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NICE

An Economic Analysis of Workplace Interventions that Promote Physical Activity

PHIAC Report

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INVESTOR IN PEOPLE

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Executive Summary

1. BACKGROUND

Two literature reviews, an effectiveness review and an economic review, have been carried out to provide information to help the Public Health Interventions Advisory Committee (PHIAC) develop guidelines on workplace interventions that promote physical activity. These reviews have highlighted the overall lack of robust quantifiable effectiveness and economic data. Modelling has been carried out to generate cost-effectiveness evidence to support the guideline development process. This report describes the modelling and provides details of the model outputs.

2. APPROACH TO ECONOMIC MODELLING

A pragmatic approach has been used to generate cost-effectiveness evidence. Two different methods have been employed, namely:

- The creation of a model that generates incremental cost-effectiveness ratios using information extracted from the literature and a modelling approach broadly in line with the NICE reference case (disease specific model);
- The use of available information on the effect of physical activity on absenteeism to estimate potential cost savings to employers (absenteeism model).

Table 1 below provides a summary of the interventions and the outputs associated with the approaches outlined above.

Table 1: Summary of modelling approaches and outputs

Model	Interventions	Economic measure	Strength of economic measure
Disease specific model	Physical activity counselling and Physical activity fitness programmes.	QALYs (long term)	In line with NICE reference case
Absenteeism model	Physical fitness programme	Cost saving	Non-health benefits considered

3. RESULTS

Cost-effectiveness Results

Table 2 provides a summary of the incremental cost effectiveness ratios (ICERs), assuming zero cost saving, generated by the disease specific model. It should be noted that, due to the absence of robust effectiveness data on which to base the economic evaluation, presented results should only be viewed as indicative. The uncertainty related to these results should be taken into account when developing guidelines.

Table 2: ICER results

Study	Intervention	ICER
Purath *et al.* (2004)	Physical activity counselling	£495.50
Chyou *et al.* (2006)	Physical activity walking programme	£686.34
Aittasalo *et al.* (2004)	Physical activity counselling	£1,234.11

Absenteeism Cost Estimates

Based on an effectiveness level of between 10% and 25%, the introduction of a physical fitness programme in the workplace may be considered broadly beneficial to the employer in terms of reduced absenteeism. The savings estimates may be considered to be conservative as, due to lack of empirical evidence, the effects of increased physical activity on factors such as employee turnover and productivity have not been considered.

4. CONCLUSION

The economic modelling outputs give support to the introduction of physical activity counselling and physical activity programmes in the workplace. However, the analyses are based on weak effectiveness evidence and a number of necessary assumptions.

Abbreviations

BMI	Body mass index (kg/m^2)
CHD	Coronary Heart Disease
DH	Department of Health
EQ-5D	EuroQol – 5 Dimensions (Quality of life measure)
HSE	Health Survey for England
ICER	Incremental cost-effectiveness ratio
NHS	National Health Service
NSF	National Service Framework
NICE	National Institute for Health and Clinical Effectiveness
PDG	Programme Development Group
PHIAC	Public Health Intervention Advisory Committee
QALY	Quality adjusted life year
RR	Relative Risk
YHEC	York Health Economics Consortium

Section 1: Introduction

The National Institute for Health and Clinical Excellence ('NICE or 'the Institute) has been asked by the Department of Health (DH) to develop guidance on public health programme interventions aimed at promoting physical activity in the workplace. This guidance will support implementation of the preventive aspects of national service frameworks (NSFs) where a framework has been published. The public health guidance published by NICE after an NSF has been issued will have the effect of updating the framework. This guidance will also support a number of related policy documents.

This guidance will provide recommendations for good practice based on the best available evidence of effectiveness, including cost-effectiveness. It is aimed at employers both in the public and private sectors. It is also aimed at professionals with occupational, public health or transport planning as part of their remit working within the NHS, local authorities and the wider public, private, voluntary and community sectors.

1.1 THE NEED FOR GUIDANCE

1.1.1 Physical Activity and Ill Health

Experts suggest that increasing activity levels will contribute to the prevention and management of over 20 conditions and diseases including coronary heart disease (CHD), diabetes, cancer, and obesity. There is also evidence to suggest that increasing physical activity levels can also help to improve mental health[1].

In 2004 the Department of Health estimated the financial cost of inactivity in England to be £8.2 billion annually. This figure includes the rising costs of treating chronic diseases such as coronary heart disease and diabetes but does not include the contribution of inactivity to obesity, which is estimated to cost the economy a further £2.5 billion each year[2].

It is estimated that around 35% of men and 24% of women undertake sufficient physical activity to meet the current national physical activity recommendations (achieving at least 30 minutes of at least moderate activity on 5 or more days a week). It is also interesting to note that physical activity has been found to vary by age, gender, class and ethnicity[3].

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1 Department of Health (2005) *Choosing activity: a physical activity action plan*. London: Department of Health.

2 Department of Health (2004) *At least five a week: Evidence on the impact of physical activity and its relationship to health*. London: Department of Health.

3 Joint Health Surveys Unit (2004) *Health survey for England 2004 – updating of trend tables to include 2004 data*. London: The Stationery Office.

Trends between health surveys for England in 1997, 1998, 2003 and 2004 found small increases in physical activity levels between 1997 and 2004[3]. Data from the national travel surveys show that the distance people walk and cycle has declined significantly in the last three decades[4].

1.1.2 The Employer's Perspective

It has been reported that physically active employees are less likely to suffer from major health problems such as coronary heart disease, less likely to take sickness leave and less likely to have an accident at work[5]. Further, findings from Goetzel *et al.*[6] suggest that about 2% of capital spent on workforce is lost to disability, absenteeism and presenteeism caused by chronic diseases, and an equal amount is spent on the direct costs of healthcare.

Furthermore, a physical activity programme may make a company an attractive place to work. In an increasingly competitive labour market this may help a company to distinguish itself from other employers, allowing it to attract new staff and maximise the health of older workers. Further, a workplace physical activity programme supports a corporate image that aims to demonstrate social responsibility. Such an image may have broad marketing benefits.

1.2 THIS STUDY

A review of economic literature related to interventions that promote physical activity in the workplace[7] revealed that overall there is limited evidence on the economic benefits of such interventions. The purpose of this study is to use economic modelling techniques to generate evidence to assist the development of guidance on public health interventions aimed at promoting physical activity in the workplace.

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4 National Statistics (2004) *National travel survey 2004*. London: Department for Transport.
5 Dishman RK, Oldenburg B, O'Neal H *et al.* (1998) *Workplace physical activity interventions.* American Journal of Preventive Medicine 15(4): 344-361.
6 Goetzel *et al.*, Health, Absence, Disability , and Presenteeism Cost Estimates of Certain Physical and Mental conditions affecting US employees, JOEM, 2004;46:398-412.
7 Beale S, Bending M, Hutton J (2007). Workplace Health Promotion: How to Encourage Employees to be Physically Active: A Rapid Review of Economic Literature. NICE PHIAC report.

1.2.1 Approach to Economic Modelling

A pragmatic approach was used to generate cost-effectiveness evidence. Available effectiveness and cost evidence have been used wherever possible. Two different methods have been employed, namely:

- The creation of a model that generates incremental cost-effectiveness ratios using information extracted from the literature and a modelling approach broadly in line with the NICE reference case;
- The use of available information on the effect of physical activity on absenteeism to estimate potential cost savings to employers through the introduction of a workplace scheme to promote physical activity.

Section 2: Disease Specific Model

2.1 BACKGROUND

It has been reported that people who are physically active reduce their risk of developing major chronic disease by up to 50% and the risk of premature death by about 20 – 30%[8]. Physical activity is associated with benefits such as maintaining ideal body weight and reducing the risk of health problems associated with being overweight and obese.

The model described in this section of the report links increases in physical activity behaviour with reduced risk of developing health conditions. It uses published evidence on the effectiveness of workplace interventions to promote physical activity, and combines these with estimates of the risk (which varies for different levels of activity) of developing key chronic conditions. This information is used to generate data on the cost-effectiveness of the workplace interventions.

In 2006 Matrix Research and Consultancy developed a model to generate cost-effectiveness evidence to support the development of Public Health Intervention Advisory Committee (PHIAC) guidance on four interventions aimed at increasing physical activity levels. These interventions were brief interventions in primary care, pedometers, exercise referral, and walking and cycling programmes in the community. The Matrix model was later adapted by York Health Economics Consortium (YHEC) into a form suitable to generate cost-effectiveness evidence to inform the development of Programme Development Group (PDG) guidance on environmental interventions to promote physical activity. The YHEC model has subsequently been updated, modified and expanded to generate the results presented in this report.

