THE COSTS OF ILLNESS

ATTRIBUTABLE TO

PHYSICAL INACTIVITY IN AUSTRALIA
A PRELIMINARY STUDY

Commonwealth Department of
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THE COSTS OF ILLNESS ATTRIBUTABLE TO PHYSICAL INACTIVITY IN AUSTRALIA

A preliminary study

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RESEARCH OUTLINE

1. This monograph presents a preliminary analysis of the costs of illness attributable to physical inactivity, with particular emphasis on coronary heart disease (CHD), non-insulin dependant diabetes (NIDDM) and colon cancer. Other costs of illness attributable to physical inactivity are described, although in less detail.

2. The document comprises:

    (a) A review of the number of incident cases, premature mortality and health system burden attributable to CHD, NIDDM and colon cancer; review the epidemiological evidence for health gain attributable to these conditions.

    (b) Costing of these illnesses, in terms of health treatment costs and person years of life lost.

    (c) Conduct of a sensitivity analysis of cost savings from those illnesses alone if the population achieved feasible levels of increase in physical activity. Three potential levels of change were considered:

    • 5 per cent more of the population became at least moderately physically active;

    • 10 per cent or more of the population became at least moderately physically active; and

    • all insufficiently active became at least moderately active.

    (d) Description of methods for assessing cost saving for other health and social benefits to being physically active. This sets the context for relative considerations of inactivity, tobacco use, and poor diet as important dimensions of the primary prevention of non-communicable disease.

PREAMBLE

This report is preliminary, as it is one of the first attempts anywhere to cost physical inactivity, and begin the process of defining the economic burden attributable to this risk factor. The review was supported by a grant of $10,000 (which was used as salary by the first author). The other authors contributed voluntary time, in the interests of exploring the magnitude of the burden attributable to inactivity in Australia.

Overall the budget for this report was between one fifth and one twentieth of the usual budgets for health economic or costs of illness appraisals of other risk factors, such as tobacco, alcohol or nutrition. In this light, these results provide a preliminary description of the direct health system costs related to physical inactivity, and further work is suggested. This report is intended to initiate this overdue discussion.

CONTENTS

ABBREVIATIONS

AMI	Acute myocardial infarction
BOD	Burden of disease
CHD	Coronary Heart Disease
CVD	Cardiovascular (disease)
COI	Costs of illness
NIDDM	Non insulin dependent diabetes
PA	Physical Activity
PAR	Population Attributable Risk
RR	Relative Risk
USSG	US Surgeon General's Report, Physical activity and health

ACKNOWLEDGMENTS

SUMMARY

This report presents estimates for the direct health care costs of illness attributable to physical inactivity in the adult Australian population. Mortality and morbidity data for 1996 have been analysed using the most recently available national health cost data from 1993–94. The report focuses primarily on six health compromising conditions because the epidemiological evidence is reasonably strong for these diseases suggesting a causal relationship between physical inactivity and the increased risk of mortality and/or incidence of these specific diseases on the other. The diseases are coronary heart disease (CHD), non-insulin dependant diabetes mellitus (NIDDM), colon cancer, breast cancer, stroke and depression. The evidence for the first three conditions is strongest, and should be considered consistent with a causal relationship.

Population attributable risk (PAR) approaches were used to estimate the proportion of disease outcomes attributable to being inactive. National prevalence data of inactivity among adults were derived from the Active Australia 1997 National Physical Activity Survey, and estimates of relative risk (of disease outcomes for those who were inactive) were derived from multiple studies of physical activity and each specific disease. The 1997 adult Australian prevalence rate of 44 per cent of adults who were 'insufficiently active' was used as the estimate of inactivity. Conservative estimates suggested that the PARs for each disease were 18 per cent for CHD, 16 per cent for stroke, 13 per cent for NIDDM, 19 per cent for colon cancer, 9 per cent for breast cancer and 10 per cent for depression symptoms. In addition, hypothetical estimates were derived for all cause mortality, and 18 per cent was estimated to be due to inactivity. Physical inactivity contributes to the risk of 6,400 deaths p.a. in Australia from CHD, NIDDM and colon cancer, and up to 2200 more due to other conditions, including breast cancer and stroke. Of these deaths 1531 occur in people under the age of 70 years and contribute to an estimated 77,603 potential years of life lost because of inactivity. These deaths are potentially avoidable if the sedentary and low active population became at least moderately active.

The annual direct health care cost attributable to physical inactivity is around $377 million per year. For each disease, costs were estimated to be $161 million for CHD, $28 million for NIDDM, $16 million for colon cancer, $101 million for stroke, $16 million for breast cancer, and up to $56 million for depressive disorders.

The report presents a sensitivity analysis of three options for the effect on potential savings in direct health care costs if public health approaches contributed to an increase in the proportion of the population who were physically active. The scenarios were a 5 per cent point increase, 10 per cent point increase and finally, an increase where all the insufficiently active became moderately active. It is estimated that 122 deaths per year from CHD, NIDDM and colon cancer could be avoided for every 1 per cent increase in

the proportion of the population who achieve a level of sufficient and regular physical activity. These estimates indicate that one quarter of these deaths occur in people under 70 years and indicates that 1,764 life years could be gained for every 1 per cent increase in population moderate activity levels. The analysis indicates that gross savings of $3.6 million p.a. in the health care cost of these three diseases could also be achieved for every 1 per cent gain in the proportion of the population who are sufficiently active.

The report outlines issues that need to be further explored including assessing indirect costs attributable to physical inactivity, describing the cost effectiveness of the strategies to promote participation in physical activity and sport, and assessing other health and social benefits that result from increasing levels of activity and sport. In addition, other health outcomes have not been investigated in this report; costings for quality of life and other aspects of mental health, arthritis improvements, and effects upon weight, blood pressure and cholesterol require further appraisal.

In summary, physical inactivity is an important population health risk factor, comparable to tobacco use or poor diet in the risk that it poses for ill-health. This study produced estimates similar to health costing studies carried out overseas, and reinforces the evidence that there is a substantial burden of disease as well as substantial costs attributable to inactivity. Increasing attention needs to be given to methods of increasing regular moderate physical activity participation across the whole Australian community.

BACKGROUND

INTRODUCTION

Illness attributable to physical inactivity is an important issue for health care providers, policy makers and to communities. To date, there have been few attempts to quantify the economic burden of physical inactivity on morbidity and mortality. However, significant proportions of the population are inadequately active, and inactivity increases the risk of prevalent conditions such as coronary heart disease, non-insulin dependent diabetes and colon cancer.

'Cost of illness' is just one tool of health economics. Estimates of the costs of illness attributable to preventable risk factors are of importance to decision makers (Xie et al 1999). This provides some notions of the overall cost savings if the risk factor could be removed or reduced in prevalence. It is also possible to rank or rate risk factors, both from an overall 'burden of disease' perspective (AIHW 1999) and from a health costs perspective. This costing process is one of the first steps in identifying the relevant issues in primary prevention.

More importantly, health care providers and policy makers will want to put this costing information into a strategic context. The next steps after identifying the costs of illness are to identify and characterize effective strategies to address physical inactivity at a population level. This is useful for decision makers in terms of investing scarce resources in physical activity strategies. Further, they will ask how this investment compares with other options for allocating resources for a particular disease or in the health sector generally.

This study concentrates on the first step, examining the costs of illness for major illnesses attributable to physical inactivity. These diseases have been selected because the epidemiological evidence for their association with physical inactivity is compelling, as is the case for recommending regular moderate activity as a preventive measure (Bauman and Owen 1999, Bauman and Egger 2000).

This document describes the processes of estimating those disease costs. The next steps, which include strategies to reduce inactivity, also require resources and would incur costs, although these would be shared across a range of sectors. Health professionals can initiate some of the strategies to promote physical activity, while other population level strategies are in the domain of the education, sport, transport, local government and urban planning sectors. Depending on the method of financing physical activity promotion, costs will accrue to diverse government agencies, employers or to individuals. Likewise, some of the health, social and economic benefits from increased activity will accrue to the health sector (possible reduced health care costs), industry

(increased demand for equipment, clothing etc), employers (possible increased productivity from reduced absenteeism and increased mental health) and individuals (possible increased well being and reduced health care costs). The social value or benefit from participation in physical activity and sporting activities varies among people. These areas of work, assessing the methods and costs for increasing physical activity in the population, and assessing the range of benefits to multiple sectors, is beyond the scope of this report, but provides clear future directions for research in this area.

COST OF ILLNESS STUDIES

Cost of illness (COI) studies attempt to measure the economic consequences of poor health. A standardised protocol has evolved for COI studies, typically with three components:

- **Direct costs** refer to health sector costs for prevention, diagnosis and treatment of diseases and may include costs for; ambulance, inpatient, nursing home, outpatient, rehabilitation, allied health, research, community health and medical services and consumption of pharmaceuticals.

- **Indirect costs** measure the value of human life or the lost productivity potential of patients who are too ill to work or die prematurely. Society loses some or all of the productive benefit of an ill person and conversely enjoys that benefit if the illness is prevented or the patient cured. There are important and debatable issues in the measurement of indirect costs. Examples include the use of 'average weekly earnings' as an appropriate measure of a person's productive value and the use of an imputed value for non-marketed production such as unpaid household services.

- **Intangible costs** are measures of cost to the individual (and their family) who has an illness in terms of their reduction of quality of life due to such issues as pain, disability, bereavement, anxiety and suffering.

Some studies also consider a value or cost for the time spent engaged in physical activity. This value is considered to be similar to the average hourly wage, if people do not like physical activity, but is considered 'free' for people who voluntarily choose to participate, and continue to enjoy activity (Hatziandreu 1988, Jones and Eaton 1994).

Internationally, COI studies have increased in prevalence despite the debate about these methods among some health economists. A bibliometric analysis of MEDLINE publications over the past two decades revealed 189 primary COI studies, of which most were done in the past five or six years. In the area of primary prevention, a few studies have been carried out around hypertension, cholesterol therapy, and tobacco control. In addition, one North American research group has conducted three similar studies of the costs of obesity (Wolf 1998, Colditz 1999, Colditz 1999a). One of these studies, published in November 1999, has also examined the costs of physical inactivity, and is discussed later in this report (Colditz 1999). Other studies have also examined the costs of obesity, reaching the conclusion that it contributed to around

2 per cent of the total health budget in Australia (Segal 1994), with similar estimates ranging up to about 5 per cent of total health costs in studies in France, the USA and the Netherlands (WHO 1998).

COI studies have been undertaken in Australia around health risk factors to initiate debate about the relative allocation of resources between preventive interventions and treatment options for managing specific diseases and associated risk factors. Cost estimates have included: obesity, $736 million (NHMRC, 1997); poor nutrition, $2.2 billion to $3.6 billion (Crowley et al 1992); alcohol, $6.7 billion to $17.9 billion (Crowley et al 1992); and, tobacco, $9.2 billion (Collins and Lapsley 1996). These studies provide a very broad range of estimates, but are not comparable, as some have included only direct costs, and others have considered indirect costs as well.

Direct costs are relatively easy to measure given a system for disaggregating total costs between classifications based on age, gender and diseases (Mathers et al 1998). Most COI studies provide direct cost estimates, using available health and epidemiological data.

Indirect costs are less often reported, and provide an estimate of other social and economic costs due to illness and include estimates of the loss of production due to sickness or death. Additionally, estimates can be derived for other costs such as the imputed cost of non-marketed work and the police and court costs associated with drug dependence.

Indirect and intangible costs are often omitted from COI studies because they are difficult to measure in dollar terms, although they may be significant outcomes of illness and premature death. Intangibles are the essence of quality of life and may have the greatest value in terms of total community welfare. This acknowledges the large burden of costs that accrue for individuals and their families due to premature mortality, chronic disease and the loss of quality of life. Indicators to measure the impact of disease and risk factors on the quality of life are still being developed. In addition, longitudinal or experimental studies are required to assess associations between, for example, physical activity and positive well being and other quality of life indices.

USES AND MISUSES OF COST OF ILLNESS INFORMATION

COI information needs to be used with care and in context. The information is potentially useful in the development of public policy around health issues because it allows us to:

- Identify and analyse how resources are currently being allocated between different types of costs, services and diseases. Health planners have an interest in understanding the relationship between the rates of disease and health resources utilisation for that disease. The distribution of resource utilisation can be measured during a COI and assist in an analysis of equity considerations. Costs can be measured on an incidence or prevalence basis. The former is concerned with the lifetime costs for a patient for a particular disease, but may require cohort

data to be collected. The latter is a cross sectional estimate of costs, independent of the patients' stage of disease during a specified time. There are several reasons, discussed later, why this cross sectional approach is more permissible when considering physical activity and health, compared to COI reports for other risk factors.

• Identify improvements in health status and health care resource savings following potentially effective interventions. Cost/benefit analysis can be applied to determine the implication of implementing particular interventions in the community. For physical activity, few evidence based interventions exist, and the modelling of cost effectiveness may be difficult at present.

• Provide data on the cost side of the cost effectiveness analysis for a later economic appraisal and contribution to priority setting.

• Provides information relevant to the issue of inactivity and its inclusion or relevance in the policy making, political and community agenda. This is important, and the ranking of risk factors (and their relative costs) is an important issue for priority setting. For more recently recognised risk factors, such as physical activity, such information is important to policy makers, against the background of an existing plethora of known risk factors, already competing for public sector resources and programs.

The COI methodology has been criticised because it is subject to misuse. This criticism has been neatly summarised, *'to know the cost of an illness is to know nothing of real importance in deciding what we should do about the illness'* (Davey and Leeder 1993). Treatment or prevention of a disease with a high cost may be ineffective or expensive. These same resources might be used more effectively or efficiently for a different treatment or a different disease. Economists refer to this alternative and competing use of resources as their 'opportunity cost', that is, commitment of resources for one use is an opportunity foregone for a different use. With respect to the primary prevention of cardiovascular diseases, the debate will focus on the competing demands among established and more recently recognized risk factors, such as between tobacco, hypertension, and cholesterol levels [established cardiovascular risk factors], and newer ones such as physical inactivity, obesity, or antioxidant levels.

In addition to COI studies, information is required about the effectiveness of new or different interventions relevant to current practice and their respective value for money. One danger of COI studies is that they may mislead and misinform the reader because of the spurious estimates of indirect and intangible costs.

The present study aims to provide the same COI information [related to direct costs and life years lost] for physical inactivity as is currently available for many other risk factors. This will provide decision makers with the capacity to fund preventive initiatives on the basis of importance and need. Further work is related to methods for developing an evidence based approach to initiatives which increase physical activity in the population.

A central theme of this report is to use conservative methods to estimate the costs attributable to physical inactivity. These could be substantially higher than the preliminary estimates provided here, and this is further mentioned in the discussion section, where cost estimates are compared with overseas studies.

UNDERTAKING A COST OF ILLNESS STUDY

A number of steps were followed to undertake this study of the cost of illness attributable to physical inactivity. These steps are shown below, and are typically used in this setting. Reviews of the costs attributable to obesity, and one North American study costing physical inactivity used exactly the steps numbered 1 to 5 below (Wolf 1998, WHO 1998, Colditz 1999).

The steps used in this review were to:

1. Identify major diseases and conditions (including incident cases, premature mortality and health system burden) related to physical inactivity.

2. Quantify the relationship between the prevalence of physical inactivity and the associated risk of disease morbidity and mortality using population-attributable fractions (PAF).

3. Identify the relevant economic cost categories so that an estimate could be made of the costs of episodes of care and person years of life lost.

4. Quantify the total direct costs of the diseases related to physical activity.

5. Use the PAFs to apportion the share of total costs directly attributed to physical inactivity.

6. Undertake sensitivity analysis of key epidemiological and economic parameters to provide a range of cost estimates. The sensitivity analysis in this study is based on varying the proportion of the population who might become physically active.

REVIEW OF ECONOMIC STUDIES OF PHYSICAL INACTIVITY

There are few published studies of the health care costs of physical inactivity and of the potential savings from reducing the levels of population inactivity. Comparison between studies is difficult because of different assumptions and techniques employed in determining costs.

Using 1993 data, a Canadian study estimated the direct health care savings from increasing physical activity and the estimated reduction in disease incidence due to coronary heart disease (CHD), diabetes type 2 and colon cancer. There were four components of direct costs: hospitals, physicians, drugs, and research. The study estimated costs saved based upon the realistic (and actually achieved) goal of increasing the number of active Canadians by 1 per cent per year. The relative risk (for disease incidence comparing the sedentary to those who were active) used estimates of

1.6 for CHD and 1.2 for diabetes and colon cancer. The study was simplified by assumptions that would need to be tested by a sensitivity analysis. It was assumed that: there were no distinguishing features between physically active and inactive people; there was no time lag between the introduction of higher levels of activity and reduction of risk of contracting the disease; and, the potential health care savings were equivalent to the medical treatment costs avoided for a single year.

