



OPEN ACCESS

Are brief interventions to increase physical activity cost-effective? A systematic review

Vijay GC,¹ Edward CF Wilson,^{1,2} Marc Suhrcke,^{1,3,4} Wendy Hardeman,⁵ Stephen Sutton,⁵ on behalf of the VBI Programme Team

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/bjsports-2015-094655>).

¹Health Economics Group, Norwich Medical School, University of East Anglia, Norwich Research Park, Norwich, UK

²Cambridge Centre for Health Services Research, Institute of Public Health, University of Cambridge School of Clinical Medicine, Cambridge, UK

³UKCRC Centre for Diet and Activity Research (CEDAR), University of Cambridge School of Clinical Medicine, Cambridge, UK

⁴Centre for Health Economics, University of York, York, UK

⁵Behavioural Science Group, Primary Care Unit, Institute of Public Health, University of Cambridge School of Clinical Medicine, Cambridge, UK

Correspondence to

Vijay GC, Health Economics Group, Norwich Medical School, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK; vijay.gc@uea.ac.uk

Accepted 27 July 2015

ABSTRACT

Objective To determine whether brief interventions promoting physical activity are cost-effective in primary care or community settings.

Design Systematic review of economic evaluations.

Methods and data sources We searched MEDLINE, EMBASE, PsycINFO, CINAHL, EconLit, SPORTDiscus, PEDro, the Cochrane library, National Health Service Economic Evaluation Database and the Cost-Effectiveness Analysis Registry up to 20 August 2014. Web of Knowledge was used for cross-reference search. We included studies investigating the cost-effectiveness of brief interventions, as defined by National Institute for Health and Care Excellence, promoting physical activity in primary care or the community. Methodological quality was assessed using Drummond's checklist for economic evaluations. Data were extracted from individual studies fulfilling selection criteria using a standardised pro forma. Comparisons of cost-effectiveness and cost-utility ratios were made between studies.

Results Of 1840 identified publications, 13 studies fulfilled the inclusion criteria describing 14 brief interventions. Studies varied widely in the methods used, such as the perspective of economic analysis, intervention effects and outcome measures. The incremental cost of moving an inactive person to an active state, estimated for eight studies, ranged from £96 to £986. The cost-utility was estimated in nine studies compared with usual care and varied from £57 to £14 002 per quality-adjusted life year; dominant to £6500 per disability-adjusted life year; and £15 873 per life years gained.

Conclusions Brief interventions promoting physical activity in primary care and the community are likely to be inexpensive compared with usual care. Given the commonly accepted thresholds, they appear to be cost-effective on the whole, although there is notable variation between studies.

Physical inactivity leads to an increased risk of developing over 20 health conditions, including coronary heart disease (CHD), cancer, type 2 diabetes and stroke.^{1 2} In developed countries, these diseases and conditions attributable to physical inactivity account for 1.5–3% of total direct healthcare costs.³ In 2006–2007, the direct costs to the UK National Health Service (NHS) from treating the consequences of physical inactivity were estimated to be £0.9 billion.⁴ Physical activity not only improves physical health but also contributes to mental well-being.⁵ Incorporation of physical activity into individual lifestyles is known to lead to health benefits such as reduced risk of CHD, stroke and type 2 diabetes and the risk of premature death.^{6 7}

In recent years, there has been substantial emphasis on efforts to promote physical activity along the continuum of individual-level and population-based interventions.⁸ The UK's Chief Medical Officers recommend that adults undertake at least 150 min of moderate-intensity activity each week.⁹ Despite the well-reported health and economic benefits of physical activity, results from the 2008 Health Survey for England, using self-reported measures, showed that only 39% of men and 29% of women achieved the recommended levels,¹⁰ a situation that had not improved by the time of the 2012 survey.¹¹

This led to a substantial policy interest to raise the overall physical activity in the general population.¹² A wide range of interventions increase physical activity across the life course.^{13 14} The National Institute for Health and Care Excellence (NICE) has published multiple pieces of guidance on physical activity promotion. In 2006, NICE published a guideline on four commonly used methods to increase physical activity (brief interventions in primary care, exercise referral schemes, pedometers and community-based exercise programmes for walking and cycling)¹⁵ supported by an economic analysis.¹⁶ More recently, NICE produced specific guidance on approaches to increase walking and cycling,¹⁷ and updated guidance on brief advice for adults in primary care¹⁸ and exercise referral schemes.¹⁹

There is an enthusiasm within government at national and local levels to support a wide variety of initiatives to promote physical activity, and reap the health, social and economic benefits.¹² In times of particular budgetary restraint, there is an obvious need to look for low-cost initiatives. Brief interventions may be such a solution as they require less resources compared with more intensive interventions. Although they may have a small effect on an individual's behaviour, if sustained they could potentially have a significant population health impact.¹⁶

Current intervention strategies based in primary care or the community have provided the evidence that they can effectively increase physical activity.^{20–22} Moreover, recent systematic reviews and meta-analyses of randomised and non-randomised trials have shown that physical activity interventions such as brief advice, exercise on prescription and physician counselling significantly increase physical activity behaviour and fitness in the longer term.^{23 24}

Although brief interventions are effective in promoting physical activity, for policymakers and health funders it is necessary to know whether they

To cite: GC V, Wilson ECF, Suhrcke M, et al. *Br J Sports Med* Published Online First: [please include Day Month Year] doi:10.1136/bjsports-2015-094655

are cost-effective to set priorities and allocate finite public funds. Previous reviews of economic evaluations of physical activity interventions suggest that most of the current intervention strategies are cost-effective.^{25–28} However, these reviews evaluated the cost-effectiveness of physical activity in general, included intensive interventions such as supervised exercise sessions, workplace interventions and only covered the literature to 2010. In addition, the lack of economic evidence for brief interventions in physical activity has been recognised.^{29–30} Thus, we tailored our search to a specific question, that is, ‘What do we currently know about the cost-effectiveness of brief interventions delivered in primary care or community settings to increase physical activity?’

METHODS

Definitions

For the purpose of this review, we used the NICE definition of brief interventions:¹⁵ “Brief interventions involve opportunistic advice, discussion, negotiation or encouragement. They are commonly used in many areas of health promotion, and are delivered by a range of primary and community care professionals. The interventions vary from basic advice to more extended, individually-focused attempts to identify and change factors that influence activity levels”. Brief interventions are typically conducted in face-to-face sessions with or without the addition of written materials, ranging from a single session of short duration (5–30 min) to multiple brief sessions or follow-ups.³¹

Data sources

We searched for articles published up to 20 August 2014 using the electronic databases MEDLINE, EMBASE, PsycINFO, CINAHL, EconLit, SPORTDiscus, Physiotherapy Evidence Database (PEDro), the Cochrane library, the NHS Economic Evaluation Database and the Tufts Cost-Effectiveness Analysis (CEA) Registry. In addition, the references of retrieved articles were examined manually after reviewing the title and abstracts to identify any economic studies alongside clinical trials and other pertinent studies. A cross-reference search was done using Web of Knowledge, and free text searching was performed using Google scholar. The search consisted of keywords and MeSH terms related to physical activity, exercise or fitness, brief or minimal intervention, and economic or cost analysis and was limited to the English language. Details of the search strategy used are described in online supplementary appendix 1.

Study selection

Studies were eligible for inclusion if they met the following three criteria:

1. Type of study—economic analyses alongside randomised controlled trials (RCTs) or non-experimental designs, or modelling studies of physical activity interventions which were based in either primary care or the community. Comparators could include usual care or other interventions.
2. Type of intervention—(a) interventions involving verbal advice, encouragement, negotiation or discussion, delivered face-to-face in a single session or multiple brief sessions, with or without additional non-face-to-face contacts (eg, leaflets or phone calls) or (b) interventions that were reported as ‘brief’ or ‘minimal’, and aimed to increase physical activity or fitness levels (or both) at the individual level (ie, brief interventions delivered to individuals or groups). Interventions were included if they were either the primary focus of the study or one of the comparator interventions,

because physical activity interventions are often used in conjunction with or compared to other types of interventions (such as combined physical activity and dietary advice) for their physical well-being benefits.