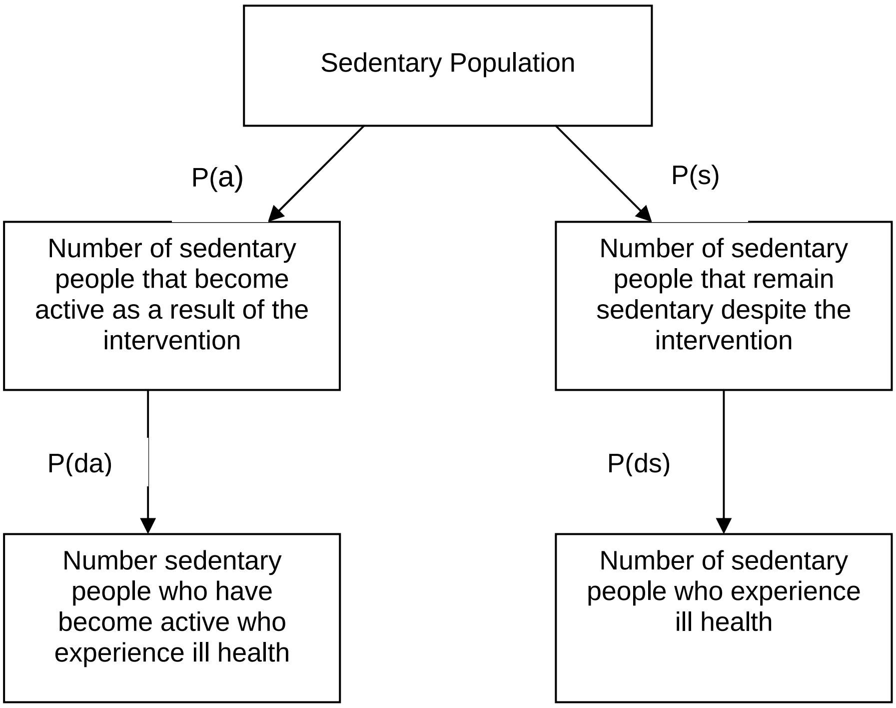
2.2 MODEL STRUCTURE

Outline details of the model structure are presented below. Further details may be found in Appendix A.

8 Department of Health. At least five a week: Evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer. 2004.

Figure 2.1 below provides a simplified representation of the model.

Figure 2.1: Diagram of model structure



Where:

P(s) = the probability that the sedentary population remain sedentary;
P(a) = the probability that the sedentary population will become active;
P(ds) = the probability of ill health in the sedentary population;
P(da) = the probability of ill health in the active population.

This model estimates the cases of coronary heart disease, stroke and type 2 diabetes that would be averted as a consequence of a proportion of the sedentary population taking up defined levels of physical activity.

Physical activity has been linked with a wide range of health benefits, including CHD, stroke, different forms of cancer, type 2 diabetes and several mental health conditions. This model focuses on CHD, stroke and type 2 diabetes as these are the conditions for which the most robust quantifiable evidence exists, both for the relationship between physical activity and risk of disease and for the quality adjusted life year (QALY) gains that result from avoiding these forms of ill health. As only a sub-set of health benefits are estimated by this model quality of life estimates may be considered as conservative.

Table 2.1 below outlines the major steps that have been used within the model.

Table 2.1: Model steps

Step	Process	Notes/main assumptions
1	Extract effectiveness evidence from the literature.	• Assume reported effectiveness is independent of baseline activity level.
2	Formulate a representative sample (by age group) of the sedentary population using information from the Health Survey for England (HSE).	• Relative risk estimates were only available for those aged between 40 and 60 years old and hence should only be applied to that age group.
3	Generate probability of developing CHD, stroke and type 2 diabetes (by age group) for the sedentary population.	• Assume 10-year risk of developing a condition is equal to the risk over the remaining life-time; • Probability risk calculations do not take into account activity levels, therefore it has been assumed that generated estimates apply to the sedentary population; • Assume the risks of experiencing CHD, stroke or type 2 diabetes are independent of one another; • CHD and stroke were estimated using the Framingham equations[9]. Diabetes was estimated using a risk equation developed by Lindström *et al.*[10].
4	Determine the reduced likelihood of developing CHD, stroke and type 2 diabetes (by age group) for the active population based on information on relative risk extracted from the literature.	• The relative risk values that were used were calculated in a range of locations. It has been assumed that these relative risks can be applied to the UK population; • It is assumed that physical activity levels are maintained over a period sufficient to ensure that the health benefits associated with that level of activity are attained.
5	Estimate the number of cases of CHD, stroke and type 2 diabetes avoided in a cohort of 1000 sedentary people as a result of a proportion becoming active.	
6	Use estimates of quality adjusted life years (QALYs) gained per health state avoided (by age group) to estimate population QALY gains.	• QALY estimates were derived using HSE EQ5D scores by age-group and condition, and ONS mortality figures (with and without CHD, stroke and type 2 diabetes).
7	Use information from the literature on cost of different interventions to generate ICER results.	• These figures merely provide guidance on the possible range of values within which ICERs may lie.
8	Generate savings of life-time health cost estimates.	

9 Anderson K M, Odell PM, Wilson WF, Kannel WB. Cardiovascular disease risk profiles. Am Heart J 1990; 121-293 –8.

10 Lindström J, Tuomilehto J. The Diabetes Risk Score. Diabetes Care 2003 26;3: 725 – 731.

The model does not consider the negative outcomes of physical activity such as injuries. Further, the estimate of cost-savings ignores any increased health costs in the longer-term that occur as a result of increased life-expectancy. However, these omissions are unlikely to significantly impact on model QALY results.

Relative Risks

To calculate the cases averted by an increase in physical activity, relative risks (RR) were obtained for CHD, stroke and type 2 diabetes. The physical activity levels used to calculate the RRs were then matched with the physical activity outcome variables employed in the effectiveness studies and the 'most appropriate' RR was determined using the following decision criteria:

- The physical activity measures employed in the RR and effectiveness studies should be as similar as possible;
- The population on which the RR and effectiveness studies are based should be as similar as possible;
- Where possible a RR study that presents 95% confidence intervals should be selected to provide an estimate of the variance in RR scores.

A literature review was conducted to identify how the RR of experiencing CHD, stroke or type 2 diabetes is associated with different levels of physical activity. The literature review identified 594 studies. Studies were excluded if they did not meet the criteria above and were not associated with a measurable change in physical activity levels. Fourteen studies were reviewed and used to obtain the RRs used in the model.

Table 2.2: Relative risks literature search results

Disease area	Number of studies	Number of studies reviewed	Studies used to obtain relative risk values
CHD relative risk	267	22	9
Stroke relative risk	125	5	3
Type 2 diabetes relative risk	202	10	2
Total	**594**	**36**	**14**

2.2.1 Relationship between Effectiveness Evidence and the Modelling Approach

Ideally, for economic modelling purposes, a quantitative measure of activity level prior to the intervention as well as a quantitative measure of activity level post intervention is required. If only a quantitative prior measure is available then it may be feasible to make assumptions based on qualitative evidence on the impact of the intervention. If no quantitative prior measure it available it is possible to use data from the Health Survey for England (HSE) and apply the effectiveness outcome to a representative population. However, where quantitative prior and post intervention measures are not available the only analyses that can be carried out are scenario or 'what if' analyses.

On the whole, the available effectiveness evidence does not lend itself to incorporation within any quantitative economic model due to its qualitative nature. Table 2.3 shows the reasons why interventions revealed by the literature searches were excluded from the modelling.

Table 2.3: Interventions included/excluded in the models

Area covered in effectiveness review	Included?	Reason for exclusion
Multi-component programmes*	Yes	
Walking interventions	Yes	
Active travel	No	Two studies reported that intervention had no effect and the third study only reported qualitative outcomes.
Stair walking	No	Effects were reported in terms of step counts. To transform these into increases in overall physical activity would require a number of unsupported assumptions. .
Areas covered in the economic review		
Multi-component programmes*	Yes	
Counselling	Yes	

* Includes counselling, health education, fitness programmes and facilities.

The studies used in the following analyses were selected because the way in which findings (with assumptions) were reported allowed the generation of quantifiable outcomes. The model incorporates evidence from five different types of interventions. Details of the component parts of the interventions are summarised in Table 2.4.