This Canadian study estimated that the annual treatment cost savings following a 1 per cent increase in the number of people who are physically active for the 3 diseases was $11.5 million. The authors acknowledge that in reality the actual savings may differ from their proposed estimate. Only variable costs such as the cost of drugs can change in the short term and new costs may arise for the treatment of other diseases that the newly active person might develop. On the other hand, there are other uncosted health outcomes such as improved mental health or reduced risks of other diseases that may also reduce the overall use of health services.

An Australian study of cardiovascular disease (Roberts et al 1987) estimated the cost saving from increasing the proportion of the adult population who are sufficiently active to gain a protective effect from CVD from the current 10–20 per cent to 50 per cent. This was a very large assumption, as no intervention studies or temporal trends have observed anywhere near a 30 per cent increase in physical activity prevalence. Nonetheless, the overall potential saving was estimated to be $274 million per year. However, in confirmation of the above criticisms of cost of illness studies this study did not indicate the level of resources required to bring about these massive behavioural changes and assumed that benefits would accrue immediately. It could be assumed that a maximal 5–10 per cent increase in the prevalence of activity might accrue from effective public health approaches (Bauman and Owen 1999), so the cost savings here would be about one sixth to one third of those cited above—in other words a saving of $45–$90 million in 1998 dollars.

An US study costing physical inactivity was published in November 1999 (Colditz 1999). This study added the cost burden of physical activity to that of obesity in North America. A simplified version of the methodology used in this present study was used, with direct costs of illness considered, and population attributable risks (see later for further explanation) were applied to CHD, diabetes, osteoporosis, colon and breast cancers and hypertension. Using only the PARs, a total cost of $24 billion was calculated, or 2.4 per cent of US Health Care expenditure. The study reported that the costs of obesity were even greater, and in total both inactivity and obesity contributed to greater health costs than estimates usually provided for tobacco or alcohol.

The above studies assessed the costs of illness. In addition, some health economic work has been conducted to examine the costs and effects of interventions to promote physical activity. This is the process of cost effectiveness analysis, and is used to compare the relative costs of competing strategies for achieving a given outcome such as reduced disease incidence or 'quality adjusted life years' (QALYs) gained. Thus promoting physical activity and sports participation can be evaluated as an alternative

strategy to medical intervention to reduce CHD. In one such modelling study (Hatziandreu et al 1988) two hypothetical cohorts of 1000 35-year-old men were followed for 30 years. One group was prescribed exercise and consumed 2000 kcal per week by jogging while the other group remained inactive. Expected health outcomes of exercise were reductions in the incidence of CHD, gains in life expectancy and gains in QALYs. Costs included direct health care, exercise equipment and clothing, medical cost of injuries and savings from CHD avoided. Indirect costs and benefits also included time spent in the exercise program and healthy time gained from the prevention program. On the basis of telephone interviews with 6 exercise experts the authors estimated that 55 per cent of participants in an exercise program enjoyed it, 35 per cent disliked it and 10 per cent were neutral. A value was placed on the time spent on exercise for these three groups of zero; average hourly rate; and, half the average hourly wage rate, respectively. This model predicted that there would be 78.1 fewer CHD events in the exercise cohort compared to the sedentary group. Life expectancy would be extended and 1,138 QALYs saved. These gains cost $6 million ($US 1985) in direct and indirect costs which equates to ratios of $11,313 per QALY gained and $76,760 per CHD incident case averted. A variation of this model was proposed that produced estimated net economic savings if only volunteers who enjoyed exercise continued the program. This also highlights the importance of the value of time spent undertaking physical activity or sport for participants in the analysis. Exercise prescription was deemed to be cost-effective because it compared favourably with the costs of other cardiovascular preventive strategies and risk factor reduction.

The health impact of inactivity in New Zealand is discussed at length in a report on the impact of sport and leisure (Jensen 1993). An estimated $48m of direct and indirect costs could be saved annually if the sedentary population was reduced by a third from 31 per cent to 21 per cent of the population. If all sedentary people became active then the saving would be $162 million. Diseases included in this study were hypertension, coronary heart, cerebrovascular, atherosclerosis, cancer of the colon and fractured neck of femur. In the absence of specific health care utilisation data, the authors used attributable risk data based on mortality and morbidity as a proxy measure. They have halved the potential savings estimates from increased activity for the population over 65 years as an acknowledgment that health care costs arise in this population 'because of the intrinsic degenerative impact of ageing'. Most of the savings occur from avoiding cardiovascular diseases and in particular from avoiding premature death. This study does not attempt to estimate the cost of reducing sedentariness.

The true economic benefit of promoting physical activity including sports participation may be underestimated by studies that focus on a single disease. Other benefits accrue from the effects of activity, which need to be valued. A Dutch study (Van Mechelen, 1997) indicates that the benefits derived from a physically active lifestyle in terms of reduced use of health care services and reduced absenteeism because of better health outweigh the costs incurred from sports injuries sustained during increased activity. Further, the study suggested that economic benefits increased with age.

British data has been used to estimate the health and healthcare costs and benefits of exercise, which includes organised sports as well as recreational activity (Nicholl 1994). The authors concluded that for sedentary people over the age of 45 years, health care costs avoided outweighed new costs incurred by their participation in exercise and sport[1]. However, the authors concluded that the reverse relationship existed for sedentary adults under 45 years ie that their additional health and other costs incurred from participation in sport and exercise outweighed the estimated costs avoided from the disease prevention effects of sport and exercise. The authors admit their work is pioneering and that 'many of the estimates used here are crude and have required unsubstantiated assumptions'. For example, they assumed that the sedentary population would only partially emulate the sporting and exercise behaviour of their active peers and therefore derive a proportion of the cost of their health care costs. However, most of the cost of exercise induced injury in the younger population is due to very vigorous activity and contact sports whereas sedentary people should probably be encouraged to participate in more moderate activity with lower injury incidence rates. The authors own data suggests that the rates of injury associated with jogging, aerobics and swimming are less than one-fifth of the rates associated with sports such as rugby, soccer, hockey and cricket (Nicholl 1993). A recent epidemiological review (Powell 1998) showed that injury incidence rates were very low following participation in regular moderate activities, such as walking or gardening. Additionally, the British analysis (Nicholl 1993) focussed on disease incidence, that is, the occurrence of a new disease within a specified period. Thus, promoting moderate physical activity and sport amongst younger adults provides a life-long reduction in risk of disease and thus has the potential to reduce the cost of treating those diseases throughout life.

OTHER ECONOMIC AND SOCIAL BENEFITS OF PHYSICAL ACTIVITY AND SPORT

Economic studies have indicated that physical activity has a positive impact on a number of variables such as discounted lifetime costs (Emmett et al 1989), productivity due to reduced absenteeism (Shephard 1991) and capacity for independent living amongst older people (Canadian Fitness and Lifestyle Research Institute 1996). None of these studies have provided the costings for these benefits, indicating they are difficult to document and quantify. For example, for worksite studies, there is much written about the potential cost savings of physical activity programs, but little hard data to document these in terms of physical activity outcomes or employer cost savings (Dishman et al 1998).

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[1] Note that this study, as many others do, infers that there is a substantial economic cost to participation; alternative models based on the recent epidemiological evidence for moderate regular physical activity participation have proposed different approaches to population energy expenditure through physical activity. For example, accumulation of 10 minute quanta of physical activity through the day, or incidental activity such as short walks to public transport or using the stairs, may provide sufficient physical activity for health gain, without some of the costs (and acute risks) of more vigorous sports participation. This provides a quandary, as the sport and recreation sector is partly driven by participation in organised activities, and by the economic growth in the sector as an outcome, whereas health is driven predominantly by health care and system costs and savings.

The sport and recreation sector has expanded rapidly over the last 2 decades. A 1995 Canadian study (op cit) indicated that on average adults spent almost $700 p.a. to participate in physical activity and sport. The largest item was equipment, followed by membership fees, transport, clothing and coaching. An average of $800 was spent on child participation in physical activity and sport. Spending levels correspond with activity levels such that those who are sedentary spend on average $191 compared with an expenditure of $1,161 by those who are highly active. Expenditure on fitness related items such as clothing and equipment has increased four-fold between 1969 and 1978 and doubled between 1978 and 1986. The 1995 estimate of all participation related expenditure in Canada was $21.5 billion.

The ecomonic impact of the Australian sports sector has been studied (Tasman Asia Pacific and Ernst & Young 1998). The authors concluded that the sector's output was $7.9 billion in 1995–96, but it is less clear what proportion of this output is derived from individual participation in sport. The 'Active recreation sports industry' with sales of $2.2 billion includes sports clothing and equipment, and, services such as aerobics and swimming. The report asserts the importance of workforce fitness for industrial productivity and recommends increased government assistance to encourage sports participation[2].

A report on the social and economic impact of sport and leisure in New Zealand was published in 1993 (Jensen et al 1993). The total economic impact of the industry, including an estimated multiplier effect of 1.98 was $1,648 million or 2.4 per cent of Gross Domestic Product.

The economic costs and benefits for the sport and recreation sector are one method of costing participation. The diverse reports and studies above mostly occurred before the landmark US Surgeon General's Report on Physical Activity (1996), which indicated the potential benefits to be gained from regular moderate and incidental forms of physical activity, building it into everyday life, rather than a complete focus on organised or vigorous activities. In this context, health benefits are possible without any increase in the proportion who are 'aerobically active', or any obligatory increase in the Sport and Recreation Sector. The strategies to achieve increases in incidental activity might also be different, comprising changes in perceptions of what is activity, and in working across sectors to make everyday physical environments more conducive to being active.

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[2] This poses the same issues as above; sports participation may have an economic cost for participation which has other putative benefits, such as economic growth; from a health perspective alone, these costs may not all be necessary, as much of the population preference is for incidental physical activity (such as walking), compared to organised sports. This is especially true of middle aged and older adults (Booth, Bauman, Owen et al 1997). Hence the individual dollar costs of participating in recommended levels of moderate intensity physical activity could be less than assumed in 'organised sport' oriented reports.

An integrated multi-sectoral strategy may be the most effective methods of promoting physical activity in Australia. This will include strategic planning across sectors and in consultation with each other, as well as efforts to increase incidental activity, regular walking and daily tasks, and increase organized sport and increased use of recreational facilities and resources. All of these elements in concert could produce population changes in physical activity participation levels.

PHYSICAL ACTIVITY AND HEALTH

EVIDENCE OF HEALTH BENEFITS FROM PHYSICAL ACTIVITY AND SPORTS PARTICIPATION

The study of physical inactivity as an independent risk factor for several major chronic diseases began in earnest during the 1980s. The epidemiological evidence now indicates a strong and almost certainly causal relationship between physical inactivity and mortality from cardiovascular disease, diabetes and colon cancer (US Surgeon General 1996, Bauman and Owen 1999, Powell and Pratt 1996). The evidence is of the same strength as the risks between tobacco smoking and heart disease, although fewer studies have explored the physical activity and health relationship. Each year, new studies identify consistent and stronger associations between physical inactivity and adverse health risks. Over the next decade, the range of health benefits attributable to regular moderate activity will broaden. Finally, there is clear evidence of a dose response relationship, with some benefits being realized by activating the completely sedentary, and many benefits achieved by participation in moderate activity levels such as '*around half an hour of moderate intensity activity on most days of the week*' (USSG 1996, Bauman and Egger 2000).

The relationship between inactivity and disease outcomes shows the following features across many epidemiological studies:

- Despite the use of different measures of activity and fitness, the relationship to health outcomes appears similar among studies in diverse populations; where better measures of exposure and outcome were used, stronger associations were noted (Powell 1987).

- After adjustment in several studies for confounding factors which also contribute to disease such as hyperlipidemia, hypertension and obesity, there are independent favourable effects of physical activity upon disease states, as well as PA having a role in amelioration of other risk factors (for example, in weight maintenance, increasing HDL cholesterol or reducing blood pressure).

- A dose relationship is established (Powell 1987, Berlin 1990) such that more activity provides more health benefit (conversely, the least active groups in populations have poorer health outcomes).

Physical activity confers a protective effect from all cause mortality even if adopted in middle and later life (Kampert 1996, Lee and Paffenbarger 1997). The benefit can be achieved within two or three years of adopting an active lifestyle (Paffenbarger 1993, Blair 1995). A key element of the literature here is the work in the Dallas cohort study reported by Blair (1995). This paper shows that the results of becoming active confer a

benefit on cardiovascular and all cause mortality more rapidly than changes to other risk factors. For example, increasing fitness or activity reduced all cause mortality within two years, which is half the time required following smoking cessation to see such effects. This deals with the time lag criticism in health economics, because for physical activity, more than for tobacco, hypertension or diet, there appears to be a relatively short time lag to observe benefits. This means that there is likely to be relative temporal concurrence between activity changes and several important health outcomes.

Most studies have focussed on cardiovascular disease in part because CVD is a major contributor to overall mortality. Pooled data from all the epidemiological studies suggest that the risk of an incident or fatal event is around twice as high for the sedentary or low active population compared to the at-least moderately physically active population (Berlin 1990, US Dept of Health 1996). Physical activity is both an independent risk factor as well as acting to modify other risks such as hypertension, obesity, high-density lipoproteins and total cholesterol (Bauman 1991).

Recent studies indicate an inverse relationship between physical activity and the risk of cerebrovascular disease (stroke) either by providing a protective mechanism to reduce blood-clot formation and/or reducing levels of high blood pressure (Shinton 1993, Wannamethea 1992, Fagard 1994). The evidence here is not yet universally accepted, but is evidenced by each study replicating the finding of a similar protective role for the active segment in the population.

There is substantial evidence that physical activity has a protective effect upon the development of colon cancer and precancerous polyps in the large bowel (Slattery 1997, US Dept of Health 1996, Neugut 1996, Colditz 1997). Several recent studies also indicate a protective effect against the risk of breast cancer particularly for younger women (Coogan 1997, Thune 1997), although there is less evidence here than for colon cancer prevention.

The incidence of Non Insulin Dependent Diabetes Mellitus (NIDDM) is lower amongst the physically active even after adjusting for the effect of overweight and obesity. It has been suggested that between one third and a half of the new cases of diabetes could be prevented by the adoption of moderate physical activity (Helmrich 1994, Manson 1991), and that this effect is independent of body weight.

While very vigorous or elite level sport may contribute to an increased risk of osteoarthritis in joints that are over-used, there is some evidence that in the general population with osteoarthritis and rheumatoid arthritis, moderate activity may assist in relieving symptoms and improving functional capacity (Minor 1991). Physical activity increases bone mass during adolescence and reduces bone mass loss during middle and later years. Reduced bone mass is characteristic of osteoporosis which is itself a precursor for an increased risk of bone fracture later in life (Drinkwater 1994). Physical activity may also modify other predisposing factors for falls and hence the risk of fractures such as muscle strength, balance and agility (Lord 1994, 1995).

Improved mental health, such as reduced levels of anxiety, depression and stress are associated with participation in physical activity at both the clinical level for individuals and at the population level (Petruzello 1991, Stephens 1988, Simonsick 1991). These outcomes, along with others such as quality of life, are difficult to quantify in a health costing study, as much of this morbidity would not contribute to health care utilisation or measureable costs.

All of the above dimensions are explored in this costing study. The best evidence is for CHD, diabetes and colon cancer, so these form the leading three evidence based diseases for preventive costing; other issues with increasing and consistent evidence will also be considered, including some aspects of mental health, stroke, and breast cancer. There is some evidence that physical activity protects against gallbladder disease, but this evidence is confined to few studies, and is not yet consistent enough to include in this report. There are also positive effects of moderate physical activity upon systolic and diastolic blood pressure levels, and this could contribute to substantial savings in pharmaceutical costs for hypertension. More prolonged amounts of physical activity also contribute to weight control, better lipid profiles, and more favourable cardiovascular risk profiles. These effects on other risk factors are worthy of further and separate exploration, but are beyond the scope of this report. Finally, the consistent relationship between physical activity and all cause mortality provides a global estimate of potential savings, but as discussed later, may substantially over estimate cost savings. Thus, this report uses epidemiological evidence which is the best substantiated, and provides a conservative underestimated of the disease burden, and hence the health costs, attributable to inactivity.

