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RESEARCH

Interventions to promote walking: systematic review

David Ogilvie, MRC fellow,[1] Charles E Foster, senior researcher,[2] Helen Rothnie, research associate,[3] Nick Cavill, research associate,[2] Val Hamilton, research assistant,[4] Claire F Fitzsimons, SPARColl project coordinator,[3] Nanette Mutrie, professor of exercise and sport psychology,[3] on behalf of the Scottish Physical Activity Research Collaboration (SPARColl)

[1]Medical Research Council Social and Public Health Sciences Unit, Glasgow G12 8RZ

[2]British Heart Foundation Health Promotion Research Group, University of Oxford, Oxford

[3]Department of Sport, Culture and the Arts, University of Strathclyde, Glasgow

[4]Development and Alumni Office, University of Glasgow, Glasgow

Correspondence to: D Ogilvie
d.ogilvie@msoc.mrc.gla.ac.uk

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ABSTRACT

Objective To assess the effects of interventions to promote walking in individuals and populations.

Design Systematic review.

Data sources Published and unpublished reports in any language identified by searching 25 electronic databases, by searching websites, reference lists, and existing systematic reviews, and by contacting experts.

Review methods Systematic search for and appraisal of controlled before and after studies of the effects of any type of intervention on how much people walk, the distribution of effects on walking between social groups, and any associated effects on overall physical activity, fitness, risk factors for disease, health, and wellbeing.

Results We included 19 randomised controlled trials and 29 non-randomised controlled studies. Interventions tailored to people's needs, targeted at the most sedentary or at those most motivated to change, and delivered either at the level of the individual (brief advice, supported use of pedometers, telecommunications) or household (individualised marketing) or through groups, can encourage people to walk more, although the sustainability, generalisability, and clinical benefits of many of these approaches are uncertain. Evidence for the effectiveness of interventions applied to workplaces, schools, communities, or areas typically depends on isolated studies or subgroup analysis.

Conclusions The most successful interventions could increase walking among targeted participants by up to 30-60 minutes a week on average, at least in the short term. From a perspective of improving population health, much of the research currently provides evidence of efficacy rather than effectiveness. Nevertheless, interventions to promote walking could contribute substantially towards increasing the activity levels of the most sedentary.

INTRODUCTION

Physical inactivity increases the risk of many chronic diseases—notably, coronary heart disease, type 2 diabetes, and cancer of the colon.[1] Accumulating 30 minutes of moderate intensity physical activity on most days is enough to provide substantial health benefits,[2] but most adults in the United Kingdom do not currently achieve this.[1 3 4] Increasing the population level of physical activity, particularly among the most sedentary, has therefore become a leading aim of contemporary public health policy.[5 6]

Walking has been described as near perfect exercise.[7] Even walking at a moderate pace of 5 km/hour (3 miles/hour) expends sufficient energy to meet the definition of moderate intensity physical activity.[8] Compared with many sports and other recreational pursuits, walking is a popular, familiar, convenient, and free form of exercise that can be incorporated into everyday life and sustained into old age.[7 9] It is also a carbon neutral mode of transport that has declined in recent decades in parallel with the growth in car use.[1] There are therefore compelling reasons to encourage people to walk more, not only to improve their own health but also to address the problems of climate change.[10-12]

Numerous systematic reviews have examined the effectiveness of interventions to promote physical activity in general,[13 14] but we know of none that has examined how best to promote walking in particular; furthermore, many—including those underpinning recent guidance issued by the National Institute for Health and Clinical Excellence (NICE)—have been restricted to particular types of intervention[15 16] or study design.[17] Walking may be influenced by environmental and societal conditions as well as by interventions targeted at individuals.[18] We therefore conducted a systematic review of the best available evidence across all relevant disciplines to determine what characterises interventions effective in promoting walking; who walks more and by how much as a result of effective interventions; and the effects of such interventions on overall physical activity and health.

METHODS

Search strategy

We searched 25 databases for studies of interventions or changes related to walking published from 1990 onwards. We imposed no limits on characteristics of participants, study design, intervention, or language. We also searched a purposive sample of 12 websites as well as reference lists, existing systematic reviews, and our own archives. We then invited an international group of experts to nominate additional primary

studies (particularly unpublished or recently published studies). Further details of the search strategy are on http://sparcoll.org.uk/images/bmjsupp.pdf.