Table 2.4: The Intervention types and components

Study	Intervention types	Intervention components
Purath *et al.* (2004)	Physical activity counselling	• One 30 minute health promotion consultation; • One 30 minute follow-up telephone call consultation conducted by an occupational nurse.
Chyou *et al.* (2006)	Physical activity walking programme	• Occupational nurses providing employees with programme services and resources for the promotion of walking.
Aittasalo *et al.* (2004)	Physical activity counselling	• One 11 hr training session per nurse; • One 30 minute physical activity counselling session; • Two 30 minute fitness tests performed by a Physiotherapist; • One 30 minute physical activity follow-up counselling session.
Østerås *et al.* (2006)	Physical activity programme	• One 30 minute interview plan conducted by a counsellor; • 6 months fitness programme; • One follow-up counselling by an occupational therapist.

Table 2.5 provides details of how reported effectiveness material has been incorporated into the model. In all cases it has been assumed that the resulting increase in physical activity is maintained long enough to obtain the health benefits associated with that physical activity level.

It should be noted that there was insufficient evidence available to match RRs with any sub-groups. Further, as none of the studies from which RRs were extracted were based in the UK there could be generalisability issues.

Table 2.5: Effectiveness review evidence used within the model

Study	Country	Intervention	Reported effectiveness incorporated within model	Assumption/interpretation of evidence	Follow-up
Purath *et al.* (2004)	USA	Physical activity counselling	36.6%	A difference was taken between the intervention and control group. This resulted in an effectiveness of 36.6%.	6 weeks
Chyou *et al.* (2006)	USA	Physical activity walking programme	13%	The workplace consisted of 724 female employees of which 191 (26%) completed the programme. Of these 91 (48.9%) increased their physical activity. The effectiveness was calculated from these two pieces of information.	Not reported
Aittasalo *et al.* (2004)	Finland	Physical activity counselling	21%	The self-reported change for the counselling and fitness testing group was estimated. The intervention increase was reported at 48% and the control at 27%. The value of 21% was obtained from the difference in values of the self reported activity of these two groups.	12 months
Østerås *et al.* (2006)	Norway	Physical activity programme	No effect reported	Point estimates were not available. Scenario analyses of different levels of effectiveness have been generated using evidence from this study. .	6 months

2.3 RESULTS

2.3.1 Quality Adjusted Life Years (QALYs)

The average QALY gains, based on the effectiveness of each intervention in a cohort of 1,000 people aged between 40 and 60 years old, have been generated. These estimates are presented in Table 2.6. The QALY estimates are in line with QALY estimates generated for other public health interventions, such as those for environmental interventions to promote physical activity (0.125)[11], as well as interventions to reduce obesity (workplace counselling (0.087), counselling by primary care staff (0.132) and whole school approach (0.025)[12]).

Table 2.6: Average QALY per cohort of 1,000 sedentary individuals

Study	Intervention	Total QALY gains	QALY (95% CI)
Purath *et al.* (2004)	Physical activity counselling	115.04	0.12 (-0.13,0.26)
Chyou *et al.* (2006)	Physical activity walking programme	81.59	0.08 (-0.03,0.12)
Aittasalo *et al.* (2004)	Physical activity counselling	110.35	0.11 (-0.02,0.19)
Østerås *et al.* (2006)	Physical activity programme	-	-

2.3.2 Intervention Costs

The interventions were costed by their individual components. Details of how costs were estimated can be found in Appendix A.

Table 2.7: Intervention costs

Study	Intervention	Cost per employee
Purath *et al.* (2004)	Physical activity counselling	£57.00
Chyou *et al.* (2006)	Physical activity walking programme	£56.00
Aittasalo *et al.* (2004)	Physical activity counselling	£136.19
Østerås *et al.* (2006)	Physical activity programme	£267.00

11 Beale S, Bending M, Trueman P. An Economic Analysis of Environmental Interventions that Promote Physical Activity. March 2007 (unpublished report prepared on behalf of NICE).

12 Redmond S. Trueman P. The Cost-effectiveness of interventions to prevent obesity. February 2006 (unpublished report prepared on behalf of NICE).

2.3.3 Incremental Cost-effectiveness Ratios

$$ICER \quad \frac{Costs_{(intervention)} - Costs_{(base\_case)}}{Effects_{(intervention)} - Effects_{(base\_case)}}$$

The difference between the effects of the intervention and the effects of the base case are equivalent to the QALYs gained through averting the three diseases by increased physical activity ($Effect_{(intervention)}$ – $Effect_{(base\_case)}$). The base case cost was assumed to be zero and there were assumed to be no cost savings. A technical explanation for this methodology can be found in Appendix A (Step 5). ICER point estimates are displayed in Table 2.8.

Table 2.8: Model ICER Point Estimates

Study	Intervention	ICER
Purath *et al.* (2004)	Physical activity counselling	£495.50
Chyou *et al.* (2006)	Physical activity walking programme	£686.34
Aittasalo *et al.* (2004)	Physical activity counselling	£1,234.11
Østerås *et al.* (2006)	Physical activity programme	-

2.3.4 Associated NHS Health Cost Savings

Associated NHS health cost savings have been estimated based on assumptions relating to the age at which a health condition was developed and the likely associated life-expectancy. These factors were combined with estimates of the average annual cost of treating an individual with CHD, stroke or type 2 diabetes. Details of how these estimates were derived can be found in Appendix A. The figures reported in Table 2.9 should only be considered as indicative of likely NHS health cost savings.

Table 2.9: Estimated lifetime health cost savings from cases averted (based on effectiveness evidence

Study	CHD		Stroke		Type 2 diabetes		Total lifetime NHS health costs saved*
	Cases averted	Life-time health cost savings*	Cases averted	Life-time health cost savings*	Cases averted	Life-time health cost savings*	
Purath *et al.* (2004)	15.86	£384,944	0.95	£12,620	4.27	£144,380	**£541,944**
Chyou *et al.* (2006)	7.83	£189,948	3.02	£126,072	2.39	£51,528	**£367,547**
Aittasalo *et al.* (2004)	9.10	£220,870	4.91	£150,358	3.90	£57,348	**£428,576**

*Costs are discounted at a rate of 3.5%.

The total estimated NHS health cost saving resulting from averting cases of CHD, stroke and type 2 diabetes through implementing a workplace physical activity programme for a cohort of 1,000 sedentary employees ranges from £367,547 to £541,944.

Table 2.10 shows that estimates for the net cost savings resulting from the interventions range from £292,388 to £484,944.

Table 2.10: Net cost savings

Study	Total lifetime cost saved*	Cost of intervention	Net NHS cost saving*
Purath *et al.* (2004)	£541,944	£57,000	£484,944
Chyou *et al.* (2006)	£367,547	£56,000	£311,547
Aittasalo *et al.* (2004)	£428,576	£136,188	£292,388

*Costs are discounted at a 3.5% rate of discount.

2.3.5 Inclusion of NHS Cost Savings in ICER

Table 2.11 shows results under two scenarios, firstly where cost savings are assumed to be zero and secondly where an estimate of average NHS cost savings have been included in the calculation. In both cases the base case cost was assumed to be zero.

Table 2.11 Model ICER Point Estimates

Study	Intervention	ICER (assuming no cost saving)	ICER (incorporating mean cost saving)
Purath *et al.* (2004)	Physical activity counselling	£495.50	Dominant
Chyou *et al.* (2006)	Physical activity walking programme	£686.34	Dominant
Aittasalo *et al.* (2004)	Physical activity counselling	£1,234.11	Dominant

When the estimated life-time cost savings are taken into account the intervention can be seen to be dominant, i.e. the intervention is both cost saving and results in a health benefit. It should be noted that the cost of the intervention is a one-off cost and life-time savings accrue over a number of years.

2.4 KEY MODEL ASSUMPTIONS

Table 2.12 lists the key model assumptions and indicates which assumptions are likely to lead to an under-estimate, an over-estimate or have an unclear impact on the cost-effectiveness results generated by the model.

Table 2.12: Impact of model assumptions on cost-effectiveness results

Model assumption	Impact on cost-effectiveness results
Under-estimates	
Published figures	Publication bias occurs when authors are more likely to submit, or editors accept, positive rather than null (negative or inconclusive) results. This may be the case when considering submitting (or publishing) studies measuring the effect of interventions that promote physical activity.
Measurement error	The estimates of effectiveness tend to rely on self-reported measures and therefore results may be subject to measurement error. If participants tend to overestimate the level of physical activity achieved the health benefit will be overestimated and therefore the resulting ICER will be an underestimate.
100% compliance	Due to a lack of published evidence on drop-out rates over time the model assumes that the level of activity achieved on completion of a study is maintained for life. This is unlikely to happen in reality. Sensitivity analyses have been carried out around levels of compliance.
No negative outcomes	The costs associated with any negative outcomes associated with increasing physical activity levels (e.g. sustaining a physical injury) are not considered in the model.
Increased health care costs	The model does not include estimates of any increase in health costs that may occur in the longer-term as a result of increases in life-expectancy that might result from taking up an active life-style.
Cost of treatment	The cost of treatment was calculated from prevalence and total costs for the whole UK population. The cost of treatment for the sedentary population maybe higher.
Over-estimates	
Framingham equations	Study of a single community that has distinctive characteristics, neither ethnically diverse nor nationally representative. When data are broken down by age and sex some of the groups are relatively small.
	Equation generates 10-year risk estimates.
Independence of risk estimates	Assume risk of experiencing CHD, stroke or type 2 diabetes are independent of one another.
Limited disease areas	The major disease areas that had associated effectiveness and relative risk evidence were included in the study. The estimated benefit is therefore likely to be an underestimate as the model did not include a number of other disease areas.
Benefits to non-sedentary population	All employees that participate in a workplace physical activity programme are likely to receive some health benefit. However, employees who are active at the outset are unlikely to benefit to the same extent as those who are sedentary at the outset.