3. Study populations—inactive adults aged 16 years or over. We excluded interventions where study populations were targeted or selected on the basis of pre-existing disease conditions (eg, osteoarthritis) because these populations require specialised interventions.

Data extraction and analysis

Initial screening of titles and abstracts against inclusion criteria was undertaken by one researcher (VGC) and potentially relevant articles were retrieved. Abstracted data were double checked by a second researcher (EW) and, if necessary, amendments were made after discussion. If there was insufficient information in the article on cost-effectiveness, we contacted the corresponding author. Included studies were assessed for methodological quality using Drummond’s checklist³² for assessing economic evaluations. The checklist considers the following aspects: study question, selection of alternatives, form of economic evaluation, data collection (effectiveness data), benefit measurement and valuation, costing, modelling, allowance for uncertainty and presentation of results (table 1). On the basis of the number of Drummond’s checklist criteria met, a rating of ‘high’ (9–10), ‘good’ (7–8), ‘fair’ (5–6) or ‘poor’ (1–4) was assigned.

We used a standardised pro forma to extract data from full texts on the type of economic analysis and perspective, interventions and comparison, participants, follow-up duration, outcome and cost-effectiveness results. To compare the economic results of the individual studies, we converted all costs to 2011 pounds sterling (£) by applying the gross domestic product deflator index (GDP values) and purchasing power parities conversion rates using the Campbell & Cochrane Economics Methods Group (CCEMG)-Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre) Cost Converter (V1.4).^{33–34} Cost-effectiveness results were grouped into those reporting intermediate outcomes such as the incremental cost of moving one inactive adult to an active category (ie, meeting the physical activity recommendations)⁹ and those reporting final outcomes such as the incremental cost per incremental quality-adjusted life year (QALY) gained, disability-adjusted life year (DALY) averted or life years gained (LYG).

RESULTS

Literature search

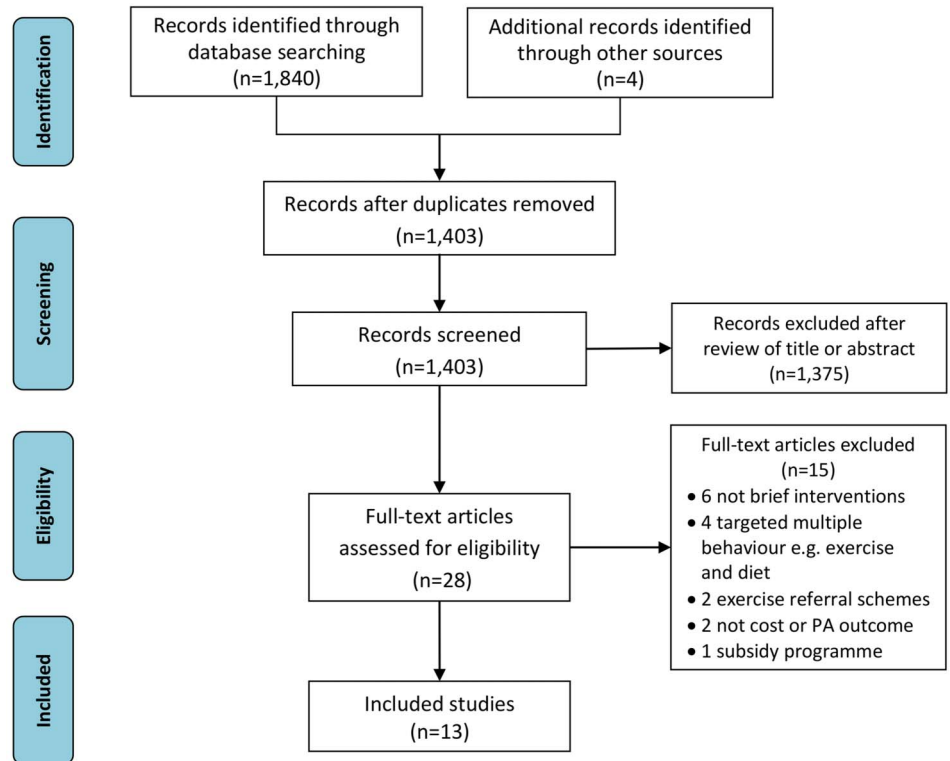
The search identified 1840 potentially relevant articles. An additional four articles were identified through reference lists and grey literature search. Following the removal of duplicates and the review of titles and abstracts, we assessed the full text of 28 articles. Thirteen met the inclusion criteria and were included in the review (figure 1). Five studies originated from the UK (one of them in Scotland),^{35–39} four from New Zealand,^{40–43} two from Australia,^{44–45} and one each from Sweden⁴⁶ and the Netherlands.⁴⁷

Of the 15 excluded studies, six reported more intensive interventions and/or did not include a face-to-face component (eg, supervised exercise sessions, mail or telephone contact);^{48–53} four included a combined intervention targeting multiple behaviours (eg, physical activity and diet);^{54–57} two were exercise referral schemes (referral to a physical activity specialist or service);^{58–59} two did not report a physical activity or cost-effectiveness outcome^{60–61} and one study evaluated the

Table 1 Critical appraisal of included economic papers using Drummond *et al*'s³² checklist

Study	Well-defined question posed in answerable form	Comprehensive description of the competing alternatives given	Effectiveness of the programme or service established	All important and relevant costs and consequences for each alternative identified	Costs and consequences measured accurately in appropriate physical units	Cost and consequences valued credibly	Costs and consequences adjusted for differential timing	Incremental analysis of costs and consequences of alternatives performed	Allowance made for uncertainty in the estimates of cost and consequences	Presentation and discussion of study results included all issues of concerns to users
Anokye <i>et al</i> ³⁵	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes, probabilistic sensitivity analysis	Yes
Boehler <i>et al</i> ³⁶	Yes	Yes	Yes	Yes	Yes	Yes	Not relevant	Yes	Yes, probabilistic sensitivity analysis	Yes
Cobiac <i>et al</i> ⁴⁴	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes, probabilistic sensitivity analysis	Yes
Dalziel <i>et al</i> ⁴⁰	Yes	Yes	Yes	Only included programme costs—cost of downstream events not included eg, CVD, diabetes	Yes	Not all sources cited (eg, source for overhead costs)	Yes	Yes	Yes, probabilistic sensitivity analysis	Yes
Elley <i>et al</i> ⁴²	Yes	Yes	Yes	Yes	Yes	Not all sources cited (eg, source for overhead costs)	Yes	Yes but excluded lost productivity from calculation (reason given by authors)	Yes, one way sensitivity analysis	Yes
Elley <i>et al</i> ⁴¹	Yes	Yes	Yes	Yes	Yes	Yes	Mostly; second year costs not discounted	Yes	Yes, one way sensitivity analysis and hypothesis test but of geometric means	Yes
Gulliford <i>et al</i> ³⁷	Yes	Insufficient detail	Yes	Yes	Yes	Insufficient detail	Yes	Yes	Yes, probabilistic sensitivity analysis	Yes
Leung <i>et al</i> ⁴³	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes, probabilistic sensitivity analysis	Yes
Lindgren <i>et al</i> ⁴⁶	Yes	Yes but hypothetical intervention	Yes	Yes	Yes	Authors state time and travel costs not included	Yes	Yes	Probabilistic sensitivity analysis and scenario analysis	Yes
Over <i>et al</i> ⁴⁷	Yes	Yes	Yes	Insufficient detail	Insufficient detail	Not all sources cited (cost, utility)	Yes	Yes	Yes, probabilistic sensitive analysis	Yes
Pringle <i>et al</i> ³⁸	Yes	Unclear if usual practice and all the relevant comparators included, although full details provided in referenced sources	Insufficient detail about source of study	Out-of-pocket expenditure excluded	Yes	Yes	Yes	Yes	Yes, one way sensitivity analysis	Minimal information about economic model and sensitivity analysis, although references to more details are provided
Shaw <i>et al</i> ³⁹	Yes	Yes	Yes	Restricted to intervention costs	Yes	Sources cited but not clear which relates to which unit cost	Not applicable to within-trial analysis, threshold analysis for £/QALY does not appear to take discounting into account	Yes	Mentioned but not described in detail	Discussion limited by broad scope of the paper (qualitative and economic analysis in one paper)
Sims <i>et al</i> ⁴⁵	Yes	Yes	Yes	Yes	Yes	Not all sources cited	Not clearly mentioned	Yes	Yes, univariate sensitivity analysis	Yes but not in detail

CVD, cardiovascular disease; QALY, quality-adjusted life year.