THE 'BURDEN OF DISEASE' IN AUSTRALIA ATTRIBUTABLE TO PHYSICAL INACTIVITY

New methods for assessing the relative importance of physical activity have recently been published. A seminal study by McGinnis and Foege (1993) identified that around 50 per cent of all mortality was associated with preventable factors. The most important factors were tobacco (contributed to 19 per cent of all deaths) and physical inactivity and nutrition (14 per cent). This was based on the epidemiological data available in about 1990, and indicated that physical activity contributed to much of the mortality in the USA.

One more recent method for assessing the 'Global Burden of Disease' (BOD) was developed by the World Health Organisation, and uses 'disability-adjusted life years' (DALYs). These were based on a composite health outcome measure, which included mortality, as well as disability, premature life lost and lost quality of life (Murray, Lopez 1996). In late 1999, an Australian BOD study was completed, which provided a new set of major health problems, including those contributing to disability as well as those causing deaths to Australians (AIHW 1999).

Data from the Australian BOD study indicated the relative contribution of physical inactivity as one of the major risk factors for disease and disability. Overall, physical activity ranked second, after tobacco, in terms of contribution to ill-health in Australia.

Data from both mortality and disability were used to estimate these contributions of risk factors, and are shown, in summary format in figure 1 below. This shows the percent of the total disability burden attributable to various risk factors.

The AIHW report also assessed the relative risks for diseases associated with physical inactivity, and produced data very similar to the population attributable risks shown later in this report. The AIHW report suggested that physical inactivity was associated with stroke, colorectal cancer, breast cancer, hypertension, ischaemic heart disease, non-insulin dependent diabetes, falls and depression — this list was identical to the diseases chosen for this study, except that hypertension was not included separately from stroke in this disease costing study. This provided concordance between the epidemiological estimates used in the AIHW report, and developed for this COI report.

Figure 1: Percent of total burden attributable to physical inactivity in Australia — adapted from AIHW Burden of Disease and Injury in Australia, AIHW 1999
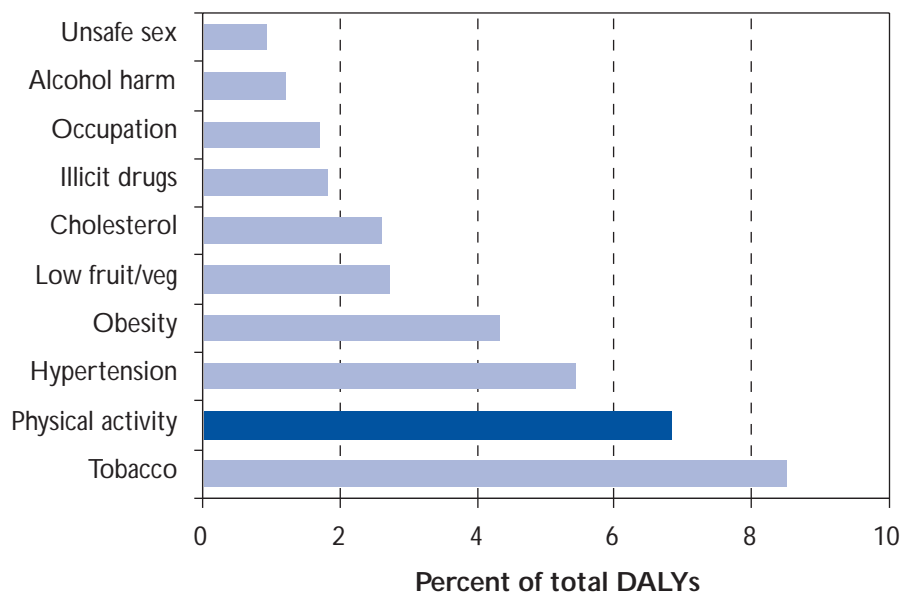
HOW ACTIVE ARE AUSTRALIANS?

PREVALENCE OF PHYSICAL ACTIVITY

Several studies have been undertaken over the last decade in an effort to categorise the physical activity status of the Australian population. As the health benefits of adequate activity are revealed, it becomes increasingly important to understand the population health gains that are potentially available from advancing strategies to increase the proportion of the population who are active. Hence the importance of knowing the current prevalence of physical activity. This study has used data from the most recent and comprehensive study of physical activity prevalence.

The data below show weighted (to the Australian adult population) prevalence rates from the Active Australia 1997 National Physical Activity Survey. This was a telephone-based survey, which asked a random representative sample of 4,824 adult Australians aged 18 to 75 years about their physical activity patterns in the week prior to the survey. Details of this survey and the methods used to calculate prevalence rates are described in the report resulting from that survey (Active Australia 1997 national survey).

The figures below show the prevalence rates of a four-category system for classifying the population by physical activity level[3]. The four categories are high, moderate, low and sedentary levels of activity, using previously established methods (Bauman, Bellew et al 1996).

Figure 2 shows these four categories for the weighted sample of Australian adults. Twenty eight percent reported high levels of physical activity, 28 per cent reported moderate levels of physical activity, and these two categories summate to 56 per cent, which is sufficiently active for health. The remaining 44 per cent are considered insufficiently active for health. Figure 3 shows these categories stratified by age group and gender, and show that the prevalence of high levels of physical activity are more common amongst younger adults, whereas moderate levels of activity show slightly higher rates in those over 60 years. Those who are completely sedentary and report no physical activity tend to increase with age.

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[3] Note that there are now various other methods for classifying the population, but these provide similar estimates of physical inactivity among adult Australians. Other methods include estimating the proportion of adults who meet the 150 minutes per week or 5 sessions of 30 minutes each week; overall, 58.7 per cent of Australians reported 150 minutes of activity in the previous week, and 49.2 per cent achieved both 150 minutes and at least five sessions (Active Australia physical activity survey 1997).

These data can be used in describing the relationship between physical activity and health. In particular, they describe the prevalence of physical inactivity, and the prevalence of moderate activity. Both of these can be used in applying the concept of population attributable risk, using both the prevalence rates described here alongside the relative risks to estimate the proportion of health outcomes that may be attributable to physical inactivity.

For estimates that only provide an active versus inactive estimate, the prevalence rates of 56 per cent and 44 per cent could be used. Where there is a dose response relationship, and estimates for moderate and vigorous activity are separated, the two sufficiently active categories, namely the moderate category and the high category could both be used.

Figure 2: Australian population categorised by physical activity level, November 1997
(weighted data, n=2500 adults aged 18-75). Overall prevalence rates using four categories of physical activity participation, based on energy expenditure estimates.
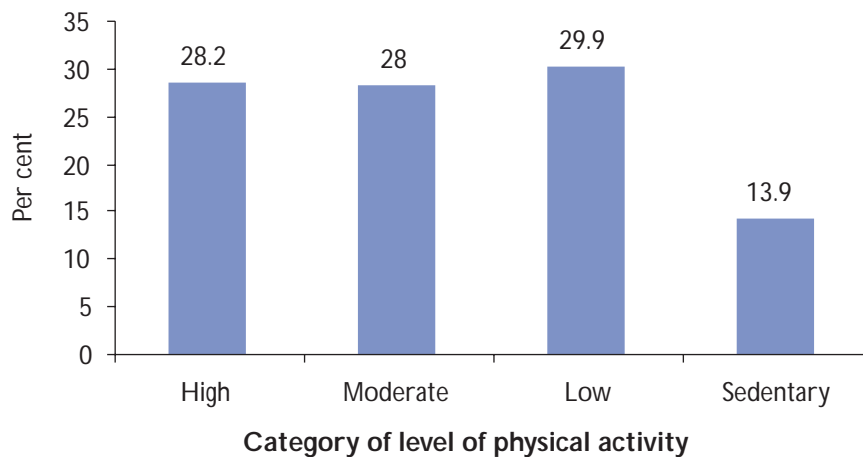
Figure 3: Australian population, categorised by physical activity level within age groups and by gender (weighted data, n=2500 adults aged 18–75). Separate analyses for females (F) and males (M).
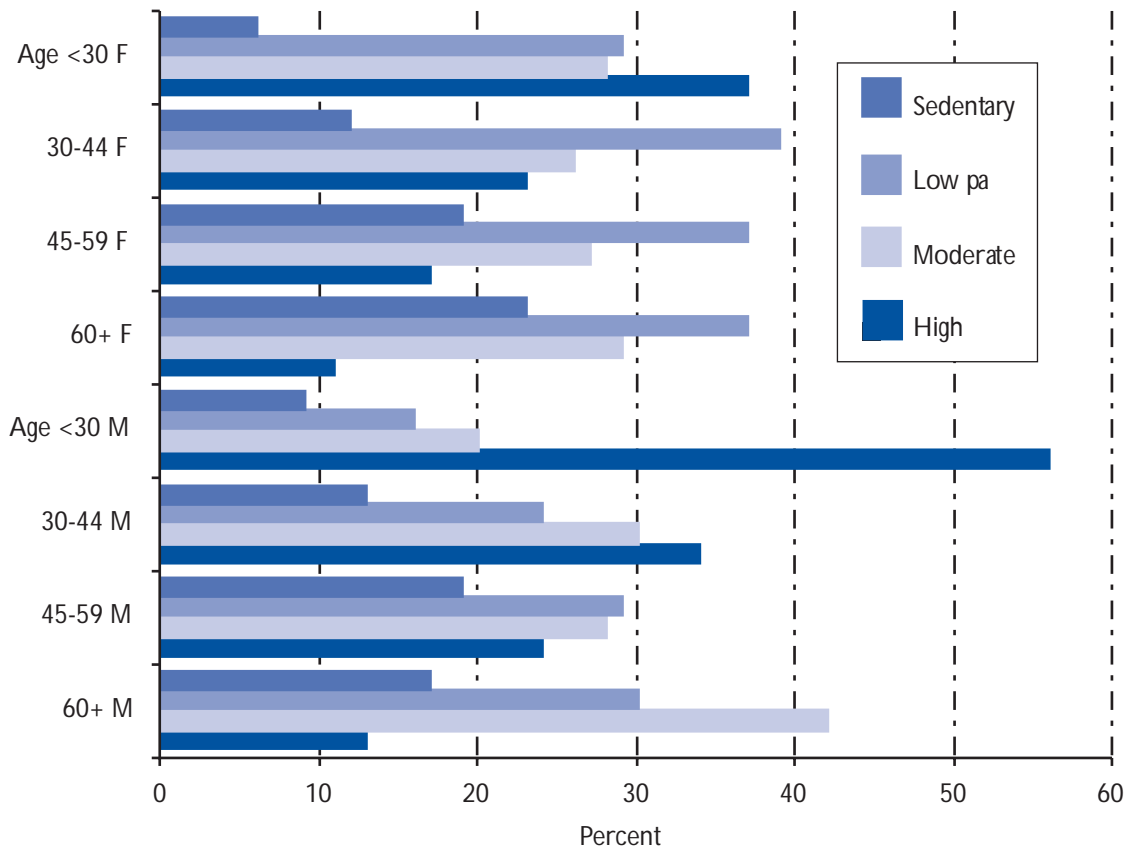
Figure 4 shows a more conservative method for calculating energy expenditure categories. This method constrains the high level of energy expenditure to those who also report at least three sessions of 20 minutes of vigorous activity. This can be described as a true 'aerobic' category and is shown in figure 4. This results in movement of a number of formerly high category activity individuals to the moderate category. Thus the prevalence of the high category is reduced to 19 per cent, but the overall prevalence of sufficiently active remains at 56 per cent. The analysis for this report has been conducted using this measure, and is shown in figure 4; it has the same age distribution as the first measure in figure 2. The same sufficiently-active estimate has been used as shown in figure 2, but the stratification of the high and moderate categories is more precise. The prevalence in the highest physical activity category has been reduced to 19 per cent overall. There is still a clear age distribution in this high level, with little age variation in the moderate levels, and increasing rates of sedentariness with increasing age.

Figure 4: Australian population: revised physical activity categories, 1997 (weighted data, n=2500 adults aged 18–75). Overall prevalence rates using four categories of physical activity participation, based on energy expenditure estimates, but restricting the 'high' category to 'aerobic levels' of participation; low and sedentary unchanged.
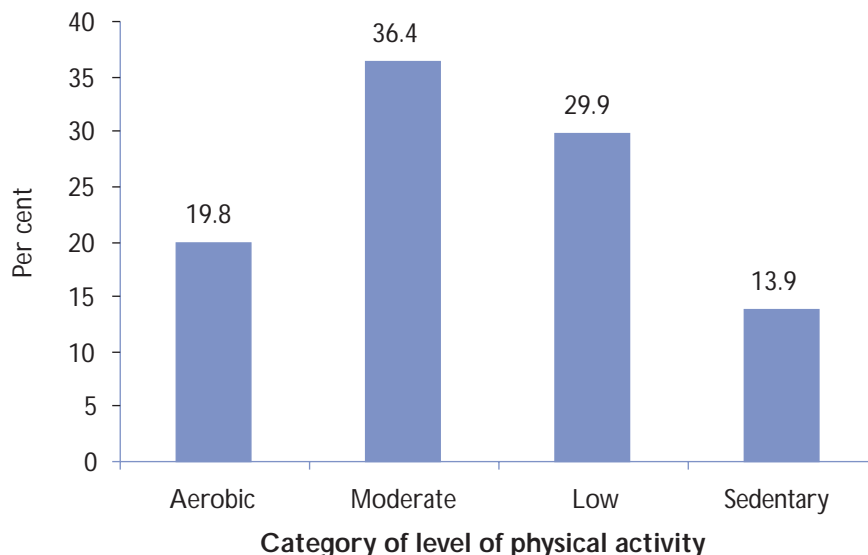
These data identify the level of participation in regular physical activity among adult Australians. Around half of the adult population engaged in at least moderate levels of activity in the previous week, suggesting that the at risk population is the remaining half, those who reported no activity or only very low levels. This prevalence rate, of around 50 per cent, is twice the rate of smoking and three times the rate of hypertension among adult Australians.

POPULATION ATTRIBUTABLE RISK (PAR) AND THE HEALTH BENEFITS OF INCREASED PHYSICAL ACTIVITY

Introduction

This section describes the epidemiological concept of population attributable risk (PAR), and defines its role in prevention. Using this concept of PAR, the amount of morbidity and mortality attributable to physical inactivity can be assessed, and an estimate made of the fraction of disease that might be prevented if the population became more active. This concept is useful for defining the health benefits of regular moderate activity, and then extrapolating these to health utilisation data to estimate direct health costs.

The epidemiological concept of population attributable risk

Risks of disease are often assessed by comparing rates of health or disease in some groups exposed to a risk factor, compared to those not exposed to the risk factor. For example, those who smoke tobacco are more than ten times as likely to develop lung cancer, compared to non-smokers. This is usually described as a relative risk (the ratio of rates of disease or outcome, in the exposed group compared to those unexposed to the

risk factor). The relative risk is a measure of the strength of association between exposure and outcome. For example, those with high blood pressure show a three to five fold increase (300–500 per cent increase) in the risk of stroke, whereas those who are physically inactive show a 1.5 fold increase in risk of stroke, compared to the physically active (a 50 per cent increase in risk). Thus one would conclude that high blood pressure shows a stronger association with stroke than does physical inactivity.

Absolute comparisons between groups are often described in terms of attributable risks. The risk difference (also known as the excess absolute risk) is the difference between rates of outcomes experienced by groups who are exposed or unexposed to putative risk factors. The attributable fraction (aetiological fraction) is the risk difference divided by the rate of the outcome among exposed individuals. This concept expressed for the whole population is known as the population attributable risk (PAR). This is defined as the proportion of a given health outcome attributable to a risk factor in the population.

PAR depends on the risk of exposure (relative risk), and upon the prevalence of the risk factor in the population. The prevalence of insufficient physical activity for health in the Australian adult population is around 44 per cent (Australian National Physical Activity Survey 1997 — see figure 2; this estimate was chosen for use in this study). Internationally, physical inactivity is typically the most prevalent of cardiovascular risk factors. It is more prevalent in populations than other recognised CHD risk factors such as high blood pressure, tobacco use and high cholesterol levels. The relative risk for all cause mortality appears to lie between 1.5 to 2 times as high among inactive adults, compared to active adults.