Table 2.12: Impact of model assumptions on cost-effectiveness results (continued)

Unclear	
Relative risks apply to the UK population	The relative risks were taken from a number of international studies. It is unclear whether these are all applicable to the UK. Further to this the relative risks are not specific to the type of physical activity undertaken within the study.
No sub-group analyses	An analysis of subgroups could not be undertaken due to a lack of data for the UK and internationally.
Interpretation of published evidence	The interpretation of the published effectiveness evidence may bias the cost-effectiveness estimates.
Correlate evidence	The model relies on correlate evidence on increases in physical activity. The studies do not show causality.
	Reported effectiveness is independent of baseline activity levels.
Inference from reported outcomes	Reported information did not always specify the proportion of people who complied with an intervention, their average increase in physical activity or the intensity of that physical activity. Where these details were missing assumptions had to be made.

2.5 SENSITIVITY ANALYSES

2.5.1 Effectiveness Sensitivity Analyses

Sensitivity analyses were performed for seven different levels of effectiveness, namely 1%, 5%, 10%, 15%, 20%, 25% and 50% and these are reported for each study in Tables 2.13 – 2.15. The point estimates for the effectiveness in the studies were 37% in Purath *et al.* (2004), 13% in Chyou *et al.* (2006) and 21% in Aittasalo *et al.* (2004).

Table 2.13: Purath *et al.* (2004) ICER for level of effectiveness

Effectiveness level	Cost per user	Total QALY	Per user QALY	ICER
1%	£57.00	3.14	0.003	£18,135.12
5%	£57.00	15.72	0.016	£3,627.02
10%	£57.00	31.43	0.031	£1,813.51
15%	£57.00	47.15	0.047	£1,209.01
20%	£57.00	62.86	0.063	£906.76
25%	£57.00	78.58	0.079	£725.40
50%	£57.00	157.15	0.157	£362.70

Table 2.14: Chyou *et al.* (2006) ICER for level of effectiveness

Effectiveness level	Cost per user	Total QALY	Per user QALY	ICER
1%	£56.00	6.325	0.006	£8,853.72
5%	£56.00	31.625	0.032	£1,770.74
10%	£56.00	63.250	0.063	£885.37
15%	£56.00	94.875	0.095	£590.25
20%	£56.00	126.500	0.127	£442.69
25%	£56.00	158.126	0.158	£354.15
50%	£56.00	316.251	0.316	£177.07

Table 2.15: Aittasalo *et al.* (2004) ICER for level of effectiveness

Effectiveness level	Cost per user	Total QALY	Per user QALY	ICER
1%	£136.19	5.25	0.005	£25,916.34
5%	£136.19	26.27	0.026	£5,183.27
10%	£136.19	52.55	0.053	£2,591.63
15%	£136.19	78.82	0.079	£1,727.76
20%	£136.19	105.10	0.105	£1,295.82
25%	£136.19	131.37	0.131	£1,036.65
50%	£136.19	262.74	0.263	£518.33

2.5.2 Compliance Sensitivity Analysis

The model assumes that once individuals have included physical activity in their lifestyles then they will continue to exercise for the remainder of their lifetime. There is a lack of available published evidence in the form of long-term natural history studies of physical activity interventions to enable an understanding of how compliance may be influenced by a number of factors including age of uptake, life-style or profession, sub-group, etc. Sensitivity analyses were carried out to generate ICERs assuming seven different intervention effectiveness levels (1%, 5%, 10%, 15%, 20%, 25% and 50% of the population). The results of these analyses can be interpreted in terms of compliance[13].

Table 2.16 shows ICER outputs for different levels of compliance based on the effectiveness (13%) and intervention cost (£56) estimated from information reported in Chyou *et al.* (2006) (note that this was the most conservative effectiveness estimate that was used in the model). Results show that if a threshold of £30,000 is assumed then the intervention can be considered cost-effective when the level of compliance is at least 2.5%.

[13] For example, outcomes for 50% effectiveness are equal to those that would be produced in a scenario where all the population were 50% compliant and outputs for the 25% effectiveness level are equal to those that would be generated if half of the population were 50% compliant.

Table 2.16: Variation of ICER with different levels of compliance

Percent compliance	QALY per person	ICER
100.0%	0.081592791	£686.34
80.0%	0.065274233	£857.92
60.0%	0.048955674	£1,143.89
40.0%	0.032637116	£1,715.84
20.0%	0.016318558	£3,431.68
10.0%	0.008159279	£6,863.35
5.0%	0.00407964	£13,726.70
2.5%	0.00203982	£27,453.41
2.0%	0.001631856	£34,316.76
1.0%	0.000815928	£68,633.51

Note: Shaded cells represent compliance levels of the intervention that would not be considered cost-effective under a £30,000 threshold.

Table 2.17 shows ICER outputs for different levels of compliance and includes the cost saving to the health service. Results show that if a threshold of £30,000 is assumed then the intervention can be considered cost-effective when the level of compliance is at least 10%. The ICER values are larger than those in Table 2.16 because the intervention cost over 15 years considerably offsets the cost savings to the NHS from the intervention.

Table 2.17: Variation of ICER (including cost saving to the NHS and a 15 year intervention cost) with different levels of compliance

Percent compliance	QALY per person	ICER
100.0%	0.081592791	£2,326.69
80.0%	0.065274233	£2,908.36
60.0%	0.048955674	£3,877.81
40.0%	0.032637116	£5,816.72
20.0%	0.016318558	£11,633.43
10.0%	0.008159279	£23,266.87
5.0%	0.00407964	£46,533.73
2.5%	0.00203982	£93,067.46
2.0%	0.001631856	£116,334.33
1.0%	0.000815928	£232,668.66

Note: Shaded cells represent compliance levels of the intervention that would not be considered cost-effective under a £30,000 threshold.

2.5.3 Intervention Cost

The model assumes that the cost of the intervention is a one-off cost incurred at the outset of the modelled period. However, to achieve high levels of compliance it is possible that 'booster sessions' may be helpful. The results of the sensitivity analysis presented in Table 2.18 show a range of scenarios in which ICERs have been calculated under different assumptions, namely:

- Cost saving;
- No cost saving;
- Cost saving and intervention costs incurred annually until retirement;
- No cost saving but intervention costs incurred annually until retirement.

Under these assumptions it can be seen that in all cases the interventions can be considered cost-effective, assuming a threshold of £30,000.

Table 2.18: Intervention cost sensitivity analysis

Study	Intervention	ICER			
		Assuming cost saving	**Assuming no cost saving**	**Assuming cost saving and intervention costs occurring annually**	**Assuming no cost saving but intervention cost occurs annually**
Purath *et al.* (2004)	Physical activity counselling	Dominant	£496	£221	£4,436
Chyou *et al.* (2006)	Physical activity walking programme	Dominant	£686	£2,327	£6,145
Aittasalo *et al.* (2004)	Physical activity counselling	Dominant	£1,234	£8,400	£11,049

2.6 KEY POINTS

- The average QALY estimates per person, based on effectiveness evidence in the literature range from 0.08 to 0.12. These values are in line with QALY estimates generated for other public health interventions, such as those for environmental interventions to promote physical activity (0.125) as well as interventions to reduce obesity (workplace counselling (0.087), counselling by primary care staff (0.132) and whole school approach (0.025)).

- The QALY gain estimates are likely to be conservative as they only consider the gains resulting from avoiding CHD, stroke and type 2 diabetes.

- Based upon the effectiveness levels taken from the literature, ICERs range from approximately £496 to £1,234 per QALY. These values have been generated assuming no cost saving.

- Further analyses suggest that interventions may be cost saving. However, there is considerable uncertainty surrounding the health cost saving estimates.

- The results from the modelling exercise lend support to the economic case for the development of physical activity programmes and counselling in the workplace.