Study selection and inclusion criteria

We included randomised controlled trials and non-randomised controlled before and after experimental or observational studies of the effects of any type of intervention—including environmental and fiscal, legislative, and other policy interventions—on how much people walk. The effects of the intervention had to be compared with those observed in a "no intervention," "attention control," or "minimal intervention" control or comparison group, area, or population. Studies had to report a specific measure of walking (self reported, objective, or both) at both baseline and follow-up. We excluded studies in which the "control" condition consisted of an alternative intervention intended or likely to promote walking and that exceeded "standard" or "usual" care, treatment, or practice, or in which the purpose, setting, and outcome of the intervention were all primarily clinical (see http://sparcoll.org.uk/images/bmjsupp.pdf). After obviously irrelevant references had been removed, one of several reviewers assessed all remaining titles and abstracts for inclusion. Another reviewer cross checked all undecided cases, plus a 10% sample of exclusion decisions. Articles obtained in full text were then reassessed for inclusion by one of several reviewers, with a 10% sample of exclusion decisions (other than obviously irrelevant studies) being cross checked by another reviewer and all undecided cases being reviewed by the team in plenary session (fig 1).

Data extraction and validity assessment

For each included study, a pair of reviewers extracted data, assessed validity, and verified each other's work, with any discrepancies being resolved by discussion.

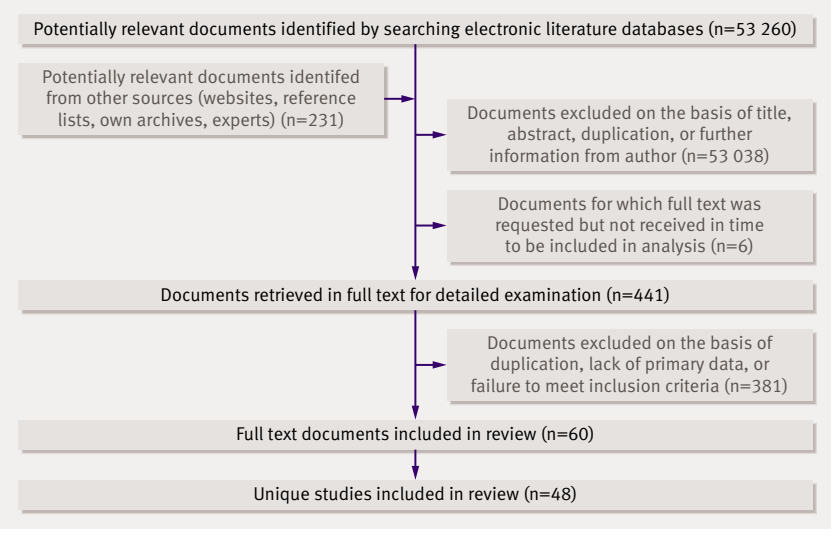

Fig 1 | Review flowchart. Details of excluded studies are on http://sparcoll.org.uk/images/bmjsupp.pdf

We summarised study validity using seven binary criteria based on those used in previous systematic reviews and applicable across the range of included study designs (tables 1 and 2).[17 19 20] We extracted the available outcome measures on walking and the results of statistical tests (95% confidence intervals or P values) where authors reported them, and systematically considered the suitability of the data reported in each study for meta-analysis. We also extracted any available evidence on how effects on walking were distributed between social groups; evidence of effects on overall physical activity, cardiorespiratory fitness, other risk factors for disease, health, and wellbeing; evidence about adverse effects; and data on economic evaluation.

Data synthesis

We categorised studies according to the main approach of the intervention studied. We summarised the outcome for each study in terms of the net change in walking after adjustment for changes in the control group, using the most inclusive measure of walking available for each study, and tabulated the key characteristics and outcomes of the studies within each category in descending order of study validity. The types of interventions, study designs, participants, and outcome metrics and the durations of follow-up were too heterogeneous to permit meta-analysis, even within categories of intervention; in addition, many studies did not report confidence intervals so we could not construct a conventional forest plot. By making a set of simplifying assumptions (box), however, we were able to plot the relation between estimated effect size, sample size, and study validity (figs 2 and 3).

Calculation of a common primary outcome metric

Studies used a wide range of metrics to quantify the net change in walking in the intervention group compared with the control group. The most promising candidate for a single common metric with which to synthesise the results of all studies was the net change in time spent walking (minutes/week). Some studies reported outcomes using other metrics that we were able to convert to an approximate net change in time spent walking (minutes/week) using the following assumptions: average duration of a "session" of walking=30 minutes[w4]; average distance of a trip in which the main mode of transport was walking=0.7 miles (1.1 km)[w61]; average walking speed=3 miles/hour (5 km/hour); average step rate=100 steps/minute[w62]; 10 trips to and from school/week. Six studies reported outcomes using metrics that could not be expressed in these terms[w11 w29 w52-w55 w58-w60]; these are listed in table 1 and 2 but do not appear in figures 2 or 3.