Using the relative risks derived from epidemiological studies, and the prevalence of physical inactivity, the Population Attributable Risk (PAR) can be calculated. This percentage of deaths or any outcome in a population that could be attributed to inactivity should, strictly speaking, be called the PAR fraction, or attributable fraction, as it represents a *percentage* of the outcome attributable to exposure. This measure is useful for assessing the public health importance of risk factors, as it represents the proportion of cases or deaths (or other outcomes) prevented if exposure to the risk factor were eliminated (Bauman 1998).

Two factors contribute to the magnitude of the PAR: prevalence and the strength of association. Note that a higher prevalence of inactivity in the population, or a stronger association between inactivity and a health outcome will both result in a greater PAR.

The formula for the Population Attributable Risk (PAR) used is shown below where:

- P = prevalence of inactivity in the population; and

- RR = relative risk (of the outcome) in the sedentary/low activity group compared with the active group.

$$Population\ attributable\ risk\ =\ \frac{P(RR\text{-}1)}{1 + P(RR\text{-}1)}$$

Using the formula above, some examples are described below. Assume that P, the population prevalence of physical inactivity is 0.5 (around 50 per cent inactive), and the relative risk for the relationship between inactivity and incident coronary heart disease (CHD) is estimated to be around 1.9 (from Berlin 1990),

$$\text{then the PAR} \quad = \quad \frac{0.5\,(1.9\text{-}1)}{1+\,0.5\,(1.9\text{-}1)} \quad = \quad 0.31.$$

This implies that about 31 per cent of the risk of developing CHD is attributed to inactivity. Changes to the prevalence of inactivity in the population will influence this, and prevent up to 31 per cent of cases of CHD[4]. Table 1 describes the relationship between varying prevalence rates of inactivity (or any other risk factor), the relative risk used (based on epidemiological evidence) and the PAR.

Table 1: Population attributable risk estimates for different relative risks and different prevalence rates of a risk factor

	Prevalence of the risk factor in the population						
Relative risk	10%	20%	30%	40%	44%(a)	50%	60%
	Population attributable risk estimates						
1.2	0.02	0.04	0.06	0.07	0.08	0.09	0.11
1.5	0.05	0.09	0.13	0.17	0.18	0.20	0.23
1.9	0.08	0.15	0.21	0.26	0.28	0.31	0.35
2.5	0.13	0.23	0.31	0.38	0.40	0.43	0.47
3.5	0.20	0.33	0.43	0.50	0.52	0.56	0.60

Note: PAR of 0.04 means that 4 per cent is preventable if exposure to the risk factor is eliminated.
(a) Current level of inactivity among Australian adults assumed to be 44 per cent based on Active Australia survey 1997.

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[4] Similarly, if the relative risk were smaller (say 1.2 or 1.5) or greater (as an example, RR=2.5) then this would influence the PAR. This is shown in table 1 below. A small relative risk would contribute to only around 6 per cent of events if the prevalence of the risk factor were 30 per cent, but would contribute to 11 per cent of events if the prevalence of the risk factor were 60 per cent. If the relative risk was much larger (RR=2.5), and the prevalence of the risk factor in the population was 30 per cent, then 31 per cent of events might be prevented if exposure to the risk factor was eliminated. If the RR=2.5 and the prevalence of the risk factor was 60 per cent, then 47 per cent of events might be preventable. These data represent relative risks and prevalence rates relevant for any epidemiological studies estimating the risks of physical inactivity and adverse health outcomes.

Applying the PAR to the relationships between physical inactivity and disease

The summary estimates of PAR for physical inactivity are based on the relative risks observed in epidemiological studies and the prevalence of inactivity. Australian data suggest the prevalence of inactivity to be around 44 per cent as discussed above.

Applying the PAR concept suggests that if physical inactivity were eliminated (and the whole population adopted regular moderate physical activity), then:

- Around a third of coronary artery disease deaths would be prevented (Powell and Blair 1994).

- A quarter of diabetes deaths and colon cancer deaths could be prevented (Powell and Blair 1994; Bauman 1998).

- Up to 12 per cent of breast cancer risk is attributable to inactivity and is thus preventable, especially among postmenopausal women (Mezzetti 1998).

- About 15 per cent of the risk of ischaemic stroke may be attributable to lack of physical activity and is thus preventable (Shinton 1997).

- Some of the risk of hip fractures, perhaps 10–16 per cent, might be explained by physical inactivity and thus indicates a considerable preventable morbidity (Johnell 1995, 1996).

Physical activity, using the PAR approach, is seen as a central risk factor for cardiovascular disease, at least as important as other recognised risk factors (Pate et al 1995). In addition, physical activity has the potential to improve other risk factors, including weight control, blood pressure reduction, and improving cholesterol profiles. Overall, inactivity is considered to be the second most important modifiable risk factor for population health, after tobacco smoking (McGinnis and Foege 1993). The association between risk factors and outcomes are biologically fixed, and not amenable to intervention. The only component of the PAR, which could be changed, is prevalence, and thus, through increasing physical activity participation, the burden of illness could be reduced (Powell and Blair 1994).

In addition to preventing mortality, it is considered likely that moderate physical activity would reduce the risk of developing the conditions in the first place (reduced incidence), and reduce morbidity and hospital admissions from many of these conditions. The assumptions underlying the analyses in this report are that the risk factors for mortality are also risk factors for incidence and morbidity. Epidemiological studies may be limited here, except for diabetes, where incidence is the outcome measure most often reported. Nonetheless, these assumptions are reasonable, and are used to estimate disease costs in the next chapter.

A literature review of the epidemiology of disease attributable to physical inactivity has been summarised in the tables in the Appendix. The relative risk estimates from these studies have been graphed in figures 5 to 12, with detailed summaries shown in the

Appendix tables for each disease outcome. These figures and tables are for illustrative purposes only, and show data from a diverse range of epidemiological studies which illustrate the relationships between PA and health outcomes of interest in this report. Note that using the evidence in the same way is not always possible; these analyses sometimes compare moderate and vigorous levels of activity (for stroke, diabetes), and sometimes compare incidence and mortality risk differentials (Coronary Heart Disease).

This is an epidemiological review to demonstrate the magnitude of the risks for each disease outcome. In figure 5, studies are summarized which indicate risks of stroke in those who are active, compared to the inactive. Most studies show a relative risk or odds ratio of around 0.5, suggesting half the risk in the physically active group. This is not a formal meta analysis as these studies are not statistically pooled — this would require much additional work. Furthermore, these stroke studies use diverse methods, with several employing case-control designs, whereas for other disease outcomes, almost all studies were population cohorts followed for between 7 and 30 years.

Figure 6 show the results from the meta-analysis by Berlin (1990) — these are summary estimates derived from all the studies to that date. Figure 5 shows relative risks for CHD mortality for the vigorous and for moderate activity, with around a 50 per cent increase in risk for the inactive compared to the moderately active group. In addition, the summary research suggests that incidence of CHD is also increased by a similar amount among the inactive. Results from studies since 1990 further extend the findings of this meta-analysis, also showing that similar findings are found for women, and in other populations in Europe and elsewhere (Bauman and Owen 1999).

Figure 7 shows the few studies for diabetes, suggesting a 20–30 per cent risk reduction in diabetes incidence in those who are active. Figure 8 shows summary estimates from more than 25 epidemiological studies for the prevention of colon cancer — these show a 30–40 per cent reduction in risk in the active group. Note that figure 8 shows the data expressed by study design, with the better designed cohort studies producing smaller protective estimates (around 30 per cent reduced risk), compared to the 40 per cent reduction in risk suggested by the pooled case control studies.

Figure 9 shows data for breast cancer, derived from case-control and cohort studies. One study found no difference in risk in those who were active, and the other three studies showed slight risk reductions in the active group. Figure 10 shows data for depression, as one of the groups of outcomes which have been explored in relation to mental illness and general well being. Three studies are shown in figure 11 relating to falls, with varying results, although favouring the active group in each study. Figure 12 shows data from many studies for all cause mortality, with a 20–40 per cent risk reduction typically suggested for the active group compared to the inactive. In figure 12, the vigorous activity groups tend to show slightly more risk reduction than the moderately active groups, but both are clearly protective in reducing risks of all cause mortality.

Figure 5: Relative risk for stroke, physically active persons relative to sedentary persons
[comparing moderate and vigorous activity]
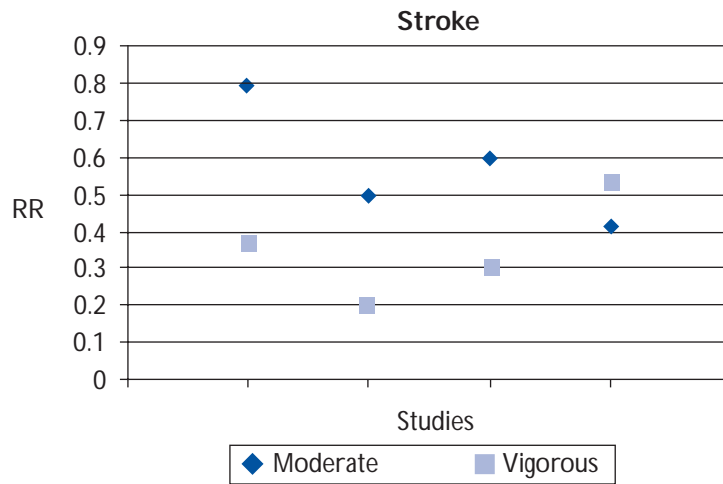
Figure 6: Relative risk for CHD for sedentary persons relative to physically active persons [derived from meta analysis, Berlin 1990]. Note that this chart examines the pooled association from many studies for CHD incidence and mortality.
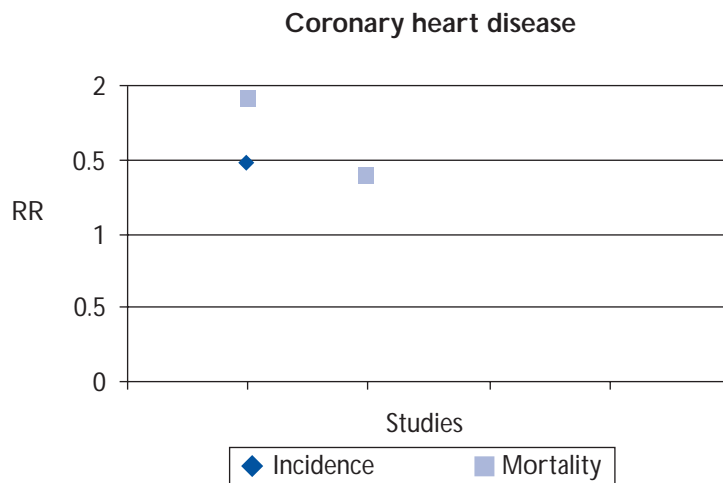
Figure 7: Relative risk for diabetes incidence, active persons relative to sedentary persons
[health effects of moderate and vigorous activity levels]

Diabetes incidence
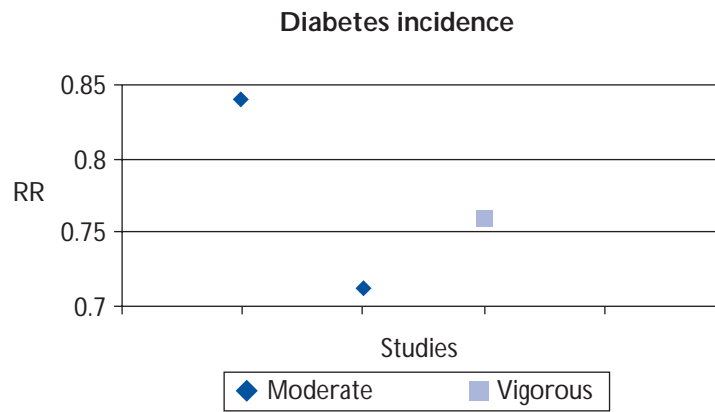
Figure 8: Relative risk for colon cancer of physically active persons relative to sedentary persons [pooled estimates across studies; note different study designs are shown, with a stronger protective relationship observed from case-control designs]

Colon cancer
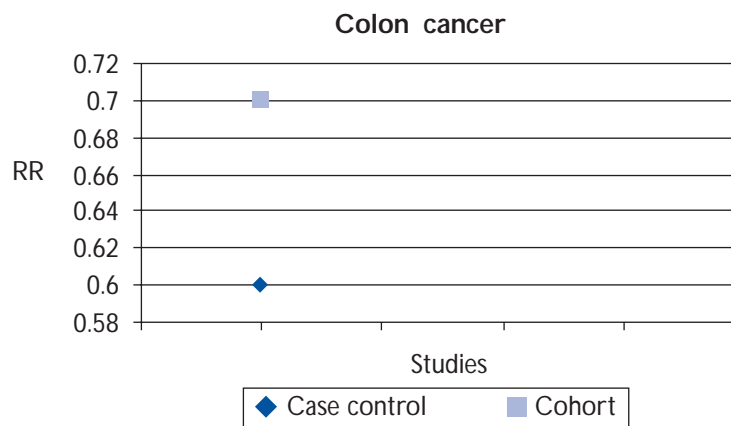
Figure 9: Relative risk for breast cancer for physically active women relative to sedentary women

Breast cancer
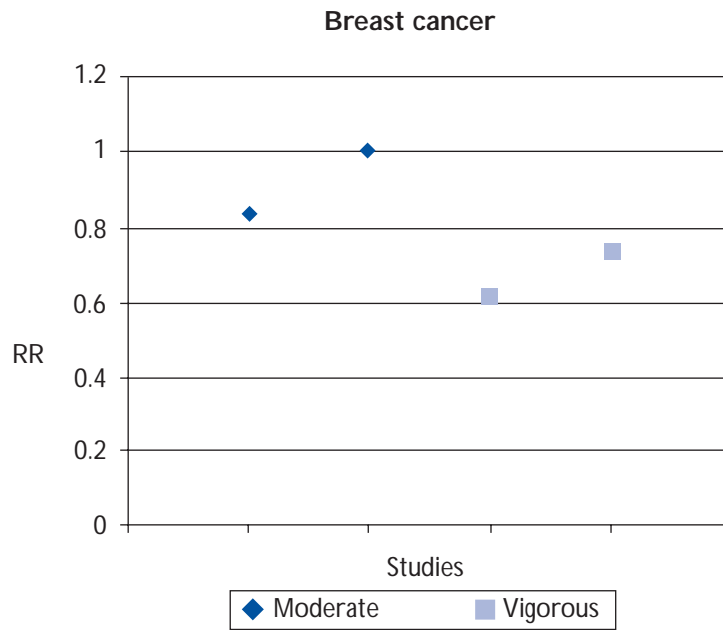
Figure 10: Relative risk for depression for physically active persons relative to sedentary persons

Depression
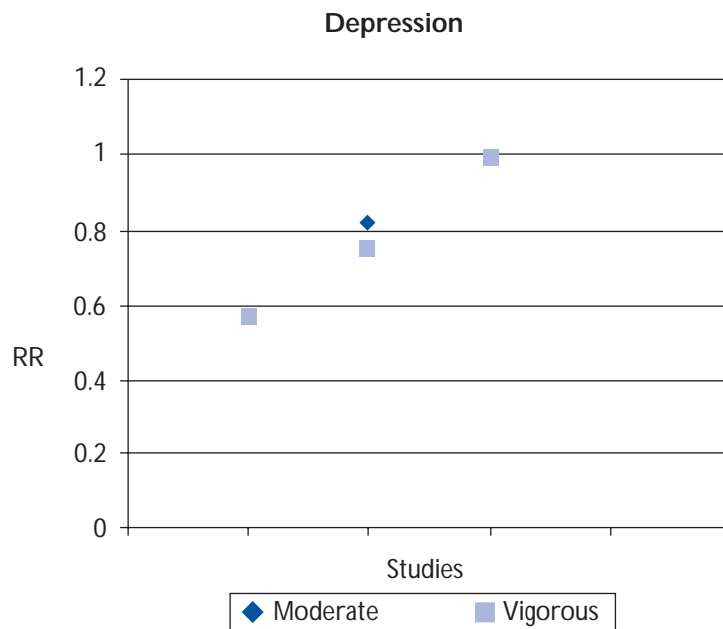
Figure 11: Relative risk for falls: physically active compared to inactive

