify the cost savings resulting from walking interventions to prevent CHD, we incorporated the etiologic fraction model also known as population attributable fraction (PAF) in the economic evaluation. PAF is defined as the proportion of disease cases which would be prevented by eliminating exposures from the population, assuming the exposures are causal (Rockhill et al. 1998). The PAF model has been widely used in the 2002 World Health Organization Report (World Health Organisation 2002), economic studies conducted in North America (Canadian Fitness and Lifestyle Research Institute 1996; Katzmarzyk et al. 2000; Katzmarzyk and Janssen 2004), the UK (Allender et al. 2007) and Australia (Stephenson et al. 2000; Econtech 2007) to cost physical inactivity as a major risk factor for a range of diseases.

PAF relies on identification and synthesis of scientific evidence about the strength of the association between risk exposure and disease incidence, thus establishing causality and magnitude of the risk of the exposed individuals compared to the unexposed individuals (Macera and Powell 2001). It also requires determination of the population prevalence of the risk factor. Therefore, we first performed a meta-analysis to quantify the effect size of walking interventions in reducing CHD risk. Next we applied PAF to estimate the direct healthcare costs of CHD attributable to physical inactivity, which provided a key parameter for us to further estimate the cost savings from walking interventions to prevent CHD. We argued that the total healthcare cost was a function of the levels of exposure to risk factors within a certain time interval: $C = f(R_1, R_2, R_3, R_4 \ldots)$, where C denotes the total healthcare cost, and R the level of exposure to a risk. We therefore proposed the following mathematical model to estimate cost savings from actual walking participation: $S = Z_{\mathrm{w}} \frac{C_{\mathrm{Ina}}}{Z_{\mathrm{Ina}}}$ where S specifies the actual cost savings from walking for CHD prevention; Z_{w} the size of walking population; Z_{Ina} the size of physically inactive population; C_{Ina} the cost of CHD attributable to physical inactivity, which is estimated as $C_{\mathrm{Ina}} = \delta_{\mathrm{PAF}} \cdot C_{\mathrm{T}}$, where δ_{PAF} denotes *PAF* and C_{T} the total direct healthcare cost of CHD to the health system.

A sensitivity analysis with respect to changes in walking participation level and injury rate was performed to further estimate potential cost savings.

Meta-analysis of the efficacy of walking interventions in reducing CHD risk

A detailed description of the search strategy was provided in Zheng et al. (2009). A brief description was provided here. Medline, SportDiscus and the Cochrane Database of Systematic Reviews were searched to identify relevant studies using MeSH search strategy and

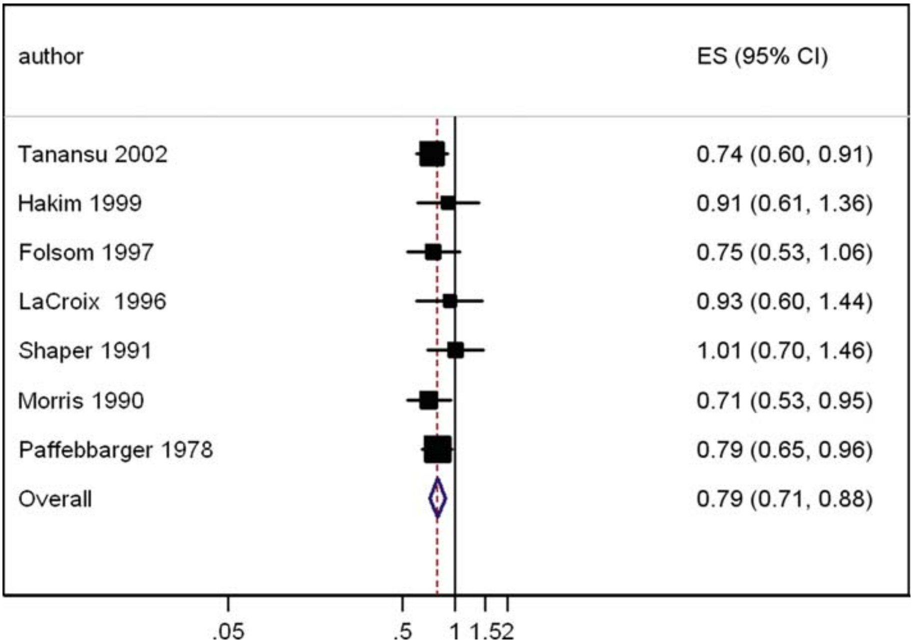

Fig. 1 Pooled RR for men (2.5–3.5 h/w of normal walking vs. inactivity)