RESULTS

We screened 53 491 references and assessed the full text of 441 documents (fig 1). Forty eight studies met our inclusion criteria: 19 randomised controlled trials and 29 non-randomised controlled studies.[w1-w60] Twenty seven studies were concerned with walking

in general (tables 1, 3, and 4); 21 studies were concerned solely with walking as a mode of transport (tables 2 and 5) (see also http://sparcoll.org.uk/images/bmjsupp.pdf).

Effects of interventions on walking in general

Brief advice to individuals—Six studies [w1-w6] (five randomised controlled trials) reported the effects of brief advice given face to face either in the workplace[w1] or by clinicians[w2 w3 w6] or an exercise specialist[w4 w5] in primary care. A significant net increase in self reported walking was found in both studies with follow-up periods of up to six weeks,[w1 w2] but in only two of the four studies with longer follow-up.[w3-w6]

Remote support to individuals—Three randomised controlled trials evaluated interventions delivered by telephone or internet; all found a significant net increase in self reported walking.[w7-w9]

Group based approaches—Six studies (three randomised controlled trials) evaluated interventions involving various approaches (such as lay mentored meetings, led walks, or educational sessions) delivered in groups.[w10-w16] The randomised studies[w10-w13] were more likely to find a significant net increase in self reported walking than the less robust, non-randomised studies.[w14-w16]

Pedometers—In seven studies (six randomised controlled trials) pedometers, coupled with various supporting measures, formed a key part of the

Table 1 | Summary validity assessment for included studies on walking in general

Study	Criterion							Total criteria met
	Randomisation*	Exposure†	Representative-ness‡	Comparabil-ity§	Attrition or sample size¶	Period of assessment**	Instrument††	
Brief advice to individuals								
Purath[w1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	7
Calfas[w2]	—	Yes	Yes	Yes	Yes	Yes	Yes	6
Kerse[w3]	Yes	Yes	—	Yes	Yes	Yes	Yes	6
Halbert A[w4]	Yes	Yes	—	Yes	Yes	Yes		5
Halbert B[w5]	Yes	Yes	—	Yes	Yes	Yes		5
Norris[w6]	Yes	—	—	Yes	Yes	Yes	Yes	5
Remote support to individuals								
Napolitano[w7]	Yes	Yes	—	Yes	Yes	Yes	Yes	6
Jarvis[w8]	Yes	Yes	—	Yes	Yes	Yes	—	5
Nies[w9]	Yes	Yes	—	Yes	Yes	Yes	—	5
Group based approaches								
Coull[w10]	Yes	Yes	Yes	Yes	Yes	Yes	—	6
Fisher[w11]	Yes	Yes	—	Yes	Yes	Yes	—	5
Pereira[w12 w13]	Yes	—	—	Yes	Yes	Yes	Yes	5
Ferreira[w14]	—	—	—	Yes		Yes	Yes	3
Michalowski[w15]	—	Yes	—	—	Yes	Yes	—	3
De Kraker[w16]	—	—	—	—	—	Yes	—	1
Pedometers								
Schofield[w17]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	7
Merom[w18]	Yes	Yes	—	Yes	Yes	Yes	Yes	6
Barilotti[w19 w20]		Yes	—	Yes	Yes	Yes	Yes	5
Croteau[w21]	Yes	—	—	Yes	Yes	Yes	Yes	5
Talbot[w22]	Yes	—	—	Yes	Yes	Yes	Yes	5
Tudor-Locke[w23]	Yes	Yes	—	Yes	—	Yes	Yes	5
Baker[w24]	Yes	—	—	Yes	—	Yes	Yes	4
Community level approaches								
Brownson (Bootheel)[w25]	—	Yes	Yes	Yes	—	Yes	Yes	5
Brownson (Ozarks)[w26]	—	Yes	Yes	Yes	—	Yes	Yes	5
Reger-Nash (Wheeling)[w27 w28]	—	Yes	Yes	Yes	—	Yes	Yes	5
NSW Health[w29]	—	—	—	—	Yes	Yes	—	2
Reger-Nash (Welch)[w30]	—	—	—	—	—	Yes	—	1