- In all cases it is assumed that the resulting increase in physical activity is maintained long enough to obtain the health benefits associated with that level of physical activity.

- The effectiveness evidence did not allow a consideration of sub-groups.

- The available effectiveness data were derived from non-UK studies and hence there could be generalisability issues.

Section 3: Absenteeism Cost Estimates

3.1 INTRODUCTION

Evidence that increased physical activity reduces absenteeism is limited. Estimates of the cost of absenteeism have been generated for private sector and public sector employers. These are based on different levels of uptake of physical activity for a cohort of 1,000 employees.

The calculations use absenteeism evidence from Lechner *et al.* (1997) and estimate the number of days that an employer could save as a result of introducing an intervention to promote physical activity. The published evidence suggests that intervention effectiveness ranges from between 13% and 40%. The absenteeism model therefore considers effectiveness levels ranging from between 1% and 50%. A median wage rate was applied to the total days lost through absenteeism at each effectiveness level to obtain a per employee saving. The choice of median wage is preferred over the mean as earnings data has a skewed distribution and this measure is influenced less by extreme values.

Table 3.1: Absenteeism level and wages

Effectiveness level	Absenteeism level (days)[14]	Median wage (weekly)[15]	Hours (weekly)[16]	Daily rate[17]	Hourly rate[18]
Public sector 1	3.7	£387.8	37	£77.56	£10.48
Private sector 1	3.2	£355.6	35	£71.12	£10.16
Private sector 2	8.78	£355.6	37.5	£71.12	£9.48

Note 1: Public Sector 1: Police; Private Sector 1: Banking; Private Sector 2: Factory.

Note 2: The choice of median is preferred over the mean for earnings data as it is influenced less by extreme values and because of the skewed distribution of earnings data.

The absenteeism level displayed in Table 3.1 are the average reduction in days of short-term sick leave that result from participation in the intervention. The figures in the table show that the median wage for the private sector is lower than that for the public sector. This could be explained by the skewness of lower wages in the private sector of the economy.

14 Lechner L, de Vries H, Adriaansen S, Drabbels L. Effects of an Employee Fitness Program on Reduced Absenteeism. *Journal of Occupational and Environmental Medicine*, 1997; 39: 827-831.

15 Annual Survey of Hours and Earnings 2006 Office for National Statistics. Annual Survey of Hours and Earnings First Release http://www.statistics.gov.uk/pdfdir/ashe1006.pdf.

16 Annual Survey of Hours and Earnings 2006 Office for National Statistics http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14630.

17 Annual Survey of Hours and Earnings 2006 Office for National Statistics http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14630.

18 Annual Survey of Hours and Earnings 2006 Office for National Statistics http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14630.

3.2 RESULTS

The results (displayed in Tables 3.2 – 3.4 and in Graph 3.1) are presented for three different sectors of the economy. They show that at a 1% effectiveness level the cost saving per year for public sector 1, private sector 1 and private sector 2 is £2,870, £2,276 and £6,244, respectively. At a 50% effectiveness level the cost saving per year for public sector 1, private sector 1 and private sector 2 is £143,486, £113,792 and £312,217, respectively. The savings may be considered as conservative as, due to lack of empirical evidence, the effects of increase physical activity on factors such as employee turnover and productivity have not been considered.

The rows shaded grey in the Tables 3.2 - 3.4 shows the level of effectiveness that must be achieved so that, from the employer's perspective, the savings in absenteeism per employee cover the cost of an employee fitness programme (£56 Chyou *et al.* (2006)). These effect sizes are 20% in public sector 1, 25% in private sector 1 and 10% in private sector 2.

Table 3.2: Public sector 1

Effect	Number	Wage (daily)	Absenteeism level (days)	Cost saving/year	Cost Per employee
1%	10	77.56	3.7	£2,870	£2.87
5%	50	77.56	3.7	£14,349	£14.35
10%	100	77.56	3.7	£28,697	£28.70
15%	150	77.56	3.7	£43,046	£43.05
20%	200	77.56	3.7	£57,394	£57.39
25%	250	77.56	3.7	£71,743	£71.74
50%	500	77.56	3.7	£143,486	£143.49

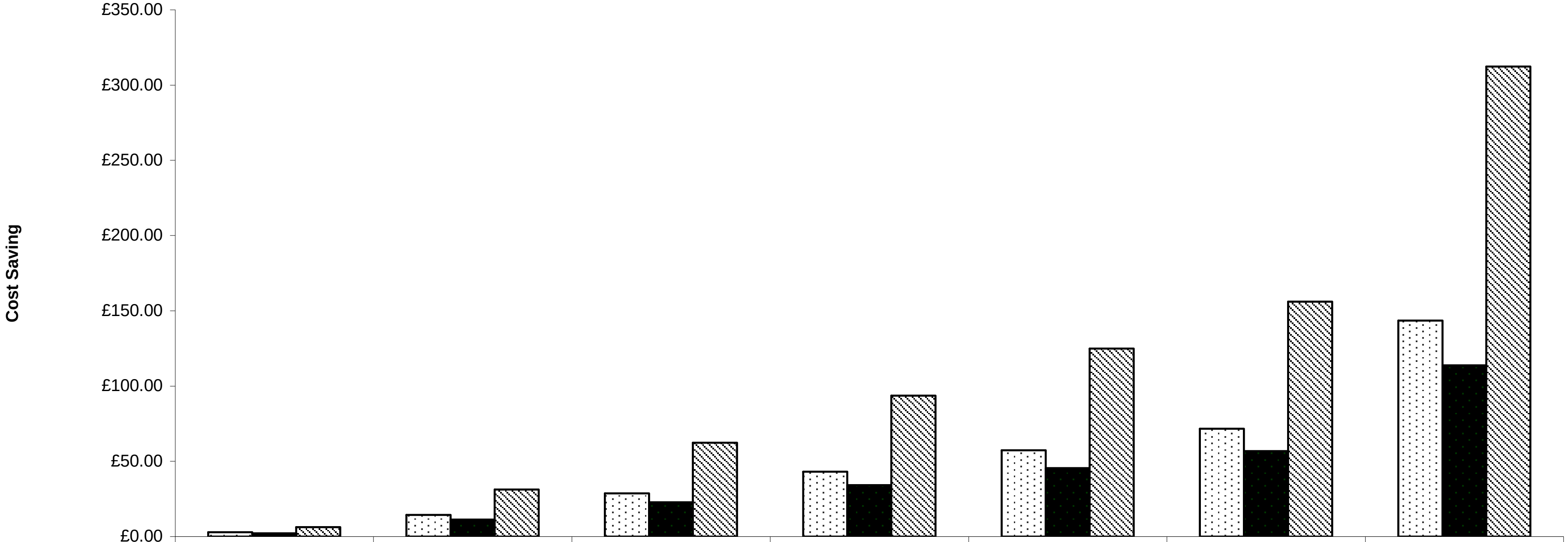
Table 3.3: Private sector 1

Effect	Number	Wage (daily)	Absenteeism level (days)	Cost saving/year	Cost Per employee
1%	10	71.12	3.2	£2,276	£2.28
5%	50	71.12	3.2	£11,379	£11.38
10%	100	71.12	3.2	£22,758	£22.76
15%	150	71.12	3.2	£34,138	£34.14
20%	200	71.12	3.2	£45,517	£45.52
25%	250	71.12	3.2	£56,896	£56.90
50%	500	71.12	3.2	£113,792	£113.79

Table 3.4: Private sector 2

Effect	Number	Wage (daily)	Absenteeism level (days)	Cost saving/year	Cost Per employee
1%	10	71.12	8.78	£6,244	£6.24
5%	50	71.12	8.78	£31,222	£31.22
10%	100	71.12	8.78	£62,443	£62.44
15%	150	71.12	8.78	£93,665	£93.67
20%	200	71.12	8.78	£124,887	£124.89
25%	250	71.12	8.78	£156,108	£156.11
50%	500	71.12	8.78	£312,217	£312.22

Graph 3.1: Workplace physical activity cost savings through reduction of absenteeism



	1%	5%	10%	15%	20%	25%	50%
Public sector 1	£2.87	£14.35	£28.70	£43.05	£57.39	£71.74	£143.49
Private sector 1	£2.28	£11.38	£22.76	£34.14	£45.52	£56.90	£113.79
Private sector 2	£6.24	£31.22	£62.44	£93.67	£124.89	£156.11	£312.22

Effectiveness

Public sector 1 Private sector 1 Private sector 2

3.3 KEY POINTS

- The results show that at a 1% effectiveness level the cost saving per year for public sector 1, private sector 1 and private sector 2 is £2,870, £2,276 and £6,244, respectively. At a 50% effectiveness level the cost saving per year for public sector 1, private sector 1 and private sector 2 is £143,486, £113,792 and £312,217, respectively.
- Based on an effectiveness level of between 10% and 25%, the introduction of a physical fitness programme in the workplace may be considered broadly beneficial to the employer in terms of reduced absenteeism.
- It should be noted that the results generated in this section are based on those reported in a single study.