combined terms of ‘physical activity’ OR ‘exercise’ OR ‘walking’ AND ‘cardiovascular disease’ OR ‘coronary heart disease’. The search was limited to English-language papers from 1954 to September 2007. Studies were included for the meta-analysis only if they were primary prevention studies with walking assessed as an exposure and CHD as an outcome. The relative risks (RRs) for the same outcome measure were pooled using inverse variance weighting (Woodward 2005).

Given the evidence of gender difference in CHD incidence (Lloyd-Jones et al. 1999; Lawlor et al. 2001; Australian Institute of Health and Welfare 2004; Thom et al. 2006), we pooled the relative risks for men and women separately for summary estimation using random-effect models allowing for between-study variance (Figs. 1, 2). For one study which involved both genders (LaCroix et al. 1996), we pooled the RRs from the study twice: once with studies involving male study populations only, once with studies involving female study populations only to minimize method-induced bias.

The dose-response of walking in reducing CHD risk was obtained from a recent study by Zheng and colleagues, which suggested that an increment of 8 MET-hours/week or 30 min of normal walking a day for 5 days a week was associated with 19% (95% CI, 14–23%) CHD risk reduction ($P_{\text{heterogeneity}} = 0.56$; $I^2 = 0\%$) (Zheng et al. 2009).

The population prevalence of exposure to physical inactivity

There have been two national physical activity surveys conducted in Australia: the National Physical Activity Survey (NPAS) by the Australian Institute of Health and Welfare (AIHW) (Armstrong et al. 2000) and the National Health Survey (NHS) by the Australian Bureau of Statistics (2006). We relied on the former for estimates of physical activity for our study as it

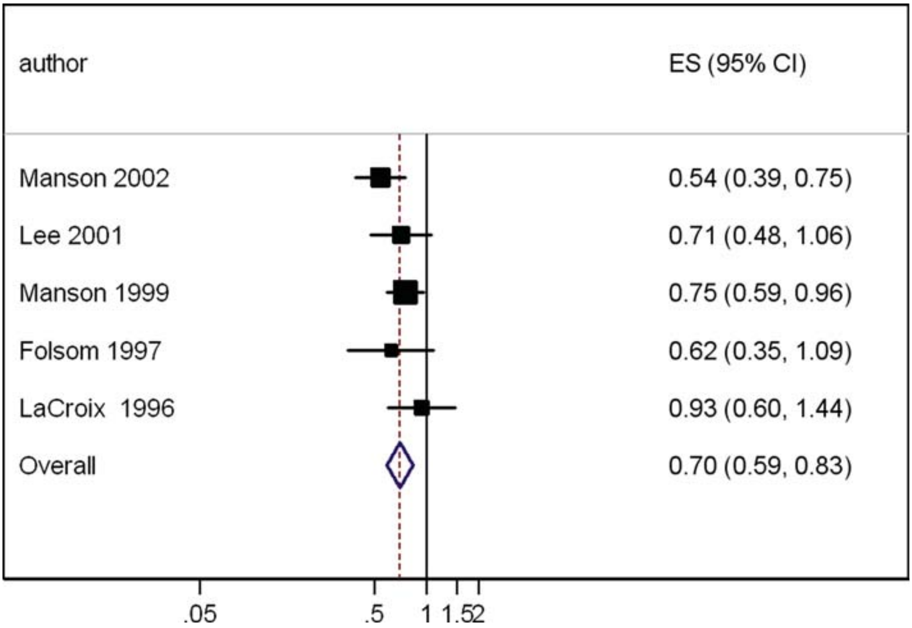

Fig. 2 Pooled RR for women (2.5–3.5 h/w of normal walking vs. inactivity)

followed the national physical activity recommendation guidelines in Australia (Department of Health and Aged Care Australian Government 1999) and the US (Haskell et al. 2007). The survey captured overall physical activity level by including physical activity for getting to and from places as well as for exercise and recreation. Its test-retest reliability was showed to be acceptable with a Kappa coefficient of 0.52 (Timperio et al. 2003; Brown et al. 2004).