*Were participants, groups, or areas randomly allocated to intervention and control status?
†Did authors show both that participants did not receive concurrent intervention that could have differentially influenced walking in intervention and control groups and that control group was not contaminated by receiving part or all of intervention being studied?
‡Were study samples randomly recruited from study population with response rate of at least 60%, or were they otherwise shown to be representative of study population?
§Were baseline characteristics of intervention and control groups, populations, or areas comparable, or if there were important differences in potential confounders at baseline were these appropriately adjusted for in analysis?
¶Were outcomes studied in cohort or panel of respondents with attrition rate of less than 30%, or were results based on repeated cross sectional design with minimum achieved sample of at least 100 participants in each wave in both intervention and control groups?
**Was quantity of walking assessed over period of >1 day?
††Was instrument used to assess walking appropriate to research question(s) of study—that is, capable of measuring outcome under consideration and either shown to be a valid and reliable measure in published research or in pilot study or recognised as acceptable measure—or example, previously used in national physical activity or travel survey?

intervention (or one intervention arm of a more complex trial).[w17-w24] Three studies, all with follow-up periods of up to three months, found a significant net increase in self reported walking or in step counts[w17-w20]; the three studies with longer follow-up all found that a significant net increase in step counts after 4-16 weeks was not sustained at 24 weeks[w22 w23] or 12 months.[w24]

Community level approaches—Five non-randomised studies of interventions applied to whole geographical communities measured effects in whole populations rather than in those participating directly in an intervention.[w25-w30] All involved a combination of approaches such as mass media campaigns augmented by community events and other local supportive measures,[w27 w28 w30] modest environmental improvements,[w25 w29] formation of walking groups,[w25 w26 w29] and written materials or brief advice for individuals.[w25 w26] Three studies found a significant net increase in self reported walking, but one was reported only briefly[w30] and another had significant methodological limitations[w29]; the most robust evidence of effectiveness was for an intervention with a substantial mass media component.[w27 w28]

Effects of interventions on walking as a mode of transport

Targeted or individualised promotion of active travel—One randomised controlled trial of an intervention to promote active commuting to work found a significant net increase in self reported walking.[w31] Thirteen non-randomised studies of individualised marketing of "environmentally friendly modes" of transport to households[w32-w50] consistently reported a net increase in the proportion of trips made on foot (usually

Table 2 | Summary validity assessment for included studies on walking as a mode of transport

Study	Criterion							Total criteria met
	Randomisation*	Exposure†	Representative-ness‡	Comparability§	Attrition or sample size¶	Period of assessment**	Instrument††	
Targeted or individualised promotion of active travel								
Mutrie[w31]	Yes	Yes	Yes	Yes	—	Yes	Yes	6
Marinelli[w32]‡‡	—	Yes	Yes	Yes	Yes	—	Yes	5
Socialdata (Perth pilot)[w33-w36]‡‡	—	Yes	Yes	Yes	Yes	—	Yes	5
Socialdata (Perth)[w37-w40]‡‡	—	Yes	Yes	Yes	Yes	—	Yes	5
Sustrans (Frome)[w41]‡‡	—	Yes	Yes	Yes	Yes	—	Yes	5
Sustrans (Gloucester pilot)[w42]‡‡	—	Yes	Yes	Yes	Yes	—	Yes	5
Socialdata (Melville)[w43]	—	Yes	Yes	—	Yes	—	Yes	4
Sustrans (Bishopston)[w44]	—	Yes	Yes	—	Yes	—	Yes	4
Sustrans (Cramlington)[w45]	—	Yes	Yes	—	Yes	—	Yes	4
Sustrans (Gloucester)[w46]	—	Yes	Yes	—	Yes	—	Yes	4
Sustrans (Nottingham)[w47]	—	Yes	Yes	—	Yes	—	Yes	4
Sustrans (Sheffield)[w48]	—	Yes	Yes	—	Yes	—	Yes	4
Haq[w49]	—	Yes	—	—	—	Yes	—	2
TAPESTRY (Viernheim)[w50]	—	—	Yes	—	—	—	Yes	2
School travel initiatives								
McKee[w51]	—	Yes	Yes	—	Yes	—	Yes	4
Rowland[w52]	Yes	Yes	—	Yes	Yes	—	—	4
TAPESTRY (Hertfordshire)[w53]	—	—	—	—	Yes	Yes		2
Miscellaneous transport interventions								
Shoup[w54 w55]	—	Yes	Yes	—	Yes	Yes	Yes	5
Troelsen[w56]	—	Yes	Yes	Yes	Yes	—	Yes	5
Hodgson[w57]	—	Yes	—	—	Yes	Yes	—	3
Cervero[w58-w60]	—	Yes	—	—	—	Yes	—	2