Section 4: Discussion

Results from the disease specific model suggest that the modelled interventions provide a net QALY gain for a cohort of 1,000 sedentary employees. The estimated health cost savings outweigh the cost of any of the interventions and therefore the interventions may be considered to be cost saving. The interventions produce both net gains in cost savings and benefits (QALYs), supporting arguments to introduce such interventions. However, this outcome relies heavily on a number of assumptions, namely:

1. Effectiveness of the interventions;
2. Study follow-up and cost of intervention;
3. Relative risks;
4. Cost of treating CHD, stroke and type 2 diabetes.

4.1 EFFECTIVENESS OF THE INTERVENTIONS

Reported information did not always give a clear indication of the proportion of people who complied with an intervention, their average increase in physical activity or the intensity of that physical activity. Where these detail were missing assumptions had to be made. These assumptions have introduced a degree of uncertainty into the model.

The model relies on correlate evidence of the effect of increasing physical activity. The studies do not show causality. Furthermore, many of the reported estimates are self-reported and therefore may be subject to measurement error.

In all cases it has been assumed that the increase in physical activity that results from the intervention is maintained long enough to obtain the health benefits associated with that level of physical activity. In addition, the available effectiveness data were derived from non-UK studies and hence there could be generalisability issues.

The equity implications of these findings also need to be considered. The modelled interventions may be more accessible to people in certain social classes or people already engaged in physical activity and other healthy lifestyles. Unfortunately, a lack of evidence meant that equity implications could not be included in the model.

4.2 STUDY FOLLOW-UP AND COST OF INTERVENTION

The model assumes 100% compliance to the intervention for the lifetime of the employee. This assumption may not reflect reality as some people may not maintain the activity levels achieved at the outset of a programme designed to promote physical activity. Searches of the literature did not reveal any long-term evidence on compliance. Given the paucity of evidence a simple assumption (i.e. 100% compliance) was considered to be the most appropriate approach.

In the base case the model assumes that the intervention cost occurs during the follow-up period reported in the studies. This period ranges from six weeks to twelve months. In the real world interventions may accrue ongoing costs.

4.3 RELATIVE RISKS

The relative risk estimates extracted from the literature are one of the main drivers of the QALY gain in the model. It should be noted that these are estimates for the reduction in risk given a level of general physical activity. They are not relative risks for a particular type of physical activity. This point is important because the relative risks for diseases may be affected by the nature of the activity as well as the overall intensity. The general physical activity relative risks were used due to a lack of evidence for specific physical activity relative risks and therefore are the best estimates of relative risk presently available.

4.4 COST OF TREATING CHD, STROKE AND TYPE 2 DIABETES

The intervention costs were calculated by summing the component parts of the intervention. The cost of treating CHD, stroke and type 2 diabetes were calculated using a more simple approach than that used to cost each intervention. They were estimated using data on total NHS cost of each condition and prevalence estimates over the additional life years gained by those who avoided the three conditions.

4.5 NON-HEALTH BENEFITS

The impact of workplace interventions to promote physical activity on absenteeism was modelled. However, additional non-health benefits were not modelled due to the lack of quantifiable evidence. In the economic literature review[19], Shephard (1992) discussed effects of a workplace physical activity programme on employee turnover, productivity and corporate image. This study reported a decrease in employee turnover in employees that participated in the programme. The author found it hard to evaluate the impact of the physical activity programme on productivity because of difficulties associated with defining an end product for some groups of employees. However, small gains in work volume were found as a result of the intervention.

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[19] Beale S, Bending M, Hutton J (2007). Workplace Health Promotion: How to Encourage Employees to be Physically Active: A Rapid Review of Economic Literature. NICE PHIAC report.

Section 5: Conclusion

The economic modelling outputs give support to the introduction of physical activity counselling and physical activity programmes in the workplace. However, the analyses are based on weak effectiveness evidence and a number of necessary assumptions.

5.1 DISEASE SPECIFIC MODEL

Based upon the effectiveness levels taken from the evidence, ICERs range from approximately £496 to £1,234 per QALY. These values have been generated assuming no cost saving. Further analyses suggest that interventions may be cost saving. However, there is considerable uncertainty surrounding the health cost saving estimates.

The effectiveness evidence did not allow a consideration of sub-groups.

5.2 ABSENTEEISM ESTIMATES

Based on an effectiveness level of between 10% and 25%, the introduction of a physical fitness programme in the workplace may be considered broadly beneficial to the employer in terms of reduced absenteeism.

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APPENDIX A

Supporting Information for Disease Specific Model

A.1 MODEL 1: METHODOLOGY

A.1.1 Introduction

This model estimates the cases of CHD, stroke and type 2 diabetes that would be averted as a consequence of a proportion of the sedentary population taking up defined levels of physical activity. The model focuses on CHD, stroke and type 2 diabetes as these are the conditions for which the most robust quantifiable evidence exists, both for the relationship between physical activity and risk of disease and for the QALY gains as a result of avoiding these forms of ill health. Results from the review of literature relating to the effectiveness of workplace interventions that promote physical activity have been used to generate model output.

Generating model output involves eight main steps, namely:

Step 1: Extract effectiveness evidence from the review of workplace interventions that promote physical activity;
Step 2: Formulate a representative sample of the sedentary population using information from HSE;
Step 3: Generate probabilities for developing CHD, stroke and type 2 diabetes in the sedentary population;
Step 4: Determine the reduced likelihood of developing CHD, stroke and type 2 diabetes for the sedentary population who have become active as a result of a workplace physical activity intervention;
Step 5: Estimate the number of cases of CHD, stroke and type 2 diabetes avoided in a cohort of 1,000 sedentary people as a result of becoming active (based on scenarios formulated as a result of evidence collated in the first step above);
Step 6: Use estimates of QALY gains per health state avoided to estimate cohort (and average/person) QALY gains;
Step 7: Use cost information extracted from the literature to generate ICER estimates;
Step 8: Use cost of illness data to estimate life-time health cost savings.

Step 1: Extract effectiveness evidence from the literature

Ideally, for economic modelling purposes, a quantitative measure of activity level prior to the intervention as well as a quantitative measure of activity level post intervention is required. If only a quantitative prior measure is available then it may be feasible to make assumptions, based on qualitative evidence, on the impact of the intervention. If no quantitative prior measure is available it is possible to use data from the HSE and apply the effectiveness outcome to a representative population. However, in cases where no quantitative prior measure and no quantitative post measure are available the only analyses that can be carried out are scenario, or ‘what if’, analyses.

On the whole, the available evidence does not lend itself to incorporation within any quantitative economic model. The reported measures bear no relation to the overall activity level of the population either prior or post intervention. However, the literature review did reveal a number of studies that included evidence that could be incorporated into the model. It should be noted, however, that these studies have been selected for inclusion into the economic analyses solely because the format of their findings (with assumptions) allows the generation of quantifiable outcomes.

The model incorporates evidence for five different types of interventions, namely:

1. Purath *et al.* (2004) – Physical activity counselling;
2. Chyou *et al.* (2006) – Physical activity programme (walking);
3. Aittasalo *et al.* (2004) – Physical activity counselling;
4. Østerås *et al.* (2006) – Physical activity programme;

The interventions were matched to a relative risk for CHD, stroke and type 2 diabetes that corresponded to the level of physical activity achieved by the programme.

Table A.1 below provides details of how material reported in the studies included in the effectiveness reviews has been incorporated into the model. In all cases it is assumed that the resulting increase in physical activity is maintained long enough to obtain the health benefits of that level of physical activity.

Table A.1: Effectiveness review evidence used within the model

Study	Country	Intervention	Reported effectiveness incorporated within model	Assumption/interpretation of evidence	Follow-up
Purath *et al.* (2004)	USA	Physical activity counselling	36.6%	A difference was taken between the intervention and control group. This resulted in an effectiveness of 36.6%.	6 weeks
Chyou *et al.* (2006)	USA	Physical activity walking programme	13%	The workplace consisted of 724 female employees of which 191 (26%) completed the programme. Of these 91 (48.9%) increased their physical activity. The effectiveness was calculated from these two pieces of information.	Not reported
Aittasalo *et al.* (2004)	Finland	Physical activity counselling	21%	The self-reported change for the counselling and fitness testing group was estimated. The intervention increase was reported at 48% and the control at 27%. The value of 21% was obtained from the difference in values of the self reported activity of these two groups.	12 months
Østerås *et al.* (2006)	Norway	Physical activity programme	No effect reported	Point estimates not available. Scenario analyses of different levels of effectiveness have been generated using evidence from this study. .	6 months

Step 2: Formulate a representative sample (by age group) of the sedentary population

The relative risk values were only available for the population aged between 40 and 60 years of age. It was not thought appropriate to use these values beyond this age range. Information from the HSE (2004) was used to generate a representative (by 5 year age group) cohort of 1,000 sedentary individuals.