The NPAS used a Computer Assisted Telephone Interviewing (CATI) method with a nationwide random sample population of adult Australians aged 18–75. It classified physical activity status in the general population into three categories: ‘sedentary’ which specified little or no physical activity; ‘sufficient’: the minimum amount of physical activity required to achieve health benefits, which was defined as ≥150 min of moderate-intensity physical activity including walking accrued over at least five sessions per week as recommended in the national physical activity guidelines (Department of Health and Aged Care Australian Government 1999); ‘insufficient’, physical activity below the minimum level as specified above. ‘Sedentary’ and ‘insufficient’ combined was broadly categorized as ‘physical inactivity’ (Stephenson et al. 2000).

The NPAS conducted for 1997, 1999 and 2000 suggested there was an increase in physical inactivity between 1997 and 1999 (Armstrong et al. 2000), but no significant differences were observed between 1999 and 2000 (Bauman et al. 2001). The NHS also indicated that age-adjusted sedentary and low level physical activity including walking among adult Australians aged 15 and over remained steady in 1995, 2001 and 2004–2005 (Australian Bureau of Statistics 2006). Therefore, we applied the median values of the prevalence of physical inactivity from the NPAS to 2004, assuming that the population prevalence of exposure to physical inactivity remained largely unchanged (Table 1).

Table 1 Percentage of adult Australians achieving 'sufficient' activity (in time and session) and physical inactivity in 1997, 1999, 2000 (actual data adjusted for age) (estimates), %

	1997		1999		2000		2004 (estimates)	
	Sufficient	Inactive	Sufficient	Inactive	Sufficient	Inactive	Sufficient	Inactive
Male	51.7	48.3	47.1	52.9	46.7	53.3	47.1	52.9
Female	50.1	49.9	43.4	56.6	45.5	54.5	43.4	56.6

Source: Adapted from 'Trends in population levels of reported physical activity in Australia, 1997, 1999 and 2000 (Bauman et al. 2001)

'Sufficient' walking

It was estimated that the prevalence of regular walking in Australia remained steady over the years (Merom et al. 2006). Based on the New South Wales (NSW) Health Survey using the NPAS measures, Merom (2007) estimated that the prevalence of walking for a minimum of 150 min accrued over five sessions or more a week was 34.8% (95% CI, 32.6%–37.1%) for male adults and 31.8% (95% CI, 30.1%–33.6%) for female adults aged 16 and over in the state of NSW in 2004. We applied the estimates to the rest of Australia for our economic evaluation as there were no published national data available on the prevalence of 'sufficient' walking using the NPAS measures. These estimates were similar to the prevalence of 'sufficient' walking in the United Stated, which was reported to be 34% (Eyler et al. 2003).

Population attributable fraction

Based on the pooled RRs of 2.5–3.5 h of normal walking a week (or 30 min a day for 5–7 days a week) versus physical inactivity, we calculated PAF for males and females using the following formula:

$$\delta_{\mathrm{PAF}} = \frac{P(Y-1)}{1+P(Y-1)},$$

where δ_{PAF} specifies the proportion of CHD cases attributable to physical inactivity; P the estimated proportion of the population exposed to physical inactivity; and Y the inverse of the relative risk $\left(\frac{1}{RR}\right)$ of 'sufficient walking' versus physical inactivity as specified above.

Results

Meta-analysis

Search output

The search strategy yielded a total of 5,167 articles. After elimination of studies with irrelevant outcomes, secondary prevention studies, reviews, and other types of publications, 503 papers containing primary data on physical activity and cardiovascular disease or associated risk factors were selected for further examination. A further 491 studies were excluded for either CHD not being an outcome or walking not being specifically assessed. A total of 11 prospective cohort studies and one randomized control trial study met the inclusion criteria for the meta-analysis. To control for selection bias, all the studies selected study populations based on comparable occupation, age, gender and health conditions. In general, all study populations were free of diagnosed cardiovascular diseases at the time of enrolment for the studies. Each study also adjusted to varying degrees for such confounders as age, sex, high-density lipoprotein cholesterol, hypertension, diabetes, alcohol intake, performed physical function score, functional status, smoking, body mass index, chronic disease score and self-rated health.