Figure 1 PRISMA flow diagram of study selection.

cost-effectiveness of a subsidy programme for general practitioner (GP) involvement in physical activity.⁶²

Characteristics of included studies

Across the 13 studies, 30 intervention strategies or scenarios were evaluated, of which 14 met the definition of brief interventions. These were grouped into: brief exercise advice, exercise on prescription, pedometers and motivational interventions (table 2).

Four studies performed economic evaluation alongside controlled trials,^{39 41–43} and two were based on quasi-experimental designs.^{36 38} Seven studies performed economic modelling using data from a single trial,^{40 44 46} a meta-analysis of RCTs,^{37 44 47} a systematic review of randomised and observational studies,³⁵ or a cross-sectional and observational study.⁴⁵ Four studies reported intermediate outcomes in terms of the cost of making one additional inactive person active;^{36 39 41 42} five reported final outcomes in terms of incremental cost per DALY⁴⁴ or QALY^{40 47} or LYG⁴⁶ or incremental net health benefit (NHB)³⁷ and four reported both intermediate and cost-utility outcomes.^{35 38 43 45}

The 13 studies that met the inclusion criteria are described in table 3. The follow-up of RCTs ranged from 12 months to 2 years. One study had a short follow-up (3 months).³⁶ Nine

studies were of good or high quality. Modelling studies adopted a lifetime horizon. The measurement of physical activity was different across studies. The studies reporting a time-based outcome used a target of $\geq 5 \times 30$ min/week of moderate or ≥ 60 min/week of vigorous-intensity activity. In pedometer-based interventions, a common threshold measure used was $\geq 10\,000$ steps/day except for one study³⁹ which used a target of a weekly increase of $\geq 15\,000$ steps. Six studies^{36 39–42 45} reported the duration of brief interventions (face-to-face), which lasted from 4 to 30 min. Most (10) of the included studies evaluated each intervention in comparison with usual care or current practice, which approximates a ‘do nothing’ scenario.

Studies reporting intermediate outcomes

The cost of converting one inactive adult to an ‘active’ category was estimated for eight studies and ranged from £96 to £986 (figure 2). An ‘active script programme’ (an organised approach to exercise counselling by GPs) evaluated by Sims *et al*⁴⁵ appeared to be the most cost-effective of the interventions considered (£96 per additional active participant compared with usual care). Boehler *et al*³⁶ evaluated the cost-effectiveness of two recruitment strategies for the delivery of brief exercise advice (disease register screening vs opportunistic patient

Table 2 Overview of interventions

Interventions	Number	Short description	Source of effectiveness data	References
Exercise advice	5	Brief exercise advice or counselling by a GP or trained health professionals	CS, MA, OS, RCT	35–37, 45, 46
Exercise on prescription	4	Verbal and written physical activity advice by a GP or practice nurse	MA, RCT	40–42, 44
Pedometers	4	Pedometer-based physical activity counselling with a step-related goal or walking programme	MA, RCT	39, 43, 44, 47
Motivational interventions	1	Motivational interviews to increase physical activity	Pre–post intervention	38

CS, cross-sectional population surveys; GP, general practitioner; MA, meta-analysis of RCTs; OS, observational study; RCT, randomised controlled trial.

Table 3 Characteristics of included studies

Study, setting, quality	Objective; economic perspective, cost year	Study type; economic analysis type	Interventions compared	Participants	Follow-up duration	Definition of physically active person	Mean time to deliver intervention per person	Outcome	
								Cost of converting to an 'active category' (£ at the time of the study) (£ inflated to 2011)	ICER (£ at the time of the study) (£ inflated to 2011)
Anokye <i>et al</i> , ³⁵ UK, good	Brief exercise advice in primary care; healthcare (NHS), 2010/2011	Economic modelling; CUA	I: brief advice C: usual care (no active intervention)	Cohort of 100 000 physically inactive but healthy adults aged ≥33 years	Modelled for lifetime	150 min of MPA or 75 min of VPA per week	Not mentioned	£136 (brief advice compared with usual care)	£1730/QALY gained
Boehler <i>et al</i> , ³⁶ UK, fair	PA promotion in primary care; health service (NHS), 2007	PA care pathway pilot-based regression model; CEA	Brief exercise comparing 2 recruitment strategies: I1: patients recruited opportunistically I2: patients on the hypertension disease register 'disease register sites'	Insufficiently active, 16–74 years	3 months	150 min of MPA per week	I1: 4 min I2: 18 min Total across intervention: I1: 28 min I2: 76 min	£886.50 (£986) disease register vs opportunistic recruitment	
Cobiac <i>et al</i> , ⁴⁴ Australia, high	PA promotion in community; health sector, 2003	Economic modelling study; CUA	I1: GP prescription—exercise prescription with follow-up phone call I2: GP referral for PA counselling to an exercise physiologist I3: mass media I4: TravelSmart (active transport) I5: pedometer I6: internet advice C: do nothing	I1: 40–79 years old less active patients I2: 60+ years sedentary I3: 25–60 years I4: 18+ years I5: 15+ years I6: 15+ years	Modelled for lifetime	150 min of moderate intensity of 5 METs per week	Not mentioned		I1: \$A11 000 (£5374) (£6500) per DALY I2: \$A75 000 (£36 638) (£44 315) per DALY I3: dominant I4: \$A 18 000 (£8793) (£10 636) per DALY I5: dominant I6: \$A2000 (£977) (£1182) per DALY when compared with 'do nothing' NZD 2053 (£865) (£1104) per QALY (lifetime)
Dalziel <i>et al</i> , ⁴⁰ New Zealand, high	Primary care-based exercise counselling/prescription; health system, 2001	RCT-based economic modelling; CUA	I: green prescription C: usual care (no additional exercise advice)	Less active participants; 40–79 years I: 451 C: 427	Modelled over full life expectancy	5×30 min of MPA or VPA per week	7 min (GP); 13 min (practice nurse)		
Elley <i>et al</i> , ⁴² New Zealand, high	Primary care exercise counselling/prescription; health funder's and societal, 2001	RCT; CEA	I: green prescription (brief oral or written advice) by a GP or practice nurse with telephone exercise specialist follow-up C: usual care (do nothing)	40–79 years old less active patients in general practice I: 451 C: 427	12 months	150 min/week	7 min (GP); 13 min (nurse)	NZD 1756 (£740) (£938)	
Elley <i>et al</i> , ⁴¹ New Zealand, high	Primary care exercise counselling/prescription with ongoing support; Societal, 2008	RCT; CEA	I: enhanced green prescription (nurse-delivered brief advice and a written exercise prescription, counselling in primary care with telephone follow-up) C: usual care (do nothing)	Physically inactive women aged 40–74 years I: 544 C: 545	24 months	150 min/week of at least MPA	10 min brief advice and a written prescription	NZD 687 (£285) (£308) sustained at 12 months; NZD 1407 (£584) (£630) sustained at 24 months	
	Universal strategy to promote PA in primary	Economic modelling; CUA	I: brief GP advice in primary care C: standard care (do nothing)	262 704 healthy participants aged	Modelled for lifetime		Not mentioned		Net health benefit of 3.2 QALYs per 1000