Information from the HSE (2004) was also used to define prevalence of smoking, systolic blood pressure levels, total/HDL cholesterol levels by age group and sex to enable CHD and stroke probabilities to be calculated. Similarly, information on body mass index (BMI), waist circumference, and use of blood pressure medication were extracted to enable type 2 diabetes risk to be estimated.

Step 3: Generate the probability of developing CHD, stroke and type 2 diabetes (by age group) for the sedentary population

The Framingham equations[20] were used to generate estimates of the predicted probability of CHD or stroke over a 10 year period and the Diabetes Risk Score, developed by Lindström and Tuomilehto[21] was used to estimate the 10 year risk of developing type 2 diabetes.

A number of assumptions were made in relation to these estimates, namely:

- The generated estimate is equivalent to the risk of developing either of these conditions over the remaining life-time;
- The risk estimates are applicable to the sedentary population;
- The risks of experiencing CHD, stroke or type 2 diabetes are independent of one another.

Step 4: Determine the reduced likelihood of developing CHD, stroke and type 2 diabetes (by age group) for the active population

This aspect of the model made use of the approach used by Matrix Research and Consulting (Matrix) in modelling the cost-effectiveness of four interventions to promote physical activity.

A literature review was conducted to identify the change in relative risk (RR) of experiencing CHD, stroke or type 2 diabetes associated with different levels of physical activity. The literature review identified 594 studies for which 14 studies were reviewed to obtain the relative risks for the model (see Table A.2).

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[20] Anderson KM, Odell PM, Willson PWF, Kannel WB. Cardiovascular disease risk profiles. Am Heart J 1990; 121:293-8.

[21] Lindström J, Tuomilehto J. The Diabetes Risk Score. Diabetes Care 2003 26; 3:725-731.

Table A.2: Relative risks literature search results

Disease area	Number of studies	Number of studies reviewed	Number of studies from which relative risk obtained
CHD relative risk	267	22	**9**
Stroke relative risk	125	5	**3**
Type 2 diabetes relative risk	202	10	**2**
Total	**594**	**36**	**14**

The physical activity levels used to calculate the relative risks (RRs) were then matched with the physical activity outcome variables employed in the effectiveness review to determine the ‘most appropriate’ RR using the following decision criteria:

- The physical activity measures employed in the RR and effectiveness studies should be as similar as possible;
- The population on which the RR and effectiveness studies were based should be as similar as possible;
- Where possible, a RR study that presents 95% confidence intervals should be selected to provide an estimate of the variance in RR scores.

In the event that these criteria still resulted in a number of alternative RR studies, the RR score used in the model was the average of the mean RR scores, and the lower and higher ends of the 95% confidence intervals were used to estimate the variance. In the event that the rules did not identify an appropriate RR study, the average of the RR studies identified for the same disease state was taken and the measure of variance employed was the lower and higher of the 95% confidence intervals from those scores.

Table A.3 matches the outcome of this exercise to the changes in physical activity levels that have been used in the model.

Table A.3: Matching of outcomes with studies reporting relative risk

Outcome variable	Study population	Matched RR study (95% CI)		
		CHD	Stroke	Type 2 diabetes
40 minutes moderate intensity activity	40-65 years	2.00 (1.00,3.33)	1.02 (0.78, 1.33)	1.28 (1.08,1.52)
90 minutes moderate intensity activity	40-65 years	3.33 (0.77,5.00)	1.22 (0.91,1.64)	1.54 (1.28,1.85)
70 minutes moderate intensity activity	40-65 years	2.00 (1.00,3.33)	1.22 (0.91,1.64)	1.54 (1.28,1.85)
50 minutes high intensity activity	40-65 years	3.33 (0.77,5.00)	1.22 (0.91,1.64)	1.54 (1.28,1.85)
30 minutes moderate intensity activity.	40-65 years	2.00 (1.00,3.33)	1.02 (0.78, 1.33)	1.28 (1.08,1.52)

A number of assumptions/limitations are associated with applying the above RRs to calculate the change in incidence of CHD, stroke and type 2 diabetes as a result of increased physical activity, namely:

- It is unlikely that all three conditions are experienced in separation from each other. However, for the sake of simplicity the model assumes that the risk of experiencing one condition is independent of the risk of experiencing the other conditions;
- The RRs employed are calculated in a range of locations. It is assumed that these RRs can be applied to a UK population;
- The RR figures are not specific to a particular activity (e.g., walking);
- No negative outcomes of physical activity, such as injuries, have been considered in the model. However, the physical activity levels and populations considered mean that this assumption is unlikely to significantly impact on model output.

Step 5: Estimate the number of cases of CHD, stroke and type 2 diabetes avoided as a result of becoming active

Using information on the:

- Risk of developing CHD, stroke or type 2 diabetes in the sedentary population;
- Effectiveness of each intervention;
- Relative risk of developing CHD, stroke or type 2 diabetes given the achievement of pre-defined levels of activity.

Estimates were derived, by age-group, for the number of cases of CHD, stroke and type 2 diabetes avoided as a result of achieving given levels of activity.

Step 6: Estimate QALY gains as a result of increased physical activity

This step involves estimating QALY gains per condition avoided (by age group). The QALYs gained from avoiding a particular health state is defined as:

$$Q = \left[Q_A \cdot (t_3 - t_1)\right] - \left[Q_d \cdot (t_2 - t_1)\right]$$

Q = quality of life gained;
Q_A = average quality of life;
Q_d = quality of life of each condition;
t_3 = average age of mortality;
t_1 = average age of onset of health state;
t_2 = average age of mortality in for different condition.

The discounted QALYs gained is defined as:

$$Q_d = Q \cdot \left(\left(\frac{1}{(1+r)} \right) \cdot \frac{(t_3 - t_2)}{(2 - t_0)} \right)$$

Where:

Q_d = discounted quality of life gained;
t_0 = average age of participants;
r = discount rate (3.5%).

Figure A.1 provides a graphical representation of the QALYs during the lifetime of an individual under the assumptions listed below:

- QALYs are constant before and after the onset of the disease;
- At time zero (t_0) the average quality of life in full health is Q_A.

The healthy person's quality of life is shown by the area under the curve that runs from Q_A on the y-axis to t_3 (which is the point of death) on the x-axis. It can be seen that quality of life deteriorates as death approaches. If a health condition is developed then quality of life will drop to Q_d. In the figure below this is shown to occur at time $t_{1.}$ With the condition the individual will die at time t_2. The QALYs gained through avoiding the condition are indicated by the area shaded in grey.