Pooled relative risks

The meta-analysis showed that the pooled RR of 7.5–10.5 MET-hours/week (or ~30 min of normal walking a day for 5–7 days a week) compared to physical inactivity was 0.79 (95% CI, 0.71–0.88) with $P_{\text{Heterogeneity}} = 0.72$ and $I^2 = 0.0\%$ for men and 0.70 (95% CI, 0.59–0.83) with $P_{\text{Heterogeneity}} = 0.35$, $I^2 = 9.7\%$ for women. Normal walking is defined as 2.5 miles/h with MET-hours/week conversion based on the index of the updated compendium of physical activities (Ainsworth et al. 2000). One metabolic equivalent task or MET is the caloric need per kilogram of body weight per hour of activity divided by the caloric need per kilogram per hour at rest (Ainsworth et al. 2000). The weekly energy expenditure score in MET-hours/week measures the weekly energy expenditure on walking (relative to resting state) per kilogram of body weight.

Population attributable fraction

As calculated below, 12.5% CHD cases for males and 19.6% CHD cases for females were attributable to physical inactivity:

$$\delta_{\text{PAF}} = \frac{P(Y-1)}{1+P(Y-1)} = 12.5\% \text{ (male)}\,; \quad \delta_{\text{PAF}} = \frac{P(Y-1)}{1+P(Y-1)} = 19.6\% \text{ (female)}\,.$$

Direct cost savings from walking to prevent CHD

Gross cost savings

We applied the mathematical model $S = Z_{\text{w}}\frac{C_{\text{Ina}}}{Z_{\text{Ina}}}$ to estimate the direct gross cost savings resulting from 'sufficient' walking interventions to prevent CHD in 2004, the year for which the most up to date data on healthcare costs were available. The direct medical costs of CHD to the health system were estimated at AU$1105.6 million and AU$654.1 million for male and female Australians aged 15 and over, respectively in 2004. These data were sourced from the National Heart Foundation of Australia (The National Heart Foundation of Australia 2005). The population size of 'sufficient' walking and physical inactivity were calculated from the estimates of the prevalence of 'sufficient' walking' and physical inactivity and the national population data for 2004 from the Australian Bureau of Statistics (2007).

As shown in Fig. 3, the direct gross healthcare cost savings from 30 min of normal walking a day for 5–7 days a week by the country's 'sufficient' walking population were estimated to be AU$162.83 million ($90.91 million for males and $70.92 million for females) in 2004.

Net direct cost savings

Net direct cost savings from walking were estimated as the direct gross cost savings from walking less direct costs associated with walking. We assumed that walking did not require

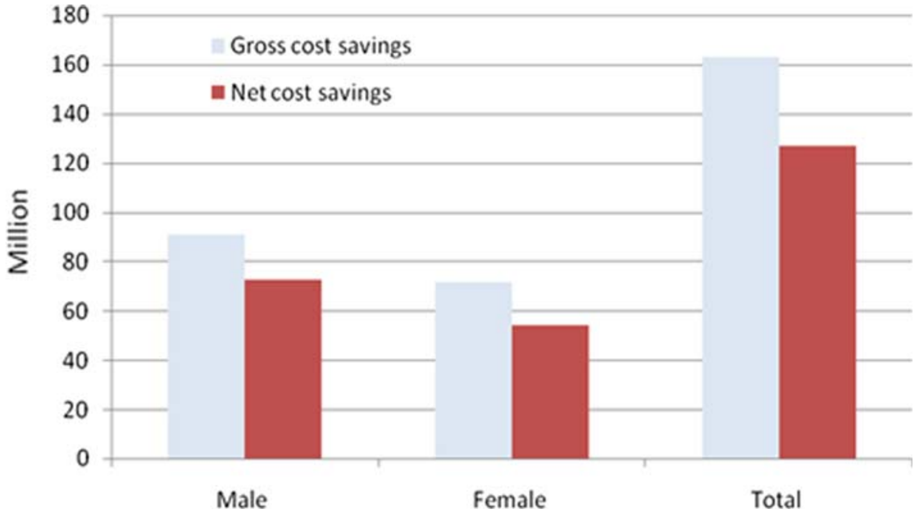

Fig. 3 Estimates of gross and net direct healthcare cost savings in 2004 (in 2004 Australian dollar), million

Table 2 Walking, running and all sport-related hospitalizations by mean bed days and total bed days, Australia, 2002–2003