Falls (incidence)
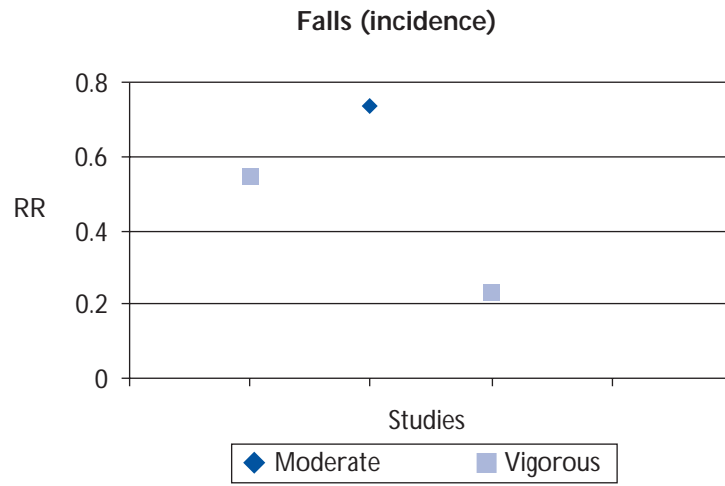
Figure 12: Relative risk of all causes of mortality for physically active persons relative to sedentary persons

All cause mortality
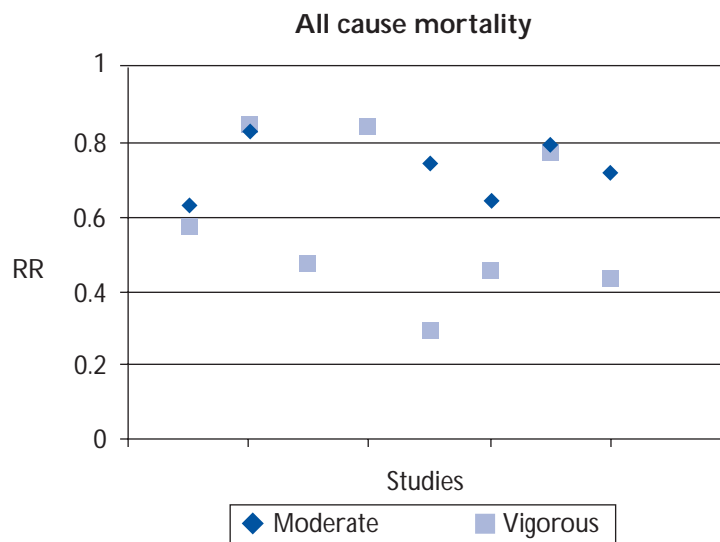
Table 2 presents a summary of the evidence and calculations that form the basis of the cost estimates in the next chapter. The epidemiological studies summarised in the Appendix indicate that the causal link between physical inactivity and the particular disease outcome is clear in spite of variations in study design and study variables. The relative risk ratio listed in this table is an estimated mean from all of the studies referred to in the Appendix. The formula outlined in this chapter has been applied for each disease to derive the Population Attributable Risk proportion. For example, the relative risk of CHD is 1.5 and the proportion who are insufficiently active is 44 per cent, thus:

$$\text{PAR} = \frac{.44\,(1.5-1)}{1 + .44\,(1.5-1)} = .18$$

This estimate of the proportion of CHD attributable to physical inactivity is considerably lower than the estimate quoted earlier (Powell and Blair 1994) and reflects more conservative estimates of the key variables. This study uses a more conservative relative risk of 1.5 compared to the US study of 1.9. There are a number of reasons for this, including some compensation for multivariate PARs, which are not yet known for PA (Bauman 1998). The PAR for stroke is more conservative than is suggested by the pooled relative risks, as there may be variants of stroke not influenced by inactivity.

A comparison between this study and the 1999 US study (Colditz 1999), in terms of PARs chosen is shown below[5]. The proportion of the population who were adequately active was 56 per cent in this study compared to around 25 per cent to 30 per cent in most US studies. The PARs used in this Australian study were very similar to the recent US study — especially for CHD, NIDDM, and cancers. The US study used a PAR for hypertension but not for stroke, and added a PAR for gallbladder disease which was not used in the Australian study. The Australian study used a stroke PAR, and added one for depression, not used in the US study. Overall, the Australian data produced similar epidemiological estimates, but justified them further in the tables in this section, whereas the US study did not detail the studies used or procedures for calculating their PARs.

[5] PARs used to estimate the COI in this 1999 Australian and the contemporary US study (Colditz 1999) compared

Disease	CHD	NIDDM	Stroke	Gall-baldder	Colon Cancer	Breast Cancer	Falls	Depress-ion	Hyper-tension
Australian study	18%	13%	16%	Not used	19%	9%	18%	10%	Not used
US study	22%	12%	Not used	22%	22%	5%	18%	Not used	12%

Table 2: Proportion of diseases attributable to physical inactivity

Disease	Relative risk	Population attributable risk (%)
All cause mortality	(moderate) 1.4 (vigorous) 1.7	18
CHD mortality and incidence	1.5	18
Stroke mortality and incidence	(moderate) 2.0 (vigorous) 3.3	16
NIDDM incidence	1.3	13
Colon cancer incidence	1.5	19
Breast cancer incidence	(moderate) 1.1 (vigorous) 1.4	9
Falls incidence	(moderate) 1.4 (vigorous) 2.5	18
Depression symptoms	1.3	10

Population attributable risk fractions have been applied to the total deaths for each disease in table 3. For example, there were 29,637 CHD deaths in Australia in 1996 of which 5,335 were attributable to physical inactivity given a PAR of 18 per cent for CHD attributable to physical inactivity. This number also indicates the potential number of deaths that could be prevented if the inactive population adopted regular moderate physical activity.

In table 3, the best evidence relates to coronary heart disease, diabetes (NIDDM) and colon cancer (Bauman, Bellew, Booth et al 1996). These three conditions are best evidenced by the epidemiological literature, and contribute to a total of 6,395 preventable deaths attributable to physical inactivity. The data for stroke and breast cancer are provisional, but the evidence is increasing for both these conditions. If these two were included there would be 8,672 deaths attributable to inactivity. The all cause estimate (shown as shaded, and derived from figure 12) is difficult to justify, as the difference between these cause-specific preventable estimates and the all-cause estimate is still a three to fourfold difference[6]. Hence the all-cause estimate is not used, as the conditions prevented, beyond the major ones listed, are not clear.

The concern for prevention is of particular importance when deaths occur at a young age. Deaths under an arbitrary age can be called premature and are closely examined for a causative factor that is amenable to being prevented. The age that is chosen to categorise premature deaths is often around 65 to 75 years; in this study 70 years of age has been used. The PAR for each disease has been applied to the number of deaths that occurred in Australia of people less than 70 years. Potential years of life lost (PYLL) is an estimate of the collective loss based on the difference between age of death less than 70 years and 70 years. PYLL is calculated by multiplying the mean age in each 5 year

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[6] The biological mechanisms which could explain this additional health benefit is not clear; hence the all cause mortality numbers, and resultant 'all cause' cost estimates, should be treated with caution. The primary focus of this report is the disease specific COI estimates.

age group from 15–19 years to 65–69 years by the difference in years between that mean age and 70 years. For example, of the 6,355 deaths less than 70 years due to CHD, 1,144 were attributable to physical inactivity and these deaths contributed 68, 455 potential years of life lost less than 70 years. These data are shown in table 4, with cumulative PYLL shown in the far right hand column. Most of the premature mortality prevented is for cardiovascular diseases, followed by diabetes.

Table 5 presents data on hospital separations or new cases of disease for each of the diseases of interest. Considerable caution needs to be exercised in applying the physical activity PARs to this data. For example, the PARs have been calculated from mortality data and it is assumed that the same proportion of risk applies to morbidity. Acute myocardial infarction is used as a proxy for all CHD incidence in this study (Taylor et al 1999). Note that there may be preventable components of other CHD related to physical activity, such as improved lipid profiles or reduced blood pressure, so this calculation provides a very conservative estimate. There were 32,810 hospital admissions due to acute myocardial infarction in Australia in 1996. The PAR for physical inactivity for CHD of 18 per cent is applied to this figure to indicate that 5,906 of those CHD admissions were as a result of physical inactivity and this number is potentially preventable.

Table 3: Mortality by cause and attributable to physical inactivity, Australia, 1996

Disease	Total deaths 1996	Number attributable to physical inactivity	Total deaths attributed to inactivity [cumulative]
CHD	29637	5335	
NIDDM	2991	380	
Colon cancer	3541	680	6395
Stroke	12806	2049	
Breast cancer	2623	228	8672
[All causes	128719	23556]	

Sources: Australian Institute of Health and Welfare; National Cancer Statistics Clearing House

Table 4: Mortality less than 70 years by cause and attributable to physical inactivity, Australia, 1996

Disease	Deaths, less than 70 years	Number attributable to physical inactivity	Potential Years of Life Lost (PYLL)	PYLL attributable to physical inactivity	Percent of all PYLL due to inactivity
CHD	6355	1144	380308	68455	71.7
NIDDM	819	104	48610	6173	6.5
Colon cancer	1475	283	15495	2975	3.1
Stroke	1675	268	99425	15908	16.7
Breast cancer	1500	131	23260	2024	2.1
[All causes	36151	6615	2113997	386861]	

Sources: Australian Institute of Health and Welfare; National Cancer Statistics Clearing House

Other preventable admissions are shown, with some (breast cancer) based on incidence data, rather than hospital admissions. Stroke data are shown, but are preliminary, as [i] there may be subtypes of stroke (such as intracranial hemorrhage) which are not preventable by physical activity, [ii] the admission rate may not reflect incidence for several reasons, including community based diagnosis and management out of hospital, and [iii] the need for frequent re-admission for those who have been hospitalised. These all contribute to a more conservative PAR being used from stroke than the epidemiological studies had suggested. The major contributors to hospital admissions were cardiovascular diseases, followed by mental health (depression), shown in the far right hand column.

The all cause estimates, shown as shaded in table 5, should be treated with caution, as explained elsewhere, as the difference between disease specific estimates and total (all cause) is very large, and the all cause estimates are likely to overestimate hospital admissions.

Table 5: Hospital separations [7] or new cases of disease(a) by cause and attributable to physical inactivity, Australia, 1996

Disease	Hospital separations or new cases(a)	Number attributable to physical inactivity	Per cent of admissions due to PA
Acute myocardial infarction	32810	5,906	24.6
NIDDM (Principal diagnosis)	11719	1,488	6.2
Colon cancer(a)	12312	2,339	9.8
Stroke	51974	8316(b)	34.7
Breast cancer [incidence](a)	9846	855	3.6
Falls	8146	1,466	6.1
Depression disorders	35939	3,594	15.0
[All causes(c)	4696000	845280]	

Sources: Australian Institute of Health and Welfare; National Cancer Statistics Clearing House

(b) All causes: uncertain estimate; derived from 1993–94 data given the issues surrounding stroke above, a conservative estimate would be derived from imputing half of the stroke admissions only as meeting the criteria of being incident cases and ischaemic stroke, which would be evidence based in terms of preventablity by physical activity increases. This estimate of half the stroke admissions is used later in table 14.

(a) Note: Breast cancer incidence is preferable for this estimate, and used above (the actual number of admissions is around 15000, and would increase the observed number of preventable admissions. On the other hand, colon cancer admissions are used, as incidence data are reported for colorectal cancer, and only the colonic tumours show strong relationships to physical inactivity.

(c) All causes: uncertain estimate; derived from 1993–94 data

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[7]   Note that this infers the same attributable risk for hospital separations as for epidemiologically-derived mortality or incidence; this is commonplace in COI studies, and is carried out here for method comparability, but may over or under estimate costs.

COST OF ILLNESS ATTRIBUTABLE TO PHYSICAL INACTIVITY

Direct health care costs have been estimated for each disease in the following tables. Cost data has been provided by the Australian Institute of Health and Welfare's Disease Costs and Impact Study. This study has disaggregated national health expenditure into the major disease categories of the International Classification of Diseases (Version 9). Ninety percent of the national Australian $34.1 billion in health expenditure in 1993–94 could be allocated into the disease categories. Expenditure that is not yet able to be disaggregated includes community health services, ambulance services, capital works, health promotion and public health programs apart from some cancer specific programs.

The total cost of each disease has been divided into its major components, namely hospital, medical, pharmaceutical, allied health, research, public health and other. These major headings have been further divided where the data is available. The column headed 'Cost of Disease' lists the total direct health costs for each disease. The relative disease PAR has been applied to this total cost to derive the proportion of costs that can be attributed to insufficient physical activity for each cost category (column 2). The third column in the following tables describes the proportion of costs that are allocated to each cost category. The allocation of national 1993–94 health expenditure has been used to analyse 1996 mortality and morbidity data. The absolute numbers of events such as annual deaths and hospital admissions were similar during this period. A health services Implicit Price Deflator (IPD) has not been used to adjust for the movement of overall prices in the two-year period. The IPD for total health services increased by approximately 3 per cent during the period (Hynes 1998).

The estimated direct health care cost for preventing and treating CHD in 1993–94 (table 6) was $894 million of which $161 million can be attributed to physical inactivity. Almost two thirds of this expenditure accrued in hospital services followed by pharmaceutical expenditure, nursing home services and medical care.

Table 6: Direct (health care) costs for coronary heart disease and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of total CHD costs %
Total hospitals	574	103	64
Total medical	88	16	10
Pharmaceuticals	105	19	12
Allied health	5	1	1
Research	11	2	1
Other and nursing homes	111	20	12
Total costs	894	161	100

Source: Mathers, C. and Penm, R. (1998) Australian Institute of Health and Welfare

For each condition, the range of costs averted is presented. The proportion of the costs, for each condition, are shown in the far right hand column of each table. Costs attributable to physical inactivity are $161 million for CHD, $16 million for breast cancer, $15.7 for colon cancer, $101 million for stroke, $27.5 for diabetes and $56 for depression.

Table 7: Direct (health care) costs for breast cancer and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Hospital inpatients			
Public hospitals	42.7	3.7	24
Private hospitals	28.6	2.5	15
Non-inpatients	8.8	0.8	5
Total hospitals	80.0	7.0	44
Nursing homes	1.5	0.1	1
Medical services			
General practitioners	3.6	0.3	2
Specialists	7.0	0.6	4
Total medical	10.6	0.9	5
Pharmaceuticals			
Prescriptions	15.8	1.4	8
Over-the-counter	0.3	0.0	0
Allied health	1.4	0.1	1
Research	19.2	1.7	11
Public health	4.9	0.4	3
Other	50.2	4.4	27
Total costs	183.9	16.0	100

Source: Mathers, et al (1998) Australian Institute of Health and Welfare and National Cancer Control Initiative

Table 8: Direct (health care) costs for colon cancer and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Hospital inpatients			
Public hospitals	42.0	8.1	52
Private hospitals	19.6	3.8	24
Non-inpatients	4.0	0.8	5
Total hospitals	65.6	12.6	81
Nursing homes	2.3	0.4	3
Medical services			
General practitioners	1.5	0.3	2
Specialists	3.3	0.6	4
Total medical	4.8	0.9	6
Pharmaceuticals			
Prescriptions	1.8	0.3	2
Over-the-counter	0.2	0.0	0
Allied health	0.4	0.1	1
Research	3.3	0.6	4
Public health and other	3.4	0.7	5
Total costs	81.6	15.7	100

Source: Australian Institute of Health and Welfare, Disease Costs and Impact Study

Table 9: Direct (health care) costs for stroke and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Total hospitals	283	45	45
Total medical	31	5	5
Pharmaceuticals	13	2	2
Allied health	5	1	1
Research	6	1	1
Other and nursing homes	292	47	47
Total costs	630	101	100(a)

Source: Mathers, C. and Penm, R. (1998) Australian Institute of Health and Welfare
(a) Numbers have been rounded.

Table 10: Direct (health care) costs for NIDDM and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Total hospitals	53.7	6.8	25
Total medical	37.7	4.8	17
Pharmaceuticals	58.1	7.4	27
Allied health	10.9	1.4	5
Research	11.5	1.4	5
Other and nursing homes	44.7	5.7	21
Total costs	216.7	27.5	100

Source: Mathers, C. and Penm, R. (1998) Australian Institute of Health and Welfare

Table 11: Direct (health care) costs for depressive disorders and proportion attributable to physical inactivity, Australia, 1993–94

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Hospital inpatients			
Public hospitals	139.1	13.9	25
Private hospitals	37.0	3.7	6
Non-inpatients	53.5	5.4	10
Total hospitals	229.6	23.0	41
Nursing homes	87.1	8.7	15
Medical services			
General practitioners	35.8	3.6	6
Specialists	102.0	10.2	18
Total medical	137.8	13.8	25
Pharmaceuticals	65.6	6.6	12
Allied health	12.4	1.2	2
Research	7.0	0.7	1
Other	22.3	2.2	4
Total costs	562.0	56.2	100

Source: Mathers, C. and Penm, R. (in press) Australian Institute of Health and Welfare

As noted already, some caution needs to be exercised in the interpretation of this data given the assumptions that have been required. For example, these estimates were based on 1993–94 costs, and expressed in 1993–94 dollars. However, the prevalence of inadequate physical activity in the community especially amongst older adults and the strength of association between inactivity and specific disease mortality and morbidity would indicate that substantial health sector resources are used in the diagnosis and treatment of preventable diseases.