Continued

Table 3 Continued

Study, setting, quality	Objective; economic perspective, cost year	Study type; economic analysis type	Interventions compared	Participants	Follow-up duration	Definition of physically active person	Mean time to deliver intervention per person	Outcome	
								Cost of converting to an 'active category' (£ at the time of the study) (£ inflated to 2011)	ICER (£ at the time of the study) (£ inflated to 2011)
Gulliford <i>et al</i> , ³⁷ UK, good	care; healthcare service, 2010			30–100 years from GPRD		150 min of moderate PA per week			participants (at a threshold of £30 000/QALY); £13 686 (£14 002)/QALY
Leung <i>et al</i> , ⁴³ New Zealand, High	Pedometer-based exercise advice to increase PA; societal, 2008	RCT; CUA	I1: pedometer-based green prescription I2: standard green prescription (exercise advice & time-related goal)	Healthy inactive adults aged ≥65 years I1: 165 I2: 165	12 months	150 min of at least MPA per week	Not mentioned	\$A667 (£290) (£313)	
Lindgren <i>et al</i> , ⁴⁶ Sweden, good	Dietary and exercise advice; societal and payer's, 2000	RCT-based economic modelling; CEA	I1: dietary advice by dietitians I2: exercise advice by a physician I3: exercise & diet C: usual care (no intervention)	Men aged 35–60 years I1: 40 I2: 39 I3: 39 C: 39	Modelled for lifetime	Regular PA of an aerobic type 2–3 times/week lasting 30–45 min	Not mentioned but included 3 visits to a physician		SEK 180 470 (£12 263) (£15 873) per LYG for exercise compared to no intervention
Over <i>et al</i> , ⁴⁷ Netherlands, good	GP counselling in addition to pedometers to increase PA; healthcare, 2009	Economic modelling; CUA	Two scenarios S1: pedometer use with diary and GP counselling S2: current practice (no additional advice)	Insufficiently active 20–65 years	Modelled for lifetime	150 min of MPA per week	Not mentioned but included 10 min GP counselling		€11 100 (£8401) (£8858) per QALY
Pringle <i>et al</i> , ³⁸ UK, fair	Community-based interventions to increase MPA; NHS, 2003	Alongside single clinical and cost study; CEA, CUA	Seven intervention categories: campaigns, exercise classes, exercise referral, motivational interviews, outdoor activity, peer-mentoring, training of PA leaders	Inactive; 343 young people and 641 adults, particularly those aged 65 years and over	Modelled for lifetime using the Matrix model ¹⁶	150 min of MPA per week	Not mentioned	£260-£1253 (£318-£1531) per completer improving MPA	£47-£229 (£57-£280) per QALY
Shaw <i>et al</i> , ³⁹ Scotland, fair	Pedometer-based walking; health services, 2008	RCT; CEA	I: minimal intervention (walking programme and pedometer) I2: maximal intervention (PA consultation, pedometer and individualised walking programme) C: 'usual behaviour'	18–65 years olds I1: 40 I2: 39	12 months	Weekly increase of ≥15 000 steps	30 min	£92 (£99) (minimal vs control) £591 (£637) (maximal vs minimal)	
Sims <i>et al</i> , ⁴⁵ Australia, fair	Active script in general practice; health service, 1996	Economic modelling; CEA, CUA	I: ASP—improving systematic PA advice by GPs C: routine GP care (no PA advice)	Less active adults aged 20–75 years, 670 GP advising sedentary patients I: 40 258 C: 10 437	Unclear time horizon	150 min of MPA per week	4 min GP consultation	\$A138 (£70) (£96) per patient to become active	\$A3647 (£1838) (£2542) per DALY saved

ASP, Active Script Programme; CEA, cost-effectiveness analysis; CUA, cost-utility analysis; DALY, disability adjusted life year; GP, general practitioner; GPRD, general practice research database; ICER, incremental cost-effectiveness ratio; LYG, life years gained; METs, metabolic equivalents; MPA, moderate-intensity physical activity; NHS, National Health Service (England); NZD, New Zealand Dollar; PA, physical activity; QALY, quality-adjusted life year; RCT, randomised controlled trial; SEK, Swedish krona; VPA, vigorous-intensity physical activity.

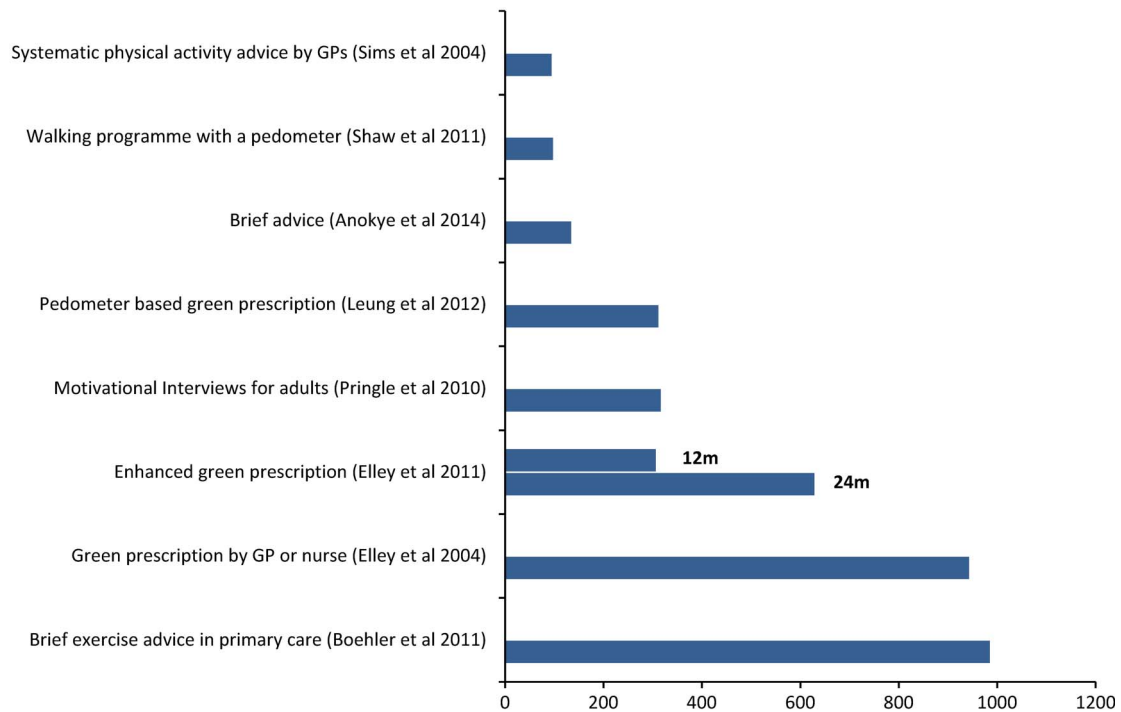


Figure 2 Incremental cost of converting one sedentary adult to an active category (2011 equivalent £ sterling; GP, general practitioner).

recruitment). They reported the incremental cost of converting one inactive adult to an active state as £986 in disease register screening compared to opportunistic screening. Elley *et al*⁴¹ reported the cost-effectiveness of ‘enhanced green prescription’ (nurse delivered exercise counselling and written prescription with telephone follow-up) at both 12 and 24 months postintervention, which showed decreasing cost-effectiveness over time of follow-up (£308 at 12 months vs £630 at 24 months).

Studies reporting final outcomes

Figure 3 summarises the results in terms of incremental cost utility, that is, per QALY or DALY or LYG. Pedometer-based brief interventions appeared likely to yield health gains at a lower cost. Pedometers (either as a motivational tool or in combination with exercise advice) were dominant as they were both cost saving and more effective when compared with usual care⁴⁴ or standard ‘green prescription’ (oral or written exercise advice by a GP or practice nurse with telephone follow-up).⁴³ GP counselling in combination with a pedometer when compared with current practice had a cost-utility of £8858/QALY.⁴⁷

Pringle *et al*³⁸ evaluated the costs and cost-effectiveness of seven broad categories of community-based interventions. Among these, only motivational interviews are relevant to the scope of this review. The analysis was conducted alongside a pre-intervention and post-intervention design and hence no ‘usual care’ or ‘do nothing’ control group was considered. Cobiac *et al*⁴⁴ compared six intervention strategies, each against ‘do nothing’, of which pedometers and exercise on prescription are relevant to this review. They reported that the use of pedometers was more cost-effective than other interventions. Likewise, Lindgren *et al*⁴⁶ modelled the cost utility of three interventions of dietary and exercise advice of which exercise advice by a physician was relevant to this review. The estimated cost utility of exercise advice by a physician was £15 873/LYG when compared with usual care.

The incremental cost-effectiveness ratio (ICER) for exercise advice or exercise on prescription (vs usual care) ranged from

£1104 to £14 002/QALY,^{35 37 40} and from £2542 to £6500/DALY.^{44 45} Motivational interviews had the lowest ICER (£57/QALY).³⁸ In a primary care setting, GP counselling in combination with a pedometer⁴⁷ had a lower cost-effectiveness ratio than a GP’s advice or counselling with written materials³⁷ (£8858 vs £14 002/QALY); both were compared with usual care.