	Male		Female		Persons	
	Total bed days[a]	Mean bed day[b]	Total bed days[a]	Mean bed day[b]	Total bed days[a]	Mean bed day[b]
Walking	712	6.4	1,220	5.8	1,932	6.0
Running	458	2.3	174	1.7	632	2.1
All sport	85,269	2.5	32,720	2.8	117,989	2.6

Data source: hospitalized sports injury, Australia 2002–2003, AIHW 2006 (Flood and Harrison 2006)
[a] Total bed days, including inward transfers
[b] Total bed days (including inward transfers) divided by cases (excluding inward transfers)

exercise equipment or training and therefore incurred no cost for these items. The cost for walking shoes was estimated to be AU$50 per pair (in 2004 price) (based on the price information from the Target Department Store in Australia) lasting for about 4 years at 1 h of walking a day. American College of Sports Medicine recommends that healthy people in the general population can begin low or moderate physical activity such as walking without the need for medical clearance (American College of Sports Medicine 2000). Therefore, we assumed that the direct cost associated with walking was only related to the cost of injury sustained during walking and the cost of walking shoes.

Since no data were available on walking-related injury cost, we derived the estimates from the total sports injury cost which stood at AU$178.5 millions for 2006/2007 in Australia (Medibank Private 2007). We estimated the proportion of walking injury cost to the total sports injury cost based on the total bed days of hospitalization required for managing walking-related injury and other physical activity-related injuries in 2002/2003 (Flood and Harrison 2006) for which the most up to date data were available (Table 2). Adjustment was made for population growth and health inflation to 2004.

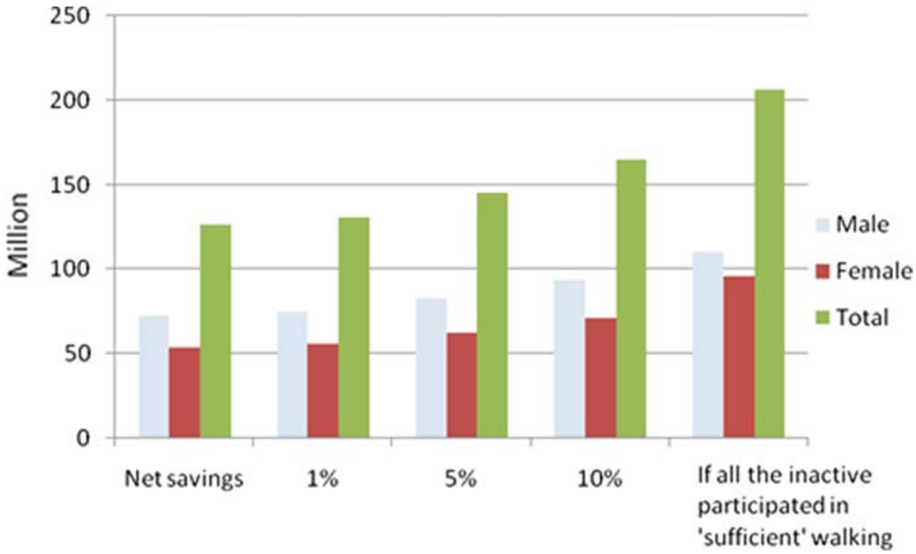

Fig. 4 Estimates of the net direct healthcare cost savings from increased participation in ‘sufficient’ walking (in 2004 Australian dollar), million

As shown in Fig. 3, the net direct healthcare cost savings for CHD prevention from 30 min of normal walking a day for 5–7 days a week by the ‘sufficient’ walking population were estimated to be AU$126.73 million in 2004.

Sensitivity analysis

Although more than 70% of adult Australians aged 15 and over were estimated to have participated in walking for exercise or recreation in the previous 12 months (Merom and Bauman 2003), less than half of the population achieved ‘sufficient’ walking. We performed a sensitivity analysis to assess potential healthcare cost savings from increased participation in ‘sufficient’ walking. As the results showed in Fig. 4, if 1, 5 and 10% more adult Australians engaged in ‘sufficient’ walking, the total potential net healthcare cost savings could increase to $130.53, $145.67 and $164.61 million, respectively. 5–10% physical activity increases were feasible targets to achieve according to the national physical activity planning and overseas experience (Stephenson et al. 2000). If the entire sedentary population engaged in ‘sufficient’ walking, the total net healthcare cost savings could reach $206.69 million.