The cost attributable to physical inactivity for the six diseases analysed in tables 6 to 11 totals $377.4 million. If the attributed costs were halved where the epidemiological evidence was less clear (stroke, breast cancer and depression), the total attributed costs would be $290 million. This is shown in figures 13 and 14.

Figure 13: Costs of six major diseases attributable to physical inactivity ($ million)
Two models: Model 1 shows all six conditions [filled bars]. Model 2 shows a conservative estimate of costs for all six conditions, with costs halved where evidence is less clear (for stroke, breast cancer, depression).

Two models: costs attributable to inactivity

Costs of inactivity ($ millions)
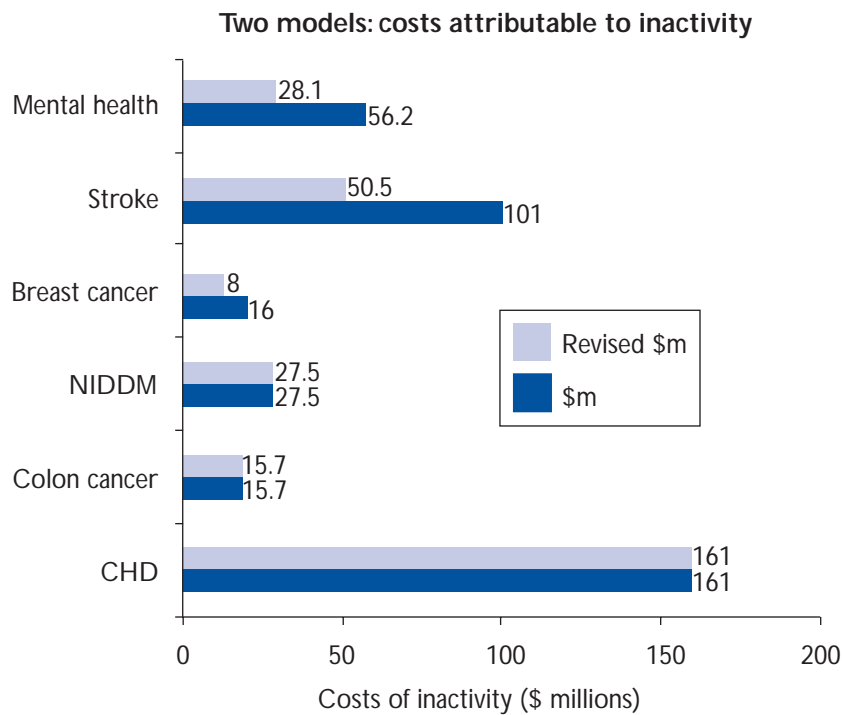
Figure 14: Total costs attributable to inactivity for six conditions ($ millions)
Model 1 [all six conditions], model 2 [costs halved where evidence less certain].
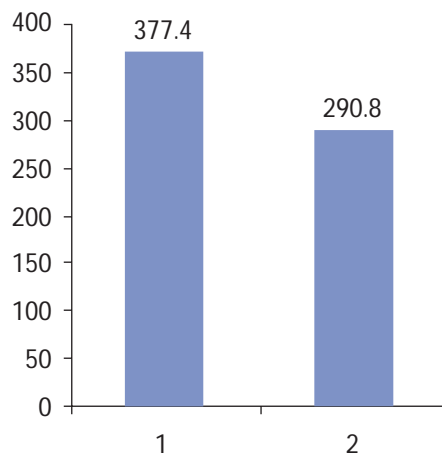
One final analysis examines the all cause costings. Table 12 shows the direct costs for all-causes, and should be treated with caution. As discussed above, the difference in costs between the major six conditions and the application of an all cause attributable fraction is large — the cost differential is a fifteen fold difference (between $377 million and $5,651 million). It is likely that the true costs of inactivity are substantially larger than the estimated $377 million, but it is biologically implausible that they would be anywhere as large as $5.6 billion. Further epidemiological evidence is required to quantify the true costs more accurately, and the all cause estimate is considered unreliable at this stage.

Table 12: Direct (health care) costs for all causes of mortality and proportion attributable to physical inactivity, Australia, 1993–94 (Note: the all cause estimated data in this table are to be treated with caution)

Cost description	Cost of disease $m	Cost attributable to physical inactivity $m	Proportion of costs %
Hospital inpatients			
Public hospitals	8430	1517	27
Private hospitals	3224	580	10
Non-inpatients	2408	433	8
Total hospitals	14062	2531	45
Nursing homes	2647	476	8
Pharmaceuticals			
Prescriptions	2972	535	9
Over the counter	1070	193	3
Medical services			
General practitioners	2590	466	8
Specialists	3050	549	10
Total medical	5640	1015	18
Allied health and dental	3075	554	10
Research	534	96	2
Other	1398	252	4
Total costs	31397	5651	100

Source: Mathers C, Penm R, Carter R, Stevenson C (1998) Health system costs of diseases and injury in Australia 1993–94. Canberra: Australian Institute of Health and Welfare

The total direct costs for the major six conditions examined in this analysis amount to around $377 million. Given the domains of activity not analysed here, this is considered a conservative estimate. These preventable costs are currently expended in other ways. The resources used in this expenditure have an alternative and forgone use. The opportunity cost of using resources for diagnosis and treatment is the foregone allocation for prevention or other use. The attributed costs may be recouped in the short, medium and longer term. One aspect of physical activity prevention related evidence is

that for CHD, benefits accrue quickly, usually within two years, and faster than the time required to reduce CHD risk following other risk factor changes (Blair 1995). This provides an argument for redistributing some of the potentially saved costs towards effective approaches to increasing physical activity in the population.

POTENTIAL HEALTH IMPROVEMENTS AND COST SAVINGS IF PHYSICAL ACTIVITY LEVELS INCREASE IN THE AUSTRALIAN POPULATION

INTRODUCTION

This section describes the potential cost savings if changes were made to physical activity participation in Australia. A sensitivity analysis is performed which examines different increases in physical activity, and the potential cost savings at each level. An increase of 5 per cent in PA participation is consistent with typical planning processes (Bauman, Bellew et al 1996), but a 10 per cent increase over a decade has been achieved in Canada in recent years and is considered the best case scenario for feasible population change[8]. In addition, an estimate is provided if all of the population achieved the goal of regular moderate physical activity.

ASSUMPTIONS

A number of assumptions have been made in order to produce the analysis of potential health gains and direct cost savings. Firstly, it has been assumed that the PAR that have been developed for mortality data apply equally to morbidity data, specifically hospital admissions and disease incidence.

Second, it is assumed that there is no time lag between the adoption of regular, moderate physical activity and a reduction in risk for each disease. As noted above some reduction in risk is likely to occur in the short term for CHD and it is unclear how long the time lag is for other diseases.

Third, health costs are immediately converted to savings when people become sufficiently active. This is somewhat unrealistic because of the possible time lag in disease risk reduction, as well as the tendency for most health care resources and therefore costs to be fixed in the short term. Variable expenses such as the cost of pharmaceuticals could be reduced in the short term. For example, it is suggested that regular moderate physical activity can reduce systolic and diastolic blood pressure by 3–5 mmHg; if this were to occur, some of the need for antihypertensive medication used to treat mild hypertension would be reduced.

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[8]   For example, a 1per cent increase in physical activity participation has been reported in Canada for the past 16 years, through population surveys conducted by the Canadian Fitness and Lifestyle Research Institute, Ottawa 1998; http://www.cflri.ca/cflri/surveys/98survey/98survey.html.

Fourth, there are no additional costs estimated for the increased population activity levels. Some of the incidental physical activity, such as regular walking, may be relatively cost neutral. Some additional costs may accrue to the individual for the cost of equipment, clothing, transport and club membership or entrance fees for sport or physical activity participation. Additional health care costs attributable to sport or activity induced musculoskeletal injury or acute cardiac events are likely to be relatively small compared to the gains from increased population levels of activity (Thompson 1994).

The following tables present 'gross' savings whereas a further analysis of disease incidence and the cost of its treatment would derive an estimate of 'net' savings. The cost of interventions to promote physical activity and sport participation have not been included in this analysis. This report has examined health care costs in a single year whereas it would be preferable and more realistic to examine discounted lifetime costs. Thus a person who becomes active will reduce their risk of disease to some extent in the current year and to greater extent in the long term. A stream of potential health care costs is generated over the remainder of the person's life because their new lifestyle contributes to the reduced risk of disease and its cost.

The fifth assumption is that there are no differences in demographic, psychological, socio-economic or other risk factor prevalence rates between the currently active population and the currently sedentary population. As already discussed in this paper there are existing differences between people who are active and those who are sedentary based on gender, age and class. The more active people tend to be young, male and higher educated.

A sixth assumption is that the marginal cost of health care remains static over time. This is unlikely, as new and more expensive diagnostic and clinical interventions become available. As a higher proportion of the population become active, the remaining sedentary population might demand or be induced to demand more medical servicing such that resource savings gained from increased levels of activity become absorbed by existing health care providers generating more services. Thus the marginal cost of treating disease would rise.

SENSITIVITY ANALYSIS: COST SAVINGS GIVEN DIFFERENT INCREASES IN THE PREVALENCE OF PHYSICAL ACTIVITY

Tables 13 to 19 pose three futuristic scenarios where the proportion of the adult Australian population who are sufficiently active increases from the current 56 per cent by 5 percentage points to 61 per cent or by 10 per cent points to 66 per cent. The final scenario has all the people who are currently sedentary or do little physical activity becoming sufficiently active.

As the proportion of the population who are sufficiently active increases, the PAR falls because the proportion of the population exposed to the risk factor of inactivity would decline. Using mid 1990s data as a base for calculations, the number of deaths and

hospital admissions decline with increasing levels of activity. The corresponding health care costs for treating each specific disease declines and potential 'savings' are generated for alternative use.

Table 13 indicates that the PAR for CHD falls from the current 0.18 (56 per cent sufficiently active) to 0.163 (61 per cent), 0.145 (66 per cent) and the hypothetical 0.0 (100 per cent). Approximately 100 deaths are avoided for every 1 per cent point gain in the proportion of the population who are sufficiently active. Approximately 112 hospital admissions for acute myocardial infarction are prevented for each 1 per cent point increase in population activity levels. For every 1 per cent increase in adult activity levels, there is a potential saving in health care costs of $2.6 million. The corresponding saving for other diseases are $2 million for stroke, $0.6 million for NIDDM, $0.3 million for colon cancer, $0.3 million for breast cancer, $1.1 million for depressive disorders and $88 million for all cause mortality.

Table 21 summarises the potential 'savings' in direct health care costs from the proposed increases in the proportion of adult Australians who become sufficiently active. The potential saving is $36 million for the 6 diseases under consideration if the proportion of active Australians increased from the current 56 per cent to an achievable 61 per cent. The saving is $76 million for the 6 diseases if the proportion reaches 66 per cent[9]. This is an achievable 10 per cent increase in the prevalence of at-least moderate activity. Such changes have been seen in Australia for tobacco use, which has declined by more than this over the past two decades.

Table 13: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of coronary heart disease

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of CHD due to physical inactivity (PAR)	.180	.163	.145	0
CHD deaths attributable to physical inactivity	5335	4830	4297	0
CHD deaths avoided by increased level of activity		505	1038	5335
Person years gained (<70 years) from CHD deaths avoided		6465	13311	55144
Acute myocardial infarction hospital admissions avoided by increased level of activity		558	1149	5906
CHD health care costs attributable to physical inactivity ($m)	161	148	130	0
Potential CHD health care savings from increased levels of activity ($m)		13	31	161

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9   The corresponding savings based on the 'all-cause' mortality are $439 million and $1,003 million, but are considered to be an over estimate, for the reasons discussed elsewhere.

Table 14: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of stroke

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of strokes due to physical inactivity (PAR)	.16	.14	.13	0
Stroke deaths attributable to physical inactivity	2049	1844	1639	0
Stroke deaths avoided by increased level of activity		205	410	1639
Person years gained (<70 years) from stroke deaths avoided		1492	3083	12726
Hospital admissions due to stroke avoided by increased level of activity		520	1040	4158(a)
Stroke health care costs attributable to physical inactivity ($m)	101	91	81	0
Potential Stroke health care savings from increased levels of activity ($m)		10	20	101

(a) Based on physical activity having a prevention role for half the stroke admissions, as a conservative estimate (see note, table 6).

Table 15: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of NIDDM

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of NIDDM due to physical inactivity (PAR)	.13	.11	.10	0
NIDDM deaths attributable to physical inactivity	380	341	302	0
NIDDM deaths avoided by increased level of activity		39	78	380
Person years gained (<70 years) from NIDDM deaths avoided		632	1264	6173
NIDDM hospital admissions avoided by increased level of activity		152	304	1488
NIDDM health care costs attributable to physical inactivity ($m)	28	25	22	0
Potential NIDDM health care savings from increased levels of activity ($m)		3	6	28

Table 16: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of colon cancer

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of colon cancer due to physical inactivity (PAR)	.19	.17	.16	0
Colon cancer deaths attributable to physical inactivity	680	616	549	0
Colon cancer deaths avoided by increased level of activity		64	131	680
Person years gained (<70 years) from colon cancer deaths avoided		279	573	2975
Colon cancer hospital admissions avoided by increased level of activity		266	532	2339
Colon cancer health care costs attributable to physical inactivity ($m)	15.7	14.2	12.6	0
Potential health colon cancer care savings from increased levels of activity ($m)		1.5	3.1	15.7

Table 17: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of breast cancer

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of breast cancer due to physical inactivity (PAR)	.087	.078	.068	0
Breast cancer deaths attributable to physical inactivity	228	206	178	0
Breast cancer deaths avoided by increased level of activity		22	50	228
Person years gained (<70 years) from breast cancer deaths avoided		210	442	2024
New cases of breast cancer avoided from increased level of activity		87	185	855
Breast cancer hospital admissions avoided by increased level of activity(a)		167	334	1466
Breast cancer health care costs attributable to physical inactivity ($m)	16.0	14.3	12.5	0
Potential breast cancer health care savings from increased levels of activity ($m)		1.7	3.5	16.0

(a) Breast cancer admissions: using incidence data — see table 5; a more conservative approach.

Table 18: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of depressive disorders

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of depressive disorders due to physical inactivity (PAR)	0.10	0.09	0.08	0.00
Deaths attributable to PA *Deaths avoided by increased PA* *Person years gained (<70 years) from deaths avoided*	*No estimate of preventable deaths is provided here as deaths from depression are rarely coded (usually coded as self inflicted harm) and hence preventable deaths not calculated*			
Hospital admissions avoided by increased level of activity		396	791	3594
Health care costs attributable to physical inactivity ($m)	56	50	44	0
Potential health care savings from increased levels of activity ($m)		6	12	56

Table 19: Effect of increasing the proportion of the Australian adult population who are sufficiently active on health indicators and potential cost avoidance of all causes of mortality

Indicator	Proportion of adult Australians who are sufficiently active			
	56%	61%	66%	100%
Proportion of all deaths due to physical inactivity (PAR)	.183	.166	.148	0
All deaths attributable to physical inactivity	23556	21367	19050	0
All deaths avoided by increased level of activity		2189	4506	23556
Person years gained (<70 years) from all deaths avoided		35937	73989	386861
Hospital admissions avoided by increased level of activity		65744	150272	845280
Health care costs from all causes attributable to physical inactivity ($m)	5651	5212	4648	0
Potential 'All Cause' health care savings from increased levels of activity ($m)		439	1003	5651

Table 20: Summary of potential savings of direct health care costs from increased levels of population physical activity, Australia, 1993–94, ($m)

Disease	Proportion of adult Australians who are sufficiently active		
	61%	66%	100%
CHD	13	31	161
Stroke	10	20	101
NIDDM	3	6	28
Colon cancer	2	3	16
Breast cancer	2	4	16
Depressive disorders	6	12	56
Sub-total	36(a)	76	378
All causes	439	1003	5651

INTERVENTIONS TO INCREASE PHYSICAL ACTIVITY PARTICIPATION AT THE POPULATION LEVEL

This report has provided an initial analysis of what is a complex epidemiological and resource utilisation issue. Defining the extent of a public health problem is not synonymous with clarifying the public health solutions to the problem. This was discussed earlier in this report under the heading of 'uses and misuses of cost of illness information'.