Figure A.1: QALYs gained through avoiding a condition

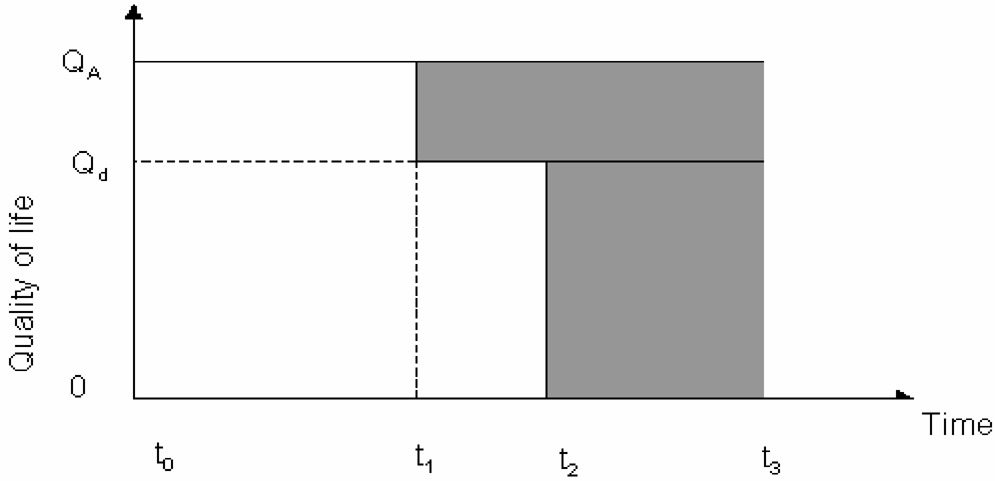
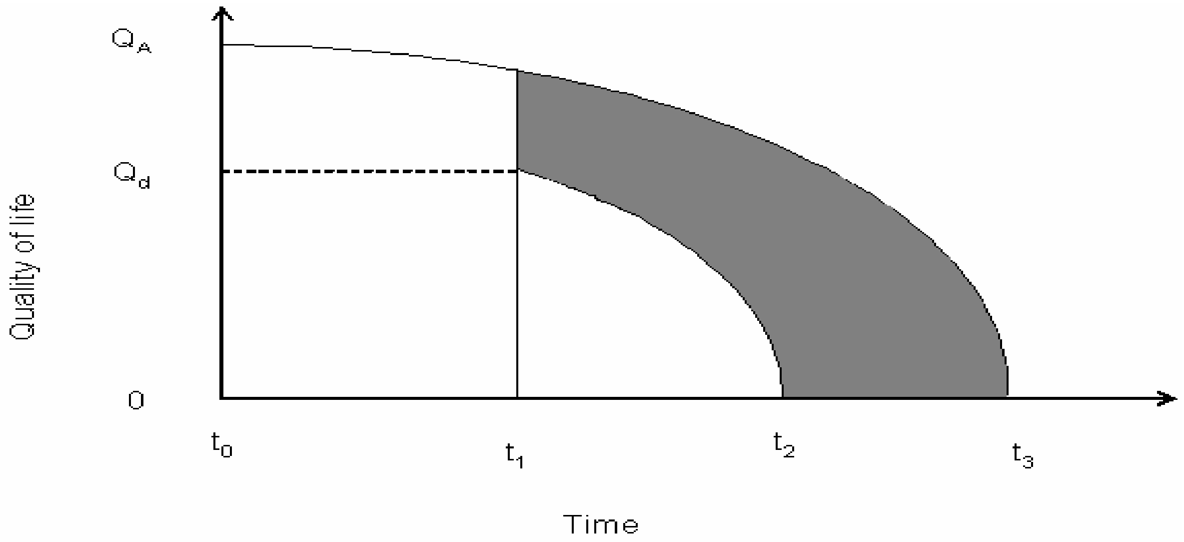


Figure A.2 provides a more realistic representation of QALYs over time, with quality of life deteriorating with age. However, the methodology used to estimate the quality of life gains through avoiding developing CHD, stroke or type 2 diabetes is that used by Matrix in the model they developed for NICE to demonstrate the cost-effectiveness of four physical activity interventions. Their methods are based on quality of life changes as seen in Figure A.1. Full details of the methodology used to estimate quality of life changes may be found in the report that accompanies that model. Summary details are presented below.

Figure A.2: More realistic representation of QALYs gained through avoiding a condition



The HSE (1996) was used to calculate the EQ-5D$_{index}$ scores for CHD, stroke and type 2 diabetes by age group and sex. These scores were compared with the averages for different age groups and genders to derive the loss in quality of life avoided by avoiding the different health states.

The average age of mortality was calculated from ONS data (t_3) and the average age of mortality for people who developed CHD, stroke or type 2 diabetes at different ages was estimated from ONS, British Heart Foundation and Yorkshire and Humberside Public Health Observatory data.

The number of life years remaining, depending on the age of onset of CHD, stroke or type 2 diabetes were then estimated.

In summary, the QALY gain is equal to the QALYs gained from the intervention minus the QALYs gained by the control group. This gain is represented algebraically below:

$$\sum_{1}^{4} a_i \left[\sum_{1}^{3} \left(P\left(d_j^s\right) - P\left(d_j^a\right) \right) \cdot Q_j \right]$$

$a =$ The population number.

$i = 1,4$ age groups. $1 = 40 - 44$, $2 = 45 - 49$, $3 = 50 - 54$, $4 = 55 - 59$.

$P(d^s) =$ Probability of disease for those that are sedentary.

$P(d^a) =$ Probability of disease for those that become active.

$j = 1,3$ for diseases. $1 =$ CHD, $2 =$ Stoke and $3 =$ Type 2 diabetes.

$Q =$ Quality of life averted

Step 7: Generate Incremental cost-effectiveness ratios (ICERs)

The incremental cost-effectiveness ratio is defined below:

$$ICER = \frac{Costs_{(intervention)} - Costs_{(base\_case)}}{Effects_{(intervention)} - Effects_{(base\_case)}}$$

Tables A.4 – A.7 provide details of the elements, costs and source of costs used to cost the physical activity interventions.

Table A.4: Intervention 1 (Purath *et al.* 2004) costs

Intervention component	Resources required	Unit cost	Cost	Source
Health promotion consultation	Occupational nurse	£57	£28.50	Curtis and Netten (2006) PSSRU
Follow-up telephone call consultation	Occupational nurse	£57	£28.50	Curtis and Netten (2006) PSSRU
Total Cost			**£57.00**	

Table A.5: Intervention 2 (Chyou *et al.* 2006) costs

Intervention component	Resources required	Unit cost	Cost	Source
Programme services and resources	Occupational nurses	£56	£56	Curtis and Netten (2006) PSSRU
Total Cost			**£56.00**	

Table A.6: Intervention 3 (Aittasalo *et al.* 2004) costs

Intervention component	Resources required	Unit cost	Cost	Source
Training sessions for nurses (11 hours)	Occupational nurse	£57	£39.19	Curtis and Netten (2006) PSSRU
(Group 1&2) PA counselling session	Occupational nurse	£57	£28.50	Curtis and Netten (2006) PSSRU
(Group 1&2) PA follow-up counselling session	Occupational nurse	£57	£28.50	Curtis and Netten (2006) PSSRU
(Group 2) Fitness testing	Physiotherapist	£40	£40.00	Curtis and Netten (2006) PSSRU
Total Cost			**£136.19**	

Table A.7: Intervention 4 (Østerås *et al.* 2006) costs

Intervention component	Resources required	Unit cost	Cost	Source
30 minute interview and plan	Counsellor	£57	£28.50	Curtis and Netten (2006) PSSRU
6-month physical activity programme	Fitness equipment	£35	£210.00	City of York Council, TFL Gym
Follow-up counselling	Occupational therapist	£57	£28.50	Curtis and Netten (2006) PSSRU
Total Cost			**£267.00**	

The effectiveness was measured in terms of QALY gains for averted disease (see Step 6). ICERs were generated for all of the five studies.

Step 8: Estimation of life-time costs averted

Cost savings focus on NHS cost savings and do not consider wider societal costs from, say, sick days avoided, increased productivity, etc. All costs are reported in 2007 prices. Where necessary, costs have been uplifted to 2007 quarter 1 values. Table A.8 summarises the annual costs per patient for treating CHD, stroke and type 2 diabetes. These estimates should only be considered as indicative.

Table A.8: Annual cost estimates of treating CHD, stroke and type 2 diabetes

Condition	Prevalence (HSE) (%)	Prevalence (number)[1]	Total NHS Costs (2007 estimates)	Cost/person/year
CHD	0.043	1,807,015	£3,984,741,871[2]	£2,205
Stroke	0.0251	1,054,792	£3,174,876,036[3]	£3,010
Type 2 diabetes	0.0369	1,550,671	£5,001,600,000[4]	£3,225

1 ONS 2007 population estimates for those aged 15 and over;
2 2003 BHF figure uplifted to 2007 cost (www.heartstats.org);
3 Saka RO, McGuire A, Wolfe CDA. Economic burden of stroke in England. King's College London, University of London (uplifted to 2007 cost);
4 HM Treasury 2006 budget figure for cost of Health (uplifted to 2007) multiplied by DH figure for percentage spend on diabetes.

It is generally recognised that if an intervention averts disease and consequently extend the life of a population then this will reduce health costs in the shorter term at the expense of increased health costs in the longer term. This is due to the fact that as the population is living for longer it incurs health-related costs for an extended period of time and, furthermore, elderly patients tend to cost more to treat per episode of ill health than younger people. As this model only considers risk over a ten year period this factor is not taken into account.

Table A.9: Health cost saving

Study	CHD		Stroke		Type 2 diabetes		Total lifetime health costs saved*
	Cases Averted	Life-time health cost savings*	Cases Averted	Life-time health cost savings*	Cases Averted	Life-time health cost savings*	
Purath *et al.* (2004)	15.86	£384,944	0.95	£12,620	4.27	£144,380	**£541,944**
Chyou *et al.* (2006)	7.83	£189,948	3.02	£126,072	2.39	£51,528	**£367,547**
Aittasalo *et al.* (2004)	9.10	£220,870	4.91	£150,358	3.90	£57,348	**£428,576**