Given the dose-response relationship that an increment of 30 min of normal walking a day for 5 days a week led to 19% of CHD risk reduction, we conducted a sensitivity analysis by increasing ‘sufficient’ walking by 30 min a day for 5 days a week, assuming that injury rates remained unchanged as there was evidence suggesting that there was no effect of greater amounts of walking on injuries for either gender (Colbert et al. 2000). The corresponding PAF for male and female adults was estimated as follows:

$$\delta_{\mathrm{PAF}} = \frac{P(Y-1)}{1+P(Y-1)} = 27.0\% \text{ (male)}\,; \quad \delta_{\mathrm{PAF}} = \frac{P(Y-1)}{1+P(Y-1)} = 36.1\% \text{ (female)}$$

As shown in Fig. 5, an increment of 30 min of normal walking a day for 5–7 days a week by the ‘sufficient’ walking population would result in potential net cost savings of $259.39 million.

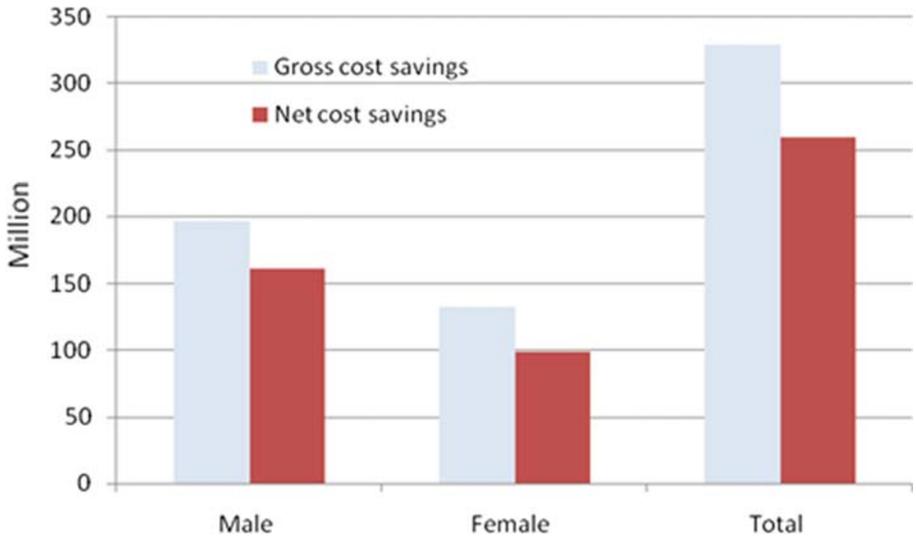

Fig. 5 Estimates of the gross and net direct healthcare cost savings from normal walking of 1 h a day for 5–7 days a week by the 'sufficient' walking population (in 2004 Australian dollar), million

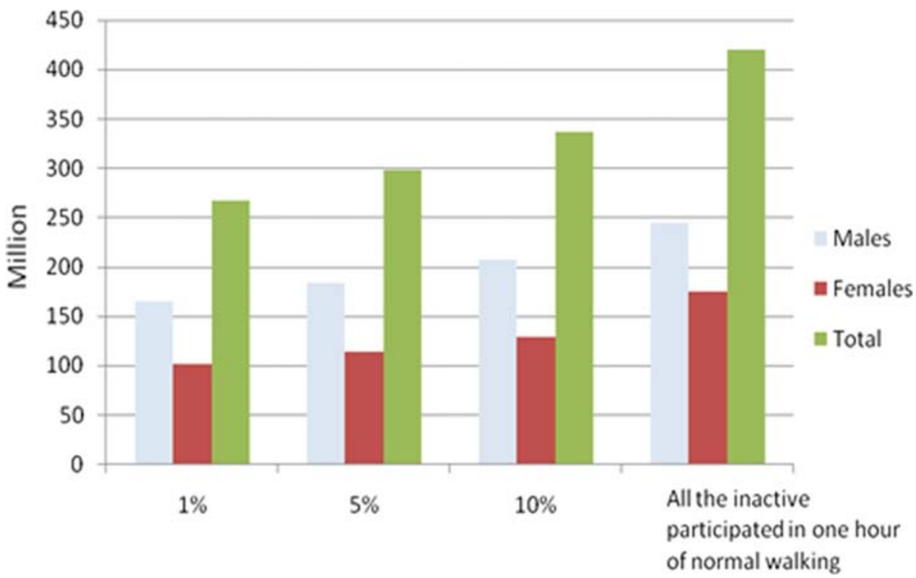

Fig. 6 Estimates of the total direct net healthcare savings if 1, 5 and 10% more adults Australian engaged in 1 h of 'sufficient' walking a day for 5–7 days a week