Nonetheless, effective strategies are emerging that are or have the potential to encourage large numbers of sedentary or low activity people to adopt a more physically active lifestyle. It is however, unrealistic to assume that all people who are sedentary or infrequently and inadequately active will become more active. For those who do become regularly and moderately active, how long will it take for their risk of disease to diminish? The risk of CHD may decline within a year or two while it is unclear what the time lag is for other diseases (Powell and Blair 1994, Blair 1995). Powell (1994) suggests that *'the magnitude of the shift will be proportionate to the quality and magnitude of the intervention effort'*. The strategies needed to increase physical activity in the population are described briefly below, but are beyond the scope of this report. The main issue is that preventable costs are only averted if successful population change occurs in the risk factor of interest.

The prevalence of physical activity has been measured in several Australian population studies (Bauman 1990, National Heart Foundation 1989, Owen and Bauman 1992, Active Australia Physical Activity Survey 1997). The type and amount of activity can be categorised according to levels of estimated energy expenditure. A four category physical activity index has been used to divide the population into 4 discrete levels of physical activity participation. Thus, in the late 1980s, it was estimated that 15 per cent of the Australian adult population reported participation in vigorous (aerobic) activity in the previous two weeks, 19 per cent were moderately active, 36 per cent reported low intensity or infrequent activity and, 30 per cent were sedentary. The least likely to be active were women, people with lower socio-economic status or lower levels of educational attainment, older adults and people from non-English speaking backgrounds (Owen and Bauman 1992).

The expressed or intended preferences of people at all levels of the physical activity index were for activities such as recreational walking and swimming (Booth,Bauman,Owen 1997) as well as opportunistic or incidental activity such as home and garden maintenance, walking and the use of stairs.

The key question is how well can the potential savings discussed above be realised? A detailed evidence based discussion of the most effective methods of promoting physical activity is beyond the scope of this document, but some examples and settings for physical activity promotion are briefly outlined below. Especially with the new emphasis on moderate activity, increasing options for physical activity are now recommended to the general community. Strategies that facilitate the ease and convenience of the increased participation are more likely to achieve participation, compliance and sustainability (US Dept of Health 1996, King 1991).

The scope and details of each of the potential interventions to increase physical activity in Australia is beyond the scope of this report. Intersectoral partnerships and the establishment of multi-sectoral interventions is a likely prerequisite for population change (NSW Physical activity taskforce 1996). Interventions to increase physical activity, including sports participation, have usually focussed on:

• a target group such as children, women or older people;

• a setting such as schools or workplaces; and

• an environment such as sporting facilities or provision of walking and bicycle tracks.

Brief details of these settings is presented, to demonstrate the kind of programs required. Three such settings are reviewed below.

SCHOOLS

Schools are perceived as an ideal setting because there is a captive audience of children and their parents (Resnicow 1997). Promoting physical activity including sports participation is an obvious extension of health education and physical education curriculum and sports programs (Sallis 1992). However, with limited resources and time, schools are required to make choices about the relative importance of competing programs and the relative investment in infrastructure to support physical activity (play equipment, sporting facilities and equipment, teachers training and support). Studies of school based physical activity related programs suggests that health education alone makes little difference to activity levels but programs that involve vigorous aerobic activity increase cardiovascular fitness by increasing activity in and out of school (US Dept of Health 1996, Sallis 1992). The effectiveness of programs are enhanced by the school's commitment (such as daily physical activity education), the use of physical education specialists, additional training for generalist classroom teachers, involvement of parents and community and a conducive outdoor environment which provides safe areas and facilities (US Dept of Health 1996, Stone 1998).

WORKPLACES

Worksites also have large captive audiences with an opportunity to encourage a mutual interest of improving or maintaining personal health and corporate productivity. There is a potential to enhance social support and modify environments to promote more

physical activity and sports participation (Shephard 1996). Despite the reporting of considerable effort especially in larger USA corporations (>500 employees) to provide exercise facilities, there is insufficient evidence to extract recommended strategies. Worksite programs are characterised by: low overall participation; selection bias (the healthy and fit volunteer to participate); high drop out rates. Evaluations of these programs are relatively scarce and have not proved useful for extracting the elements of successful workplace programs. A recent quantitative review (Dishman 1998) has failed to identify any intervention characteristics associated with clear evidence of a benefit upon increased physical activity. Policy and environmental changes have been suggested as more promising options for the future (Sallis et al 1998) and include: signs to encourage the use of stairs rather than lifts; providing stairs that are open, accessible and attractive; providing showers and change rooms; secure parking facilities bicycles; subsidising non-motorised employee transport; and, providing subsidies for the employee use of fitness clubs.

PRIMARY HEALTH CARE

The primary health case setting is considered to have great potential for the promotion of physical activity, especially to identified target groups. Over 80 per cent of adult Australians see a general practitioner (GP) at least once a year and value GPs as a preferred source of health information. This highlights the potential for the primary care as a setting for promoting physical activity (Walsh 1999). It is thought that patients infrequently receive some form of counselling about exercise and physical activity from their general practitioner or primary health care provider. The opportunity provided by the primary care setting does not easily translate into 'general' practice because of several commonly identified barriers. General practitioners identify a lack of time, disinterest by doctor and/or patient, lack of financial incentive and insufficient training as reasons why counselling does not occur more often. Several studies have demonstrated short term increases in activity following primary health care interventions, mostly through brief counselling and the provision of written information (Bull 1998, Swinburne 1998, Calfas 1996). It appears that, across these studies, General Practitioners are able to achieve a 2–5 per cent increase in short term physical activity participation following physical activity counselling, advice or prescription. This rate of success is similar to brief smoking cessation advice in this setting. Longer term maintenance of regular physical activity, for example, at follow up after one year, is less encouraging.

COMMUNITY BASED PROGRAMS AND ENVIRONMENTAL CHANGE STRATEGIES

The attraction of using community-based strategies is the potential to reach a large number of people in a familiar setting. Strategies include home-based individual or interpersonal interventions, media campaigns and interventions to modify environments so that participation in physical activities is easier, safer and more enjoyable (Sallis, Bauman, Pratt 1998). Individual strategies can be specific to personal needs and circumstances however there are serious reservation about the likely cost effectiveness due to their intensive use of resources and limited reach compared with the other

strategies. Individual approaches are seen as a complementary rather than a primary strategy to increase community activity levels. Success in terms of sustainable participation was more likely if: stage-based resources are used; contact and support is maintained such as telephone follow up; and, the use of self-monitoring by the participants.

There are few studies which have examined programs for community groups, including minority indigenous and ethnic groups. In spite of this, predisposing factors for acceptability have been described and included: community participation in the planning and implementation of programs; interventions that are culturally specific; focus on group rather than individual or family programs; identification of potential economic and social barriers to implementation.

Community wide interventions are attractive because of the potential to reach large numbers of people, some of whom will subsequently become more active. Even relatively small shifts in the proportion of the population who can sustain the change from little or no activity to moderate or vigorous activity can have considerable population health benefit. Community wide interventions rely on a cooperative and coordinated commitment of resources from multiple industry sectors.

Mass media campaigns are effective in raising awareness of physical activity and sport participation as a health issue. A recent NSW Campaign, in conjunction with Active Australia, increased awareness of the need for moderate physical activity in the NSW population (Bauman, Bellew, Vita, Owen 1999). Nonetheless, campaigns are not effective as an isolated strategy to change behaviour. However, when a mass media campaign was used in conjunction with other strategies that encourage participation and/or modify environments then modest increases in levels of physical activity could be achieved.

There is considerable optimism that environmental modification can passively achieve the population shift to a more physically active lifestyle (Sallis, Bauman, Pratt 1998). The modifications are subtle enough to be acceptable yet large enough for people to exert sufficient energy to satisfy public health criteria for moderate activity. The modifications would occur in the design of urban environments, in the workplace and in the home. Spatial access to recreational facilities appears to be related to participation in health programs and can result in small gains in fitness and participation in vigorous activity. Children will increase their activity levels when they have access to safe and enjoyable outdoor areas.

Good public transport systems that are safe and accessible increase the prevalence of walking to transport, or through increased commuting via the use of bicycles. Urban design need to make facilities and transport easier to access, as people may be less inclined to walk more than a kilometre to access services. Other legislative and fiscal strategies are required to discourage people from using private motor vehicles for short journeys in urban areas. These strategies can be synergistic, and form an integral part of other social goals for improved air quality, reduced noise, reduced traffic congestion and greater open public space.

DISCUSSION OF POPULATION STRATEGIES TO INCREASE ACTIVITY

Infrastructure within the Health, Education and Sport and Recreation sectors to advance population strategies for promoting physical activity have been or are being developed in some states. A national framework has been developed through Active Australia, representing a collaboration between Commonwealth Departments of Health, Sport and Recreation, Transport and other agencies.

The costs of developing integrated PA promotion programs is difficult to estimate. For illustrative purposes, NSW data will be used as an example of costs of an integrated program, as physical activity strategic planning is quite well advanced in that state (Physical Activity Taskforce report, NSW Health, 1998).

In NSW Health, there is a central policy unit and staff employed on the issue of physical activity across the State's 17 Area Health Services. The estimated 1997–98 budget for employing staff and operating the program was $1.8 million of which $1.3 million was allocated by the central unit and $0.5 million by the Area units (B Bellew and D Samild, NSW Health Department — personal communication). This expenditure contributed to the development, conduct and evaluation of mass media campaigns, funding R&D initiatives through Demonstration projects, primary care support programs, and managing intersectoral and policy processes related to physical activity NSW. This is considered a reasonable range of activities, supported by intersectoral partnerships to increase the useful available pool of funds for physical activity programs.

Compared to the funding allocated to tobacco control, expenditures on promoting physical activity remain lower. Current national tobacco campaigns have up to $19 million for tobacco control. If budgets include state level 'Quit' campaigns, expenditure on enforcement of tobacco legislation, and regional health education initiatives, then total State and Territory antismoking budgets are at least $15 million p.a. (AIHW 1998, Health system costs of diseases and injury in Australia 1993-4, p29).

Given the current state of knowledge about population strategies to increase physical activity, no single formula for intervention is recommended. As knowledge increases, especially from evaluation of the effectiveness and efficiency of each of the components suggested, then the investment mix is likely to change. In this early stage of the evolution of promoting population strategies, school based programs receive a large share of the allocation because of their existing infrastructure and the successful partnership that exists between the health and education sectors. In future years, community-based activities are likely to receive an increased allocation as the nature of successful strategies and the evaluation of interventions is articulated. This may comprise components of targeted public education campaigns, which have been shown to be effective (Bauman, Bellew, Owen 1999). In addition, combining these with primary care advice (high risk group strategies, targeting the sedentary) may provide the most cost effective mix of population health approaches (Hall 1988).

Exploring the effectiveness of physical activity promotion strategies is a new area of work; many more years of extensive funded intervention research exists for tobacco control and nutritional interventions. For this reason, further identification of effective approaches is warranted, especially for innovative areas of work such as environment and policy interventions (Sallis, Bauman, Pratt 1998). Such interventions extend well beyond the health sector, and may involve the participation of Sport and Recreation, Departments of Local Government, Transport, Urban Planning, School Education and others.

COMPARISON WITH OTHER COI STUDIES

This brief section describes comparisons with other COI studies, both those which focused on physical activity and those which addressed other risk factors. This section re-visits the literature reviewed earlier in this report.

1. OTHER STUDIES CONSIDERING PHYSICAL INACTIVITY

* In 1987, the Commonwealth released a report on the Economic benefits of participation in regular physical activity (Roberts 1987). This report used slightly different methods to the present study including confining PA to 'vigorous' levels of participation, including GP visits, therapy for hypertension and other risk factors, and above all, included indirect cost estimates. They reported indirect costs, for example for CHD as 2–3 times greater than direct costs. In terms of encouraging physical activity, they proposed (in 1988 dollars) a $1 million economic benefit (direct cost savings only) for each 1 per cent increase in vigorous PA participation. They proposed a total saving of around $273.6 million if direct and indirect costs were considered (in 1988 dollars). The current study proposed an overall $378 million cost saving, or around $8.6 million per 1 per cent increase in moderate PA participation (in mid 1990s dollars).

* A recent New Zealand study reported a direct and indirect cost saving of around $162 million, if the whole population became active. This would equate to a saving of $972 million if applied to the Australian population, but includes indirect costs.

* A detailed COI study of physical inactivity was produced in Canada (CFLRI, 1996). This study focused on CHD, NIDDM and colon cancer in 1993. The reduction in costs per percentage point increase in physical activity were estimated to be $10.2 million p.a. for CHD, $0.4 million for colon cancer and $0.88 million for NIDDM. This total estimate of around $12 milliion saved per 1 per cent increase in activity is similar to the current Australian estimate. The Canadian study included a greater range of out of hospital costs and physician visits, contributing to their higher estimate. Their total cost estimates, if the whole population became active, were ($777 million (CHD), $42 million (colon cancer) and $90 million (NIDDM), a total of $909 million. This is more than twice the cost savings proposed in the current study (after adjustment for population size differences) and reflects the conservative estimates used in this Australian study, and the greater range of direct costs and possibly higher costs of health care in Canada.

- Comparison with the most recent US study has been made throughout this document, because of the similarities in COI methodology, and PAR estimates used (Colditz 1999). This US study estimated that 2.4 per cent of the direct costs of health expenditure were attributable to physical inactivity; the present Australian study estimated about $378 million, which is about 1.2 per cent of the total health expenditure in Australia.

- US studies have ranked physical activity and nutrition second only to tobacco use in terms of the evidence for preventing chronic disease (McGinnis and Foege, 1993). Summative studies have suggested that the importance of physical activity is at least as great as nutrition, and greater than hypertension control in overall disease prevention (Francis, 1998).

- Studies using simulation modelling approaches have examined the economics of PA participation. Munro (1997) suggested that providing opportunities for activity for older adults is cost-effective. They modelled health gain using CHD, hypertension, stroke, diabetes, falls and fractured neck of femur and all mental disorders, which was a broader range of putative benefits than the current Australian study. The costs of a physical activity intervention would be £332 per life-year saved, which was less expensive than antismoking advice from a doctor (£700/life year saved), cholesterol screening (£3,700/life year saved) or treating hypertension (£8500).

- A 1988 US study also performed a simulation model, of two hypothetical cohorts of 35 year old males (Hatziandreu, 1988). This study also reported that exercise was cost-effective ($11,313 per QALY saved), compared to treating hypertension (>$25,000 per QALY), or treating ischaemic heart disease.

- Another US study estimated the higher medical costs incurred through a lifetime of being sedentary (Keeler, 1989). They proposed that the lifetime health system added costs of $1,900 per sedentary person might be invested in community strategies to increase PA participation.

- Jones and Eaton (1994) identified that walking was a cost-beneficial population strategy, with savings of up to $4.3 billion if the entire sedentary population became active. This level of PA participation was most efficient for those aged 45–54, where a benefit would accrue even if the time spent walking were costed at the average hourly wage rate.

- A British simulation modelling study (Nicholl, 1994) suggested that the costs of programs and PA promoting services would outweigh the benefits for young adults, but that a clear benefit would accrue for those aged over 45 years. This study focused on the costs (and injury related risks) of organised sport and recreational facilities, and not on the more recent recommendations for incidental and accumulated moderate PA, which would have much lower costs.

- A Dutch review (Van Mechelen, 1997) of population attributable risks in the Netherlands reported higher PARS for physical activity and CHD (around 40 per cent), compared to dietary saturated fat intake (PAR=13 per cent), obesity (PAR = 15 per cent), and similar to tobacco (PAR = 44 per cent). Note these cannot be added, and multivariate PARs are required (Bauman, 1998), but the ranking is illustrative of the relative importance of PA as a CHD risk factor.

2. COMPARISONS WITH COI STUDIES FOR OTHER RISK FACTORS

- An important and comprehensive appraisal of the costs of diet related disease in Australia has been reported (Crowely, 1992). If direct costs are considered, and the conservative estimates used, then this study estimated that $771 million per year might be attributable to diet. This study included outpatient and out-of-hospital costs in deriving these estimates. If alcohol-related costs were included, especially indirect costs, then costs of up to $6 billion were reported. Focusing on similar disease states, annual costs attributable to diet were $97 million for CHD, $7 million for colon cancer and $83 million for diabetes.