These economic modelling studies used either a multistate life-table modelling approach⁴⁴ or Markov chain^{35 37 46 47} or a decision tree.³⁸ Effectiveness data used in these modelling studies had a follow-up duration of up to 2 years.

DISCUSSION

The studies identified in this review suggest that brief interventions can result in a meaningful increase in physical activity at reasonable costs. When the longer term costs and health benefits are considered, brief interventions are cost-effective compared with the NICE threshold of £20 000–£30 000/QALY gained.

Successful interventions—‘bright spots’

Exercise advice,^{35 45} pedometer-based walking,³⁹ pedometer-based ‘green prescription’⁴³ and motivational interviews³⁸ had similar cost-effectiveness ratios for converting one inactive person to an active state. The ‘active script programme’ evaluated by Sims *et al*⁴⁵ had the lowest cost-effectiveness in terms of cost per additional active person. However, their economic model had rather optimistic assumptions regarding the uptake of physical activity by intervention and control group patients, and the time horizon of the study was not clear. From the reviewed studies, we observed that in the absence of continued contacts, some of the gains in physical activity experienced by participants are likely to be lost over time, resulting in the intervention becoming less cost-effective over a longer time horizon, as was evident in the analysis of ‘enhanced green prescription’.⁴¹

Promoting pedometer use,⁴⁴ pedometer in combination with exercise on prescription,⁴³ motivational interviews,³⁸ GP advice or counselling on exercise^{40 45} and brief advice³⁵ were the most cost-effective intervention strategies with respect to cost utility.

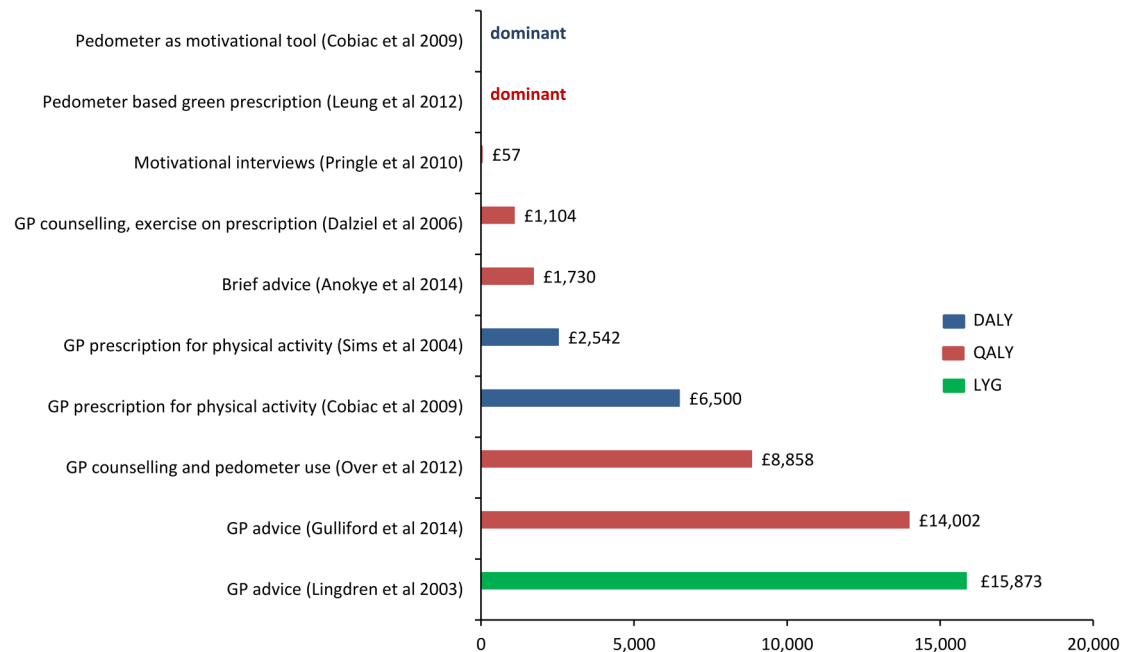


Figure 3 Cost-effectiveness ratios (cost per DALY or QALY or LYG) for different physical activity interventions (2011 equivalent £ sterling; DALY, disability-adjusted life year; GP, general practitioner; LYG, life years gained; QALY, quality-adjusted life year).

Both Leung *et al*⁴³ and Cobiac *et al*⁴⁴ found the cost-effectiveness of their pedometer intervention to be dominant, indicating that the pedometer intervention is more effective and less costly than comparators. However, note that Leung *et al*⁴³ compared pedometer-based ‘green prescription’ with standard ‘green prescription’ rather than with usual care. In contrast, Over *et al*⁴⁷ reported a considerably higher ICER for pedometer intervention compared to current practice (£8858/QALY). Although the effectiveness data for both the Cobiac *et al*⁴⁴ and Over *et al*⁴⁷ studies were based on a meta-analysis by Bravata *et al*,⁶³ the higher possible health gains in Cobiac *et al*⁴⁴ may be a consequence of the much larger proportion of inactive people in the Australian population compared to the Dutch population, and of the reported programme cost per participant being lower in the Australian estimates than in the Over *et al* studies.⁴⁷

Anokye *et al*³⁵ modelled the cost-effectiveness of brief advice in primary care using meta-analysed data, but the underlying primary evidence included both RCTs and non-randomised studies. A primary care nurse delivered ‘enhanced green prescription’⁴¹ had a more favourable ICER than a GP delivered ‘green prescription’⁴² (£308 vs £938 for converting one additional inactive adult to an active state over a 12-month period). The ‘enhanced green prescription’ had a slightly higher proportion of people who increased their activity at 12 months than just ‘green prescription’, which was most likely attributable to the extra telephone support and 6-month face-to-face, nurse-led follow-up. Three studies^{40 42 44} evaluated the cost-effectiveness of ‘green prescription’ using data from a cluster RCT.²⁰ However, they reported different cost outcomes—cost per DALY,⁴⁴ QALY⁴⁰ or the intermediate outcome.⁴²

Some of the modelling studies adopted previously reported economic models. For example, Pringle *et al*’s³⁸ model was informed by the NICE cost-effectiveness model,¹⁶ while Over *et al*⁴⁷ used the Dutch National Institute for Public Health and the Environment (RIVM) Chronic Disease Model to estimate the long-term effects of increase in physical activity. The particular disease states included in a model affect the long-term estimates of cost and health outcome. Lindgren *et al*⁴⁶ included

only CHD conditions in their model while others included multiple conditions (type 2 diabetes, CHD, breast and colorectal cancers and depression).

Methodological issues to take into account

Some of the studies failed to report sources for unit costs, and some potentially relevant costs were being excluded from the analysis. For example, Dalziel *et al*⁴⁰ included only programme costs, but excluded the healthcare cost implications of downstream health events. Similarly, Pringle *et al*³⁸ did not include out-of-pocket expenditures which might be significant and could influence the intervention attendance levels (apart from the cost-effectiveness of the intervention).

The model-based economic evaluations of brief interventions differ mainly in terms of the quality of evidence used, structure and outcome measure. Use of data on the effect of interventions in economic modelling using a systematic review and meta-analysis of RCTs is proposed as the least biased source of data.⁶⁴ LYG is a pure measurement of life expectancy whereas DALYs and QALYs adjust life expectancy for morbidity, using disability and quality-of-life weighting, respectively.^{65 66} The ICERs for both QALY and DALY outcomes varied between studies—primary care-based exercise advice evaluated by Dalziel *et al*⁴⁰ had a lower cost utility (£1104/QALY) than Gulliford *et al*’s³⁷ study (£14 002/QALY). Gulliford *et al*³⁷ used effectiveness data from a recent systematic review and meta-analysis of RCTs²³ and evaluated two scenarios of universal strategy to promote physical activity. Their model was more comprehensive than Dalziel *et al*’s⁴⁰ model in terms of inclusion of disease conditions (16 single disease or multi-disease states), model structure and intervention effects.