If 1, 5 and 10% more adult Australians could achieve 1 h of normal walking a day for 5–7 days a week, the total net direct cost savings could increase to \$267.11, \$298 and \$336.6 million, respectively. If all the inactive population engaged in 1 h of normal walking a day for 5–7 days a week, then the total net healthcare cost savings could increase to \$419.90 million (Fig. 6).

Table 3 Net cost savings with walking injury cost increased by 5, 10 and 20% (in 2004 Australian dollar), million

	Net cost savings from 'sufficient' walking 'sufficient'			Net cost savings by the walking population walking 1 h a day for 5–7 days a week		
	Male	Female	Total	Male	Female	Total
5%	72.62	53.98	126.60	160.79	98.47	259.26
10%	72.58	53.90	126.48	160.75	98.39	259.14
20%	72.48	53.74	126.22	160.65	98.23	258.88

The estimates of walking-related injury cost were based on the proportions of hospital bed days required for treating different physical activity-related injuries. However, injury incidence, severity and the need for hospitalization may vary depending on the nature of the activity and circumstances under which an injury occurs. Given the uncertainty, we varied the walking injury cost by 5, 10 and 20% increase to further estimate the net cost savings from walking.

As shown in Table 3, the net cost savings were insensitive to walking-related injury cost increases, reflecting the small proportion of walking-related injury cost relative to the overall cost of walking.

Discussion

The results of our study indicated that walking generated net economic benefits and contributed to reduction in the country's healthcare expenditure. Adult Australians aged 15 and over who met the national physical activity recommendation guidelines by taking 30 min of normal walking a day for 5–7 days a week reduced the healthcare expenditure on CHD by an estimated $126.73 million or 7.2% of the national healthcare costs of CHD annually. If the whole inactive population could achieve 30 min of normal walking a day for 5–7 days a week, the total national healthcare expenditure on CHD could be reduced by 12%. A further 12% of the total national healthcare expenditure on CHD could be reduced if the entire inactive population could engage in 60 min of normal walking a day for 5–7 days a week.

The direct healthcare cost savings resulting from walking interventions in preventing CHD would reduce the financial burden of CHD on the stakeholders of the healthcare system. The healthcare in Australia is financed by the public healthcare system through 'Medicare' scheme, private health insurance and patients. The benefit received by a patient ranges from 75 to 100% of the Medicare Benefits Schedule fee depending on factors such as where and by whom the service is delivered. Any difference between the benefit received and the healthcare fee charged must be met by the patient as an out-of-pocket or "gap" payment. The public healthcare system is financed through general taxation revenue based on an individual's taxable income. About half of all Australians have also taken up private health insurance. Approximately 43% of the population (or 9 million people) are covered by hospital insurance for treatment as private patients in both public and private hospitals.

The net healthcare savings resulting from walking interventions in preventing CHD would help to cut the Medicare levy and alleviate the tax burden on taxpayers. Such savings would in turn lead to reductions in the out-of-pocket payment for CHD-related healthcare costs and private health insurance premiums as walking interventions reduce both the risk of CHD and incidence of CHD. The claim payment by private health insurance providers would also be reduced proportionally as a result of CHD cases prevented.