- These estimates were similar to the PA related estimates for CHD in the present study, suggesting that costs saved for CHD might be similar for nutritional interventions and PA promotion.

- The costs of obesity have been assessed in numerous studies. The World Health Organisation report suggests it might contribute to 2–7 per cent of total health care costs (WHO, 1997). The WHO report cites US studies estimating the direct costs of obesity to be $45 billion, and a 1989 NHMRC report for Australia estimating the direct costs to be $464 million, much of which was attributed to the costs of treating obesity-related hypertension. This 1989 Australian estimate was about 2 per cent of total health expenditure, which is at the lower end of the WHO estimates. If the Australian Goals and Targets for obesity were met, around $59 million in savings (of direct health costs) might be expected (National Health Strategy, Issue Paper 7, 1993). Other COI studies have reach different conclusions for obesity — a recent US study reported total costs of $17.2 billion, of which most of the costs were for the moderate to severe obesity category (BMI >30). This study mainly focused on indirect costs (Thompson, 1998). Another recent paper, reviewing direct costs of obesity, reached similar conclusions to the WHO report (Seidell 1998).

- Health care costs of tobacco in Australia have been estimated at $671 million (AIHW, 1996). This AIHW estimate comprised $126 million for CHD, and $126 million for stroke and peripheral vascular disease. Much of the remaining costs of tobacco relate to lung cancer and chronic bronchitis (AIHW, 1996). The PAR for tobacco and CHD was similar to that for physical activity and CHD (23.9 per cent). The ratio of costs of tobacco to physical inactivity was around 1.8, which is similar to the preventable fractions for these two risk factors suggested by McGinnis and Foege in 1993.

• Although not strictly a costs of illness study, the AIHW 1999 Burden of disease study was able to compare physical inactivity with other risk factors; physical inactivity was associated with 13,000 deaths and 168,000 DALYs, compared to high cholesterol, which contributed to 6,550 deaths and 64,000 DALYs. Among younger adults, inactivity was associated with more disability, and in older ages, with increased risk of mortality (AIHW 1999).

In conclusion, the estimates in the current study, although conservative, are consistent with other overseas COI studies of PA. The relative importance of PA is further illustrated by comparing COI of PA with other risk factors, where PA costs are of similar magnitude. The health system under-investment in PA, relative to its costs, is a general conclusion, both for Australia and for other developed countries.

CONCLUSION

This study has attempted to measure the direct health care costs and years of life lost which are attributable to physical inactivity in the Australian adult population. As the study has used a costs of illness method, it has been necessary to include a number of assumptions, which would be challenged under real conditions. Nonetheless, this remains an accepted and replicated method for assessing risk factors, and their relative potential contribution to health costs.

There is evidence that as the prevalence of 'sufficient activity for health' increases, the incidence and fatality from specific diseases will fall. Almost half of the adult population is sedentary or do little physical activity or sport. Expressed in a more positive light, almost half of the adult population stand (or walk) to gain better health by already engaging in moderate and regular activity.

It is estimated that 122 deaths per year from CHD, NIDDM and colon cancer could be avoided for every 1 per cent increase in the proportion of the population who achieve a level of sufficient and regular physical activity. One quarter of these deaths occur in people under 70 years, and 1,764 life years could be gained for every 1 per cent increase in moderate activity levels. The analysis indicates that gross savings of $3.6 million p.a. in the health care costs of these three diseases could be achieved for every 1 per cent gain in the proportion of the population who are sufficiently active. Potential gross savings would occur for the other diseases examined as well as for all-cause mortality. Other health benefits that have not been included in this report are likely to accrue with increased physical activity, notably issues that relate to quality of life. Examples include mobility, the ability to care for oneself and a sense of wellbeing and self esteem. (Powell and Blair 1994).

The importance of physical inactivity as a primary and independent risk factor for common diseases has emerged from epidemiological studies conducted over the last 2 decades, and it makes a major contribution to the burden of disease in Australia (AIHW 1999). Physical inactivity is a major risk factor for coronary heart disease, non insulin dependent diabetes mellitus and colon cancer and a significant contributor to the pathology of stroke, breast cancer, falls in the elderly and depressive disorders.

The challenge for the sports and recreation sector and the health promotion and public health workforce is to investigate and instigate interventions that encourage the large number of people who are currently sedentary or do little physical activity or sport to change their lifestyle. Some will be encouraged to participate because of the utility gained from their individual motivation such as weight loss, fitness or the social contact that sport or other physical activities engenders. Others will benefit passively from physical changes that occur in their work, home and recreational environments.

SUGGESTIONS FOR FURTHER WORK

As is the case in most cost of illness studies, no attempt was made to quantify indirect costs attributable to physical inactivity. Several techniques are available to estimate lost productive value from premature mortality and morbidity or the societal willingness to pay for avoiding disease attributable to physical inactivity. An estimate of the indirect costs as well as the direct health care costs would provide a more realistic estimate of the societal cost of sedentariness. Equally, the benefits of encouraging large numbers of people to become more active needs to be better understood. This includes estimating the value of time spent participating in sport or other physical activity and changes to productivity and absenteeism. Measuring benefit will be enhanced by a greater understanding of the relationship between participation in sport and other physical activity and well-being and mental health.

Policy makers and health planners with an interest in allocative efficiency of resource distribution would benefit from further analysis of the cost effectiveness of alternate strategies to promote physical activity and sports participation. This is especially important given the size of the current budget that is allocated to prevention relative to the allocation for treatment services for diseases attributable to physical inactivity. Much of this evidence remains to be sought, as we enter an era of such interventions, a decade or two behind organized efforts to restrict and reduce smoking prevalence in Australia.

This study estimated the gross costs of $377 million, accruing in one year for several diseases. A more accurate study would be to extend the analysis of cost and benefit over a lifetime. It is likely that investing in strategies to encourage younger and middle aged adults to participate will generate life long gains in reduced disease incidence and the subsequent cost of diagnosis and treatment.

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APPENDIX

Sources of epidemiological studies providing data for estimating relative risks

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Stroke					
Paffenbarger et al (1984) Harvard Alumni Cohort	16 936 male Harvard alumni, 35 to 74 years of age	Fatal stroke	Kilocalorie energy expenditure based on stair climbing, walking and sports participation	Significant dose response. Compared to low category (<500 kcal/wk) RR in moderate (500-1999 kcal/wk) 0.8, and high (2000+ kcal/wk) 0.37 (p<.001 for trend)	Adjusted for differences in age, smoking and hypertension.
Wannamathee & Shaper (1992) British Regional Heart Study	British males, 40 to 59 years of age	Fatal and non-fatal stroke	6-point scale of physical activity based on frequency, intensity and energy demands of specific activities	Significant linear trend of lower stroke risk with increased level of physical activity. Compared to the inactive the RR among the moderately active was 0.5, and among the vigorously active it was 0.2.	Adjusted for age, social class, smoking, heavy drinking and body mass index
Abbott et al (1994) Honolulu Heart Program	7530 Hawaiian men of Japanese ancestry, 45 to 68 years of age	Fatal and non-fatal stroke	Three tier classification: inactive, partially active and active, based on average time spent each day in activities of varying intensities.	Significant linear trend of lower risk of all types of stroke (except thromboembolic) with higher tier of activity for men 55-68 years, but not those 45-54 years. RR of haemorrhagic stroke compared to inactive was 0.6 among partially active and 0.3 among active.	Adjusted for residual effects of age, systolic blood pressure, serum cholesterol, cigarette smoking, alcohol intake, serum glucose, serum uric acid and haematocrit.

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Stroke					
Kiely et al (1994) Framingham study	5209 people between the age of 28 and 62 years from Framingham, Massachusetts	Fatal and non-fatal stroke	Categorised as low, medium and high based on estimate of metabolic work done in a typical 24-hour period.	There were no significant protective effects from exercise for women. Among men it was only those in the older cohort (49-83 years) who showed a significant relationship. Compared to the lowest activity group the RR of stroke among men in this age range who were moderately active was 0.41 while for the highly active it was 0.53.	Adjusted for physical activity, age, BMI, smoking, systolic blood pressure, serum cholesterol, total vital capacity, left ventricular hypertrophy and glucose intolerance.

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Depression					
Camacho et al (1991) Alameda County Study	6928 adults	Depressive symptoms	Frequency and intensity of a range of leisure activities then categorised as low, medium and high.	Compared to the low activity group people with high activity level less likely to show symptoms, but not significantly less likelihood in moderately active. RR for men in high category 0.57, and for women 0.59.	Adjusted for age, physical health, socioeconomic status, social supports, life events, anomy, alcohol consumption, smoking and relative weight
Paffenbarger et al (1994) Harvard Alumni	10 201 Harvard Alumni aged 35-74 years.	Physician diagnosed depression	Kilocalorie energy expenditure based on stair climbing, walking and sports participation. Frequency of sports play was categorised for a separate analysis.	Significant linear trend showing lower rates of depression among the more active. Compared to those who are least active (<1000 kcals) the RR among the moderately active (1000-2499 (kcals) was 0.83 and among the most active (2500+ kcals) it was 0.72.	Only adjusted for age.
Cooper-Patrick et al (1997) Precursors Study	973 university students.	Clinical depression and psychiatric distress (as measured by the General Health Questionnaire).	Frequency of exercising to a sweat in average week categorised as 0, 1-2 and 3+ times.	Non-significant linear trend of lower rates of clinical depression and psychiatric distress in higher activity categories compared to the least active.	Adjusted for gender, age, smoking and substance abuse.

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Non Insulin Dependent Diabetes					
Manson et al (1991) Nurses' Health Study	87253 women aged 30 to 55 years	Diagnosed NIDDM	Frequency of participation in sweat inducing leisure activities.	Significantly reduced RR (0.84) among those doing any activity compared to those doing none. No dose response apparent for people participating in higher levels of activity.	Adjusted for age, BMI, family history of diabetes, smoking, time period, alcohol consumption, hypertension, serum cholesterol and family history of myocardial infarction.
Manson et al (1992) Physicians' Health Study	21 271 men aged 40 to 84	Diagnosed NIDDM	Number of occasions of sweat inducing exercise in a week.	Significantly reduced RR (0.71) among those doing any activity compared to those doing none. Significant linear trend of reduced risk for people doing 1, 2-4 and 5+ sessions of activity per week. Significant dose response Each 2000 kcal increase in activity associated with a 24% decrease in NIDDM.	Adjusted for age and BMI in dose response analysis and also for aspirin and B-carotene assignment, smoking, alcohol consumption, blood pressure, hypertension, serum cholesterol and parental history of myocardial infarction.
Helmrich et al (1994) University of Pennsylvania Alumni Health Study	5990 men	Diagnosed NIDDM	Kilocalorie energy expenditure based on stair climbing, walking and sports participation		Adjusted for age, BMI, family history of diabetes, time period, and hypertension.

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Falls incidence					
Farmer et al (1989) National Health and Nutrition Examination Study	3595 white women aged 40 to 77 years	Hip fracture	Recreational and non-recreational activity categorised as non, little, moderate or much.	Significant RR of 1.9 of among those who did little/no recreational activity compared to those doing moderate/much.	Adjusted for BMI, triceps skinfold thickness, arm muscle area, activity apart from recreation, menopausal status, smoking and calcium consumption. Unvalidated PA measure.
Cummings et al (1995)	9516 white women aged 65 years and over	Hip fracture	Participation in walking for exercise (no further details given).	Significantly lower RR (0.7) among those who walked for exercise compared to those who did not.	Adjusted for large range of other factors
Johnell et al (1995) The MEDOS study	2086 women 50 years of age and older who had sustained a hip fracture from Portugal, Spain, France, Italy, Greece and Turkey. 3532 controls were from the same areas and selected from population registers.	Hip fracture	Weekly time spent in sports or physical activity outside work in past scored on scale out of 12. Work related physical activity in past rated separately on a scale out of 6.	Significant linear relationship (p<.001). Compared to the least active the OR in the most active category was 0.6, and in the moderately active it was 0.81.	Adjusted for age, centre and BMI
Cooper et al (1988)	300 patients over 50 with hip fracture and 600 community controls matched by age and sex.	Hip fracture	Time spent in walking outdoors in past six weeks and other measures.	Lower, but non-significantly reduced odds in the more active categories.	Adjusted for BMI, smoking. alcohol smoking and steroid treatment.

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Lung Cancer					
Thune (1997) Norwegian cohort	53622 men 28621 women	Incidence of lung cancer	Self report PA in four broad categories	Lower risk of lung cancer for moderate PA (RR 0.75) and vigorous. PA (rr0.71) for males only	NS for females. Biologically implausible
Breast Cancer					
Coogan (1997) Case control study	4863 cases 6783 controls	Incidence of breast cancer	Occupational PA by job category	Medium PA jobs showed lower incidence (OR 0.86)	Dose response evident but vigorous jobs not quite significant. Limitation of PA measure
Chen (1997) Case Control	747 cases, 961 controls aged 21-45	Incident cases population based controls	LTPA – derived energy expenditure categories	No significant findings	No effect for younger women?
Mezzetti (1998) Italian case control study	2569 cases 2588 controls	Incident breast cancer age stratified (by menopausal status)	Work + LTPA self rated scales	Increased risk among postmenopausal low versus vigorous PA (OR=1.61) NS for premenopausal	PAR calculated premenopausal 7.5% NS Postmenopausal 14.4%
Thune (1997) Norwegian cohort	25624 women aged 20-54 13.7 yrs follow up	Incidence breast cancer	Self report PA in four broad categories	Trend significant especially. in post-menopausal women especially. if lower BMI	Complex stratification OR around 0.5 to 0.7 but not quite significant

Study	Population	Outcome	Physical activity measure	Main findings	Comment
Colon Cancer					
Harvard Alumni I-min-Lee (1993)	17607 males Alumni cohort study	Colon Cancer	PA Index (EE estimated)	High PA reduced risk (0.19) mod PA (0.56) in overweight adults only but NS	Also noted reduced risk of lung cancer. Colon cancer evidence suggestive in overweight group only
Review paper for colon cancer risk	11 case control studies 18 cohort studies	Colon cancer	Various occupational and LTPA	OR 0.5-0.6 for c-c studies RR 0.5-0.7 for cohort studies	• Due to poor measurement protective effects under estimated • Consistent effects seen for colon cancer • Biologically plausible
Coronary Heart Disease					
Berlin (1990) Meta analysis	27 cohort studies	Coronary heart disease	Various measures of occupation, LTPA	CHD RR = 1.4-1.6 CHD death RR=1.7 (high compared to sedentary)	Methodologically better studies show stronger association Moderate PA compared to nil RR around 1.4

Study	Population	Outcome	Physical activity measure	Main findings	Comment
All Cause Mortality					
Kushi (1997) Iowa cohort	40417 postmenopausal women aged 55-69	All cause mortality	3 level PA index	Medium RR=0.66 High RR = 0.58	Well designed cohort modest PA measure
Leon (1991) MRFIT study	12866 MRFIT cohort males	All cause mortality	Tertiles on Minnesota PA measure	Mod RR=0.85 High RR=0.87	Similar trends for CHD, CVD
Blair (1996)	Dallas cohort Males and Females	All cause mortality	Quintiles of fitness	Least fit RR= 2.03	Dose response shown
Lee (1995) Harvard Alumni	17321 Harvard male Alumni	All cause mortality	PA Index	Dose response for vigorous PA energy expend (RR 0.86)	Non vigorous not significant
Blair (1989)	Dallas cohort	All cause mortality	Quintiles of fitness	Q1, 3, 5 (low, mod, vigorous) RR male –3.4, 1.4, 1.0 RR female 4.7, 1.4. 1.0	
Morgan (1997)	Nottingham cohort, 1042 older adults	All cause mortality	Customary PA index	Compared to high Moderate 1.53 Low 2.07	Effects stronger for women than men
Kujala (1998) Finnish twin cohort	16,000 twins aged 25-64	All cause mortality	Self report PA intensity and frequency and duration	Regular 0.76 Occas 0.80 Compared to sedentary	Relationship even stronger for PA within twin analysis
Erikssen (1998)	Norwegian cohort 2014 men aged 40-60	All cause mortality	PA 2x/week as active and fitness measure (quintiles)	RR=0.72 mod 0.45 vigorous	Change inn fitness also associated with reduced RR