Sensitivity analysis

Eight studies included in this review^{35–37 40 43 44 46 47} properly characterised decision uncertainty by using probabilistic sensitivity analysis while the remaining studies used scenario-based or one-way sensitivity analysis. Four studies^{39 41–43} were based on ‘piggybacked’ economic evaluations conducted alongside

rigorous RCTs. These provide a source of evidence on resource use and health effects from well-designed studies with high internal validity. However, they are often constrained in terms of the range of outcome data collected or the length of follow-up, introducing difficulties in extrapolating the intervention effectiveness beyond the trial period.⁶⁷ For example, the assumptions around the maintenance of physical activity levels beyond brief interventions determine how cost-effective the intervention is. In addition, it should be recognised that economic analysis in three studies^{36 38 45} was based on evidence from non-experimental studies or theoretical scenarios.

Comparison with previous reviews

Three previous economic reviews of physical activity interventions were identified. A recent systematic review commissioned by NICE²⁹ reported that brief advice in primary care was cost-effective (when usual care was used as the benchmark). However, the evidence was limited to three studies. Garrett *et al*²⁸ reviewed the cost-effectiveness of physical activity interventions in primary care and the community, and included 13 RCTs. The review also included intensive interventions but did not include modelling studies. They reported that most interventions were cost-effective, especially where direct supervision or instruction was not required. The cost-effectiveness ratios for moving one inactive person to an active stage at 12 months varied from £262 to £3144, and the cost-utility estimated in nine studies varied from £276 to £68 798/QALY gained (2011 prices). Another review by Muller-Riemenschneide *et al*²⁵ included eight studies (6 RCTs, 1 cross-sectional and 1 economic modelling) covering a broad range of interventions promoting physical activity. The review concluded that behavioural interventions targeting sedentary healthy adults can achieve the recommended level of physical activity at a cost of £662 per participant over a 12-month period (2011 prices). However, their review included workplace-based physical activity and environmental interventions.

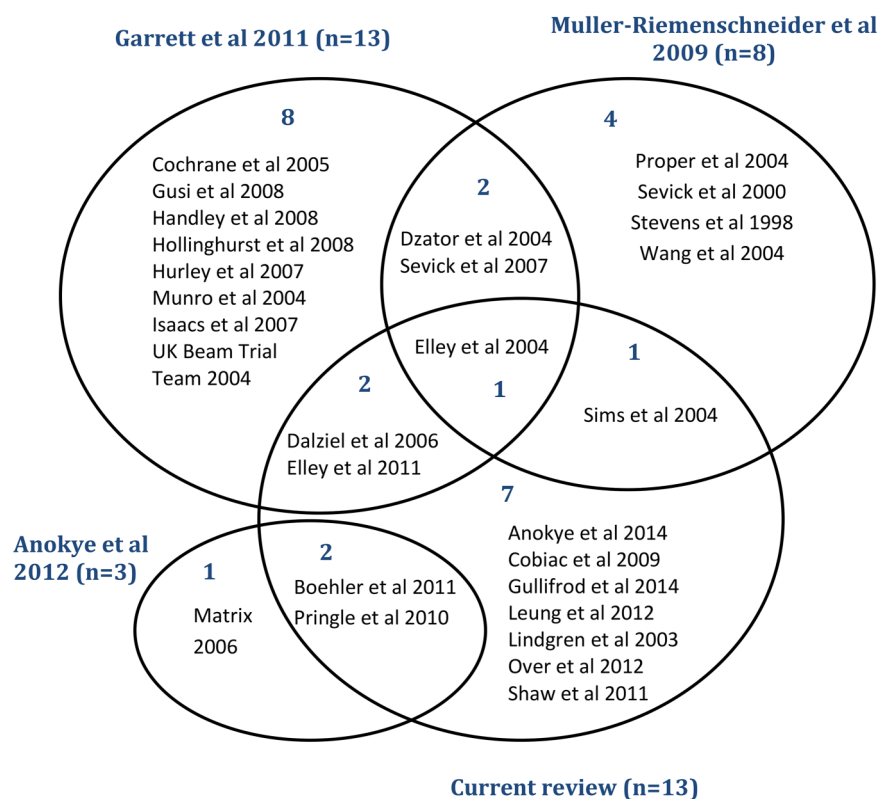
These reviews either considered the cost-effectiveness of physical activity interventions in general and were not specific to brief interventions^{25 28} or did not include other kinds of brief interventions for physical activity (eg, pedometer-based interventions).²⁹ Although six studies included in our review were also included in the previous reviews (figure 4), we include seven additional studies and looked specifically at the cost-effectiveness of brief interventions promoting physical activity in the general population.

Strengths and limitations of the review

To the best of our knowledge, this is the most comprehensive economic review to date of brief interventions for physical activity. We assessed the efficiency of brief interventions in terms of cost-effectiveness ratios, and report both intermediate (ie, incremental cost of converting one inactive adult to an active category) and final outcomes (cost per DALY or QALY or LYG). The current review includes both economic evaluations alongside RCTs and economic modelling, summarising the results of economic evaluation studies of brief interventions in primary care and community settings.

In general, the assessment of the cost-effectiveness of different brief interventions was challenging. They vary widely in terms of the methodology used in their cost-effectiveness or cost-utility analyses, including the perspective of the economic analysis, and the discounting of future values of cost and health outcomes. The reviewed modelling studies have their own limitations: the assumptions underlying the models can differ considerably, for instance, as regards the assumptions on the proportion of people becoming active as a result of the brief intervention, outcome measures and on the decay in intervention effect over time. Such methodological differences between the studies as well as other context characteristics (eg, the variability in funding mechanism, health system and cost structures) limit the generalisability of the cost-effectiveness results across

Figure 4 Venn diagram showing overlap of studies with previous reviews.



Review

different settings.⁶⁸ In addition, some of the studies included in this analysis lack intervention details, for example, time duration and/or delivery method (eg, type of provider and individual vs group delivery), making it difficult to determine whether or not the interventions were truly 'brief interventions' according to the NICE definition. It is important to describe interventions in sufficient detail,⁶⁹ such as the duration of 'brief interventions', as it affects cost-effectiveness. In this review, we included brief physical activity interventions that had at least one (initial) face-to-face contact and acknowledge that there is a need for economic reviews of non-face-to-face physical activity interventions which constitute a fast growing research area.

It would be more appropriate to compare each intervention in an iterative manner taking an account of dominance and extended dominance to determine the most cost-effective intervention.⁷⁰ The interventions included in this review were typically compared with a usual care (do nothing) intervention that compromises the ability to rank interventions. What is required in order to make this comparison is a single framework (ie, decision analytic model) to transform the short-term costs and intermediate ('disease specific') outcomes into longer term final outcomes (namely QALYs), in order both to identify the most cost-effective intervention strategy and to quantify the associated decision uncertainty.

Summary

Brief interventions delivered at the individual level by a GP, practice nurse or other healthcare professional can increase physical activity in healthy inactive adults at a reasonable cost to convert one inactive adult to being 'active'. Our findings suggest that it is possible to deliver a brief intervention for less than £15 000/QALY gained. On the basis of the cost-utility analysis, the use of pedometers and motivational interviews had the lowest cost-effectiveness ratio. Heterogeneity in interventions, study participants and study design compromises the comparability of the results across studies. It is thus difficult to rank and prioritise intervention strategies based on cost-effectiveness ratios, though most of these interventions are considered cost-effective when measured against the current NICE threshold of £20 000–£30 000/QALY.⁷¹

We conclude that brief interventions are likely to be inexpensive, but we have limited knowledge on the longer term costs and consequences of these interventions.³⁰ Thus, economic modelling from studies with a longer follow-up will improve estimates of the longer term costs and consequences of brief

interventions for physical activity in primary care or community settings.

Twitter Follow Ed Wilson at @edcfwilson

Acknowledgements The authors would like to thank Dr Dan Mason and Ms Laura Lamming for their comments on the initial version of this manuscript, and the author(s) of studies included in our review who responded to requests for clarification or further information about study data. This study was conducted on behalf of the Very Brief Interventions Programme team (see <http://www.phpc.cam.ac.uk/pcu/research/research-projects-list/vbi/vbi-research-team> for team members).