A cost-benefit analysis of walking to prevent CHD in the US (Jones and Eaton 1994) suggested that if all the sedentary adults (40% of the population) aged 35–74 began regular walking, US$4.3 billion (in 1991 dollar) would be saved each year. The analysis considered indirect as well as direct costs of both CHD and walking, making a direct comparison with our study difficult. On a per capita basis, the US study using RR similar to ours (1.9 vs. 1.7 for males and 2 for females) estimated that about AU$90 (adjusted to 2004 Australian dollar) could be saved per year if a sedentary person began regular walking for 5 h a week as compared to AU$78 (in 2004 dollar) as estimated by our study. A Japanese study (Tsuji et al. 2003), based on actual medical insurance claims, estimated that the annual direct medical cost saving per capita was about AU$112 (adjusted to 2004 Australian dollar) in those who walked for 30 min to 1 h a day compared to those who walked less than 30 min a day, and AU$441 for those who walked more than 1 h a day compared to those who walked less than 30 min a day. The higher estimates by the Japanese study may be explained to a large extent by the fact that it measured the reduction of overall medical expenditure rather than medical expenditure on CHD alone, because benefits of walking extend beyond CHD risk reduction. In addition, the Japanese study did not consider the direct cost associated with walking as our study did. A previous study costing physical inactivity in Canada (Canadian Fitness and Lifestyle Research Institute 1996) suggested that the potential gross cost saving from CHD prevention by an active Canadian was about AU$49 a year (adjusted to1993 Australian dollar) based on RR of 1.6. An Australian study costing physical inactivity (Stephenson et al. 2000) suggested that the potential gross healthcare cost saving from CHD prevention was about $AU36 (in 2004 dollar) per year if a sedentary person engaged in a minimum of 150 min of moderate physical activity a week. The estimate was based on RR of 1.5. Our study, based on RR of 1.27 for males and 1.43 for females, indicated that the annual gross healthcare cost saving by an adult Australian engaging in 30 min of normal walking a day and 5–7 days a week was about $30 (in 2004 dollar). The similar results indicated that walking compared favorably with moderate physical activity in its effectiveness in reducing direct healthcare costs of CHD.

The strengths underpinning our study include the use of meta-analysis to synthesize the scientific evidence and quantify the efficacy of walking to prevent CHD. Our model emphasized the conceptual importance that the total medical costs corresponded to the level of physical inactivity within a certain time interval. Varying physical inactivity prevalence with total medical costs held constant as previous studies did in sensitivity analysis tended to either overestimate or underestimate the actual medical costs attributable to physical inactivity. Given the observed gender difference in terms of walking prevalence, direct healthcare costs and RRs, our study separated males from females, thus minimizing estimation inaccuracy.

Our analysis has some limitations that should be taken into consideration. Firstly, the PAF model relied on cross sectional data with the assumption that walking, CHD risk reduction and healthcare cost savings occurred within the same period of time. However, the time lag between walking, disease prevention and cost savings is inevitable. Due to lack of data, our study relied on injury hospitalization to estimate walking-related injury cost, which might not accurately reflect the actual injury cost associated with walking. We also applied the prevalence of 'sufficient' walking in the state of NSW to the rest of Australia, assuming that the heterogeneity of the lifestyle between New South Wales and the rest of Australia was insignificant.

Secondly, our economic evaluation focused on quantification of the direct healthcare cost savings from 30 min of normal walking a day for 5 days a week, the minimum amount of physical activity needed to maintain health as recommended in the national physical activity guidelines of the United States and Australia. However, given the dose-response effect, insufficient walking below the minimum walking level may also generate health benefit to a less degree as compared to little or no physical activity. Therefore, our economic evaluation represented a conservative estimate of the direct healthcare cost savings from walking interventions.

Thirdly, due to lack of data, our study did not cost interventions to increase walking participation, nor did we assess the opportunity cost of walking or productivity loss from CHD. Further research is needed to assess the full extent of the economic impact of walking to prevent CHD. As our study focused on healthcare cost savings from walking to prevent CHD, more research is needed to evaluate the economic impact of walking to prevent other diseases with physical inactivity as a risk factor.

Conclusion

In conclusion, our economic evaluation showed that 30 min of normal walking a day for 5–7 days a week by adult Australians would contribute to a substantial reduction in the country's direct CHD healthcare costs. This in turn would lead to alleviation of tax burden, private insurance costs and individual out-of-pocket payments. Given the low injury risk and high adherence rate, walking should be advocated as a key population-based primary intervention strategy for CHD prevention and healthcare cost reduction.

The results of our study provide much needed information required for health planners to develop and implement evidence-based and cost-effective intervention strategies to prevent CHD in the general population and reduce the financial burden of the disease on the country's healthcare system. The study has important implications for policy makers to guide public health policy towards best practice in physical activity interventions with allocative efficiency and better health outcomes. The findings from our study will also help to motivate the general public to engage in active walking in order to reap the economic benefits as well as the health benefits.

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