Contributors EW and VGC contributed to the design of the review. VGC executed the search strategy with inputs from EW and MS, reviewed the references found, assessed studies for inclusion, appraised and extracted the data from each of the included studies, and also performed the analysis and prepared the first draft. EW double checked the extracted data for the included studies. EW, MS, SS and WH provided critical comments on quality assessment and data analysis. All authors contributed to the critical revision of the manuscript and approved the final version of the manuscript.

Funding EW is funded by the NIHR Cambridge Biomedical Research Centre. This paper presents independent research funded by the National Institute for Health Research (NIHR) under its Programme Grants for Applied Research Programme (Grant Reference Number RP-PG-0608-10079). The views expressed are those of the author (s) and not necessarily those of the NHS, the NIHR or the Department of Health. The funder had no role in study design, data collection, data analysis, data interpretation, the writing of the manuscript, and decision to submit the manuscript for publication.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

REFERENCES

- 1 World Health Organization. *Global health risks: mortality and burden of disease attributable to selected major risks*. Geneva: World Health Organization, 2009.
- 2 Waxman A. WHO global strategy on diet, physical activity and health. *Food Nutr Bull* 2004;25:292–302.
- 3 Oldridge NB. Economic burden of physical inactivity: healthcare costs associated with cardiovascular disease. *Eur J Cardiovasc Prev Rehabil* 2008;15:130–9.
- 4 Scarborough P, Bhatnagar P, Wickramasinghe KK, et al. The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs. *J Public Health (Oxf)* 2011;33:527–35.
- 5 Khan KM, Thompson AM, Blair SN, et al. Sport and exercise as contributors to the health of nations. *Lancet* 2012;380:59–64.
- 6 Department of Health. *At least five a week: evidence on the impact of physical activity and its relationship with health. A report from the Chief Medical Officer*. London: Department of Health, 2004.
- 7 Craig R, Hirani V, eds. *Health Survey for England 2009*. London: The NHS Information Centre for Health and Social Care, 2010.
- 8 Hillsdon M, Foster C, Thorogood M. Interventions for promoting physical activity. *Cochrane Database Syst Rev* 2005;(1):CD003180.
- 9 Department of Health. *Start active, stay active: a report on physical activity from the four home countries' Chief Medical Officers*. Department of Health, 2011.
- 10 Roth M. Self-reported physical activity in adults. In: Craig R, Mindell J, Hirani V, eds. *Health Survey for England 2008. Volume 1: physical activity and fitness*. Leeds: The NHS Information Centre, 2009:21–58.
- 11 Scholes S, Mindell J. Physical activity in adults. Chapter 2. In: Craig R, Mindell J, eds. *Health Survey for England 2012: health, social care and lifestyles*. Leeds: Health and Social Care Information Centre, 2013. <http://www.hscic.gov.uk/catalogue/PUB13218/HSE2012-Ch2-Phys-act-adults.pdf>
- 12 Department of Health. *Healthy lives, healthy people: our strategy for public health in England*. London: The Stationery Office (Great Britain), 2010.
- 13 Kahn EB, Ramsey LT, Brownson RC, et al. The effectiveness of interventions to increase physical activity. A systematic review. *Am J Prev Med* 2002;22:73–107.
- 14 Muller-Riemenschneider F, Reinhold T, Nocon M, et al. Long-term effectiveness of interventions promoting physical activity: a systematic review. *Prev Med* 2008;47:354–68.
- 15 National Institute for Health and Clinical Excellence. *Four commonly used methods to increase physical activity: brief interventions in primary care, exercise referral schemes, pedometers and community-based exercise programmes for walking and cycling*. Public Health Intervention Guidance No 2. London: National Institute for Health and Clinical Excellence, 2006.

What is already known on this topic

Brief interventions for physical activity in primary care or community settings are considered to be effective in increasing individuals' physical activity. However, the evidence on the cost-effectiveness of such interventions is sparse.

What this study adds

Some brief interventions increase individuals' physical activity at reasonable costs and are cost-effective, given commonly accepted thresholds. An economic evaluation of brief interventions with a longer follow-up will improve the estimates of the longer term costs and benefits of physical activity.

- 16 Matrix Research and Consultancy. *Modelling the cost effectiveness of physical activity interventions*. London: Matrix Research and Consultancy, 2006.
- 17 National Institute for Health and Clinical Excellence. *Walking and cycling: local measures to promote walking and cycling as forms of travel or recreation. NICE public health guidance 41*. London: National Institute for Health and Clinical Excellence, 2012.
- 18 National Institute for Health and Care Excellence. *Physical activity: brief advice for adults in primary care*. London: NICE, May 2013.
- 19 National Institute for Health and Care Excellence. *Exercise referral schemes to promote physical activity*. London: NICE, September 2014.
- 20 Elley CR, Kerse N, Arroll B, *et al*. Effectiveness of counselling patients on physical activity in general practice: cluster randomised controlled trial. *BMJ* 2003;326:793.
- 21 Swinburn BA, Walter LG, Arroll B, *et al*. The green prescription study: a randomized controlled trial of written exercise advice provided by general practitioners. *Am J Public Health* 1998;88:288–91.
- 22 Lawton BA, Rose SB, Elley CR, *et al*. Exercise on prescription for women aged 40–74 recruited through primary care: two year randomised controlled trial. *BMJ* 2008;337:a2509.
- 23 Orrow G, Kinmonth AL, Sanderson S, *et al*. Effectiveness of physical activity promotion based in primary care: systematic review and meta-analysis of randomised controlled trials. *BMJ* 2012;344:e1389.
- 24 Campbell F, Blank L, Messina J, *et al*. *National Institute for Health and Clinical Excellence (NICE) public health intervention guidance physical activity: brief advice for adults in primary care. Review of effectiveness evidence*. London: NICE, 2012.
- 25 Muller-Riemenschneider F, Reinhold T, Willich SN. Cost-effectiveness of interventions promoting physical activity. *Br J Sports Med* 2009;43:70–6.
- 26 Gordon L, Graves N, Hawkes A, *et al*. A review of the cost-effectiveness of face-to-face behavioural interventions for smoking, physical activity, diet and alcohol. *Chronic Illn* 2007;3:101–29.
- 27 Zheng H, Ehrlich F, Amin J. Economic evaluation of the direct healthcare cost savings resulting from the use of walking interventions to prevent coronary heart disease in Australia. *Int J Health Care Finance Econ* 2010;10:187–201.
- 28 Garrett S, Elley CR, Rose SB, *et al*. Are physical activity interventions in primary care and the community cost-effective? A systematic review of the evidence. *Br J Gen Pract* 2011;61:e125–133.
- 29 Anokye N, Jones T, Fox-Rushby J. National Institute for Health and Clinical Excellence Public Health Intervention Guidance Physical activity—brief advice for adults in primary care: economic analysis. Review of economic evidence. London: NICE, 2012.
- 30 Davis JC, Verhagen E, Bryan S, *et al*. 2014 consensus statement from the first Economics of Physical Inactivity Consensus (EPIC) conference (Vancouver). *Br J Sports Med* 2014;48:947–51.
- 31 West D, Saffin K. *Literature review: brief interventions and childhood obesity*. North West and London Teaching Public Health Networks, June 2008.
- 32 Drummond MF, Sculpher MJ, Torrance GW, *et al*. *Methods for the economic evaluation of health care programmes*. Oxford: Oxford University Press, 2005.
- 33 Shemilt I, Thomas J, Morciano M. A web-based tool for adjusting costs to a specific target currency and price year. *Evid Policy* 2010;6:51–9.
- 34 The Campbell and Cochrane Economics Methods Group (CCEMG) and the Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre). CCEMG—EPPI-Centre Cost Converter (v1.4): The Campbell and Cochrane Economics Methods Group (CCEMG) and the Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre). 2014 (12 Sep 2014). <http://eppi.ioe.ac.uk/costconversion/default.aspx>
- 35 Anokye NK, Lord J, Fox-Rushby J. Is brief advice in primary care a cost-effective way to promote physical activity? *Br J Sports Med* 2014;48:202–6.
- 36 Boehler CE, Milton KE, Bull FC, *et al*. The cost of changing physical activity behaviour: evidence from a “physical activity pathway” in the primary care setting. *BMC Public Health* 2011;11:370.
- 37 Gulliford MC, Charlton J, Bhattarai N, *et al*. Impact and cost-effectiveness of a universal strategy to promote physical activity in primary care: population-based cohort study and Markov model. *Eur J Health Econ* 2014;15:341–51.
- 38 Pringle A, Cooke C, Gilson N, *et al*. Cost-effectiveness of interventions to improve moderate physical activity: a study in nine UK sites. *Health Educ J* 2010;69:211–24.
- 39 Shaw R, Fenwick E, Baker G, *et al*. ‘Pedometers cost buttons’: the feasibility of implementing a pedometer based walking programme within the community. *BMC Public Health* 2011;11:200.
- 40 Dalziel K, Segal L, Elley CR. Cost utility analysis of physical activity counselling in general practice. *Aust N Z J Public Health* 2006;30:57–63.
- 41 Elley CR, Garrett S, Rose SB, *et al*. Cost-effectiveness of exercise on prescription with telephone support among women in general practice over 2 years. *Br J Sports Med* 2011;45:1223–9.
- 42 Elley R, Kerse N, Arroll B, *et al*. Cost-effectiveness of physical activity counselling in general practice. *N Z Med J* 2004;117:U1216.
- 43 Leung W, Ashton T, Kolt GS, *et al*. Cost-effectiveness of pedometer-based versus time-based Green Prescriptions: the Healthy Steps Study. *Aust J Prim Health* 2012;18:204–11.
- 44 Cobiac LJ, Vos T, Barendregt JJ. Cost-effectiveness of interventions to promote physical activity: a modelling study. *PLoS Med* 2009;6:e1000110.
- 45 Sims J, Huang N, Pietsch J, *et al*. The Victorian Active Script Programme: promising signs for general practitioners, population health, and the promotion of physical activity. *Br J Sports Med* 2004;38:19–25.
- 46 Lindgren P, Fahlstadius P, Hellenius ML, *et al*. Cost-effectiveness of primary prevention of coronary heart disease through risk factor intervention in 60-year-old men from the county of Stockholm—a stochastic model of exercise and dietary advice. *Prev Med* 2003;36:403–9.
- 47 Over EA, Wendel-Vos GW, van den Berg M, *et al*. Cost-effectiveness of counseling and pedometer use to increase physical activity in the Netherlands: a modeling study. *Cost Eff Resour Alloc* 2012;10:13.
- 48 Munro JF, Nicholl JP, Brazier JE, *et al*. Cost effectiveness of a community based exercise programme in over 65-year-olds: cluster randomised trial. *J Epidemiol Community Health* 2004;58:1004–10.
- 49 Rome A, Persson U, Ekdahl C, *et al*. Physical activity on prescription (PAP): costs and consequences of a randomized, controlled trial in primary healthcare. *Scand J Prim Health Care* 2009;27:216–22.
- 50 Hatziaandreu EI, Koplan JP, Weinstein MC, *et al*. A cost-effectiveness analysis of exercise as a health promotion activity. *Am J Public Health* 1988;78:1417–21.
- 51 Eriksson MK, Hagberg L, Lindholm L, *et al*. Quality of life and cost-effectiveness of a 3-year trial of lifestyle intervention in primary health care. *Arch Intern Med* 2010;170:1470–9.
- 52 Goyder E, Hind D, Breckon J, *et al*. A randomised controlled trial and cost-effectiveness evaluation of ‘booster’ interventions to sustain increases in physical activity in middle-aged adults in deprived urban neighbourhoods. *Health Technol Assess* 2014;18:1–210.
- 53 Sevick MA, Napolitano MA, Papandonatos GD, *et al*. Cost-effectiveness of alternative approaches for motivating activity in sedentary adults: results of Project STRIDE. *Prev Med* 2007;45:54–61.
- 54 Bertram MY, Lim SS, Barendregt JJ, *et al*. Assessing the cost-effectiveness of drug and lifestyle intervention following opportunistic screening for pre-diabetes in primary care. *Diabetologia* 2010;53:875–81.
- 55 Neumann A, Schwarz P, Lindholm L. Estimating the cost-effectiveness of lifestyle intervention programmes to prevent diabetes based on an example from Germany: Markov modelling. *Cost Eff Resour Alloc* 2011;9:17.
- 56 Robroek SJ, Polinder S, Bredt FJ, *et al*. Cost-effectiveness of a long-term Internet-delivered worksite health promotion programme on physical activity and nutrition: a cluster randomized controlled trial. *Health Educ Res* 2012;27:399–410.
- 57 van Keulen HM, Bosmans JE, van Tulder MW, *et al*. Cost-effectiveness of tailored print communication, telephone motivational interviewing, and a combination of the two: results of an economic evaluation alongside the Vitalum randomized controlled trial. *Int J Behav Nutr Phys Act* 2010;7:64.
- 58 Gusi N, Reyes MC, Gonzalez-Guerrero JL, *et al*. Cost-utility of a walking programme for moderately depressed, obese, or overweight elderly women in primary care: a randomised controlled trial. *BMC Public Health* 2008;8:231.
- 59 Stevens W, Hillsdon M, Thorogood M, *et al*. Cost-effectiveness of a primary care based physical activity intervention in 45–74-year-old men and women: a randomised controlled trial. *Br J Sports Med* 1998;32:236–41.
- 60 Hogg WE, Zhao X, Angus D, *et al*. The cost of integrating a physical activity counselor in the primary health care team. *J Am Board Fam Med* 2012;25:250–2.
- 61 Speck BJ, Looney SW. Effects of a minimal intervention to increase physical activity in women: daily activity records. *Nurs Res* 2001;50:374–8.
- 62 Amarasinghe AK. Cost-effectiveness implications of GP intervention to promote physical activity: evidence from Perth, Australia. *Cost Eff Resour Alloc* 2010;8:10.
- 63 Bravata DM, Smith-Spangler C, Sundaram V, *et al*. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA* 2007;298:2296–304.
- 64 Shemilt I, Mugford M, Byford S, *et al*. Incorporating economics evidence. In: Higgins JP, Green S, eds. *Cochrane handbook for systematic reviews of interventions Version 5.1.0 [updated Mar 2011]*. The Cochrane Collaboration, 2011. Chapter 15. <http://handbook.cochrane.org/>
- 65 Robberstad B. QALYs vs DALYs vs LYs gained: what are the differences, and what difference do they make for health care priority setting? *Nor Epidemiol* 2005;15:183–91.
- 66 Murray CJ, Acharya AK. Understanding DALYs (disability-adjusted life years). *J Health Econ* 1997;16:703–30.
- 67 Buxton MJ, Drummond MF, Van Hout BA, *et al*. Modelling in economic evaluation: an unavoidable fact of life. *Health Econ* 1997;6:217–27.
- 68 Wolfenstetter SB, Wenig CM. Economic evaluation and transferability of physical activity programmes in primary prevention: a systematic review. *Int J Environ Res Public Health* 2010;7:1622–48.
- 69 Hoffmann TC, Glasziou PP, Boutron I, *et al*. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014;348:g1687.
- 70 Postma MJ, de Vries R, Welte R, *et al*. Health economic methodology illustrated with recent work on Chlamydia screening: the concept of extended dominance. *Sex Transm Infect* 2008;84:152–4.
- 71 National Institute for Health and Clinical Excellence (NICE). *Guide to the methods of technology appraisal*. London: NICE, June 2008.



Are brief interventions to increase physical activity cost-effective? A systematic review

Vijay GC, Edward CF Wilson, Marc Suhrcke, Wendy Hardeman and Stephen Sutton

Br J Sports Med published online October 5, 2015

Updated information and services can be found at:

<http://bjsm.bmj.com/content/early/2015/10/05/bjsports-2015-094655>

These include:

Supplementary Material

Supplementary material can be found at:

<http://bjsm.bmj.com/content/suppl/2015/10/05/bjsports-2015-094655.DC1.html>

References

This article cites 51 articles, 19 of which you can access for free at:

<http://bjsm.bmj.com/content/early/2015/10/05/bjsports-2015-094655#BIBL>

Open Access

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections

Articles on similar topics can be found in the following collections

[BJSM Reviews with MCQs](#) (117)
[Open access](#) (190)

Notes

To request permissions go to:

<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:

<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:

<http://group.bmj.com/subscribe/>