*Were participants, groups, or areas randomly allocated to intervention and control status?
†Did authors show both that participants did not receive concurrent intervention that could have differentially influenced walking in intervention and control groups and that control group was not contaminated by receiving part or all of intervention being studied?
‡Were study samples randomly recruited from study population with response rate of at least 60%, or were they otherwise shown to be representative of study population?
§Were baseline characteristics of intervention and control groups, populations or areas comparable, or if there were important differences in potential confounders at baseline were these appropriately adjusted for in analysis? (See also footnote ‡‡.)
¶Were outcomes studied in cohort or panel of respondents with attrition rate of less than 30%, or were results based on repeated cross sectional design with minimum achieved sample of at least 100 participants in each wave in both intervention and control groups?
**Was quantity of walking assessed over period of ›1 day?
††Was instrument used to assess walking appropriate to research question(s) of study—that is, capable of measuring outcome under consideration and either shown to be a valid and reliable measure in published research or in pilot study or recognised as acceptable measure—for example, previously used in national physical activity or travel survey?
‡‡Studies met criterion of comparability by indicating that control group was recruited either from same population as intervention group or from neighbouring area chosen for its similarity. They did not show that baseline characteristics of individuals or households in intervention and control groups were similar or adjust for any differences in such characteristics.

measured in the local population as a whole) and an increase in time spent walking in those studies that reported this outcome.[w33-w40 w43-w48] The methods of these non-randomised studies, however, were often not clearly described, and only one reported the statistical significance of the observed increase in walking.[w37-w40]

School travel initiatives—Three studies evaluated interventions aimed at changing the mode of children's travel to school.[w51-w53] Only one—a small non-randomised trial of an active commuting pack—found a significant net increase in self reported walking on the school journey.[w51]

Miscellaneous transport interventions—We found four other non-randomised studies.[w54-w60] A directive that employers should subsidise employees who chose not to commute by car was associated with a significant increase in the proportion walking to work,[w54 w55] and a three year multifaceted initiative to promote cycling in a city was associated with a net increase in walking after adjustment for trends in control areas and other confounders.[w56] Two less robust studies of a sustainable transport campaign[w57] and a car sharing club[w58-w60] found no significant effect on walking.

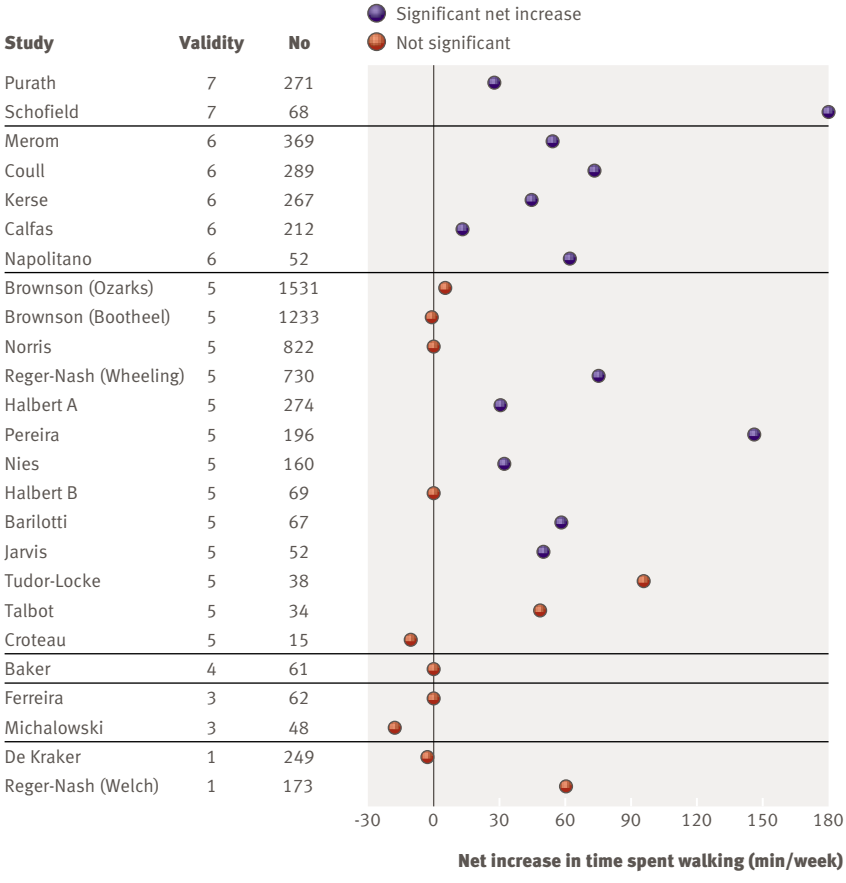

Fig 2 | Estimated net increase in walking in general. Studies are ranked by validity (number of criteria met, see tables 1 and 2), then sample size

Characteristics of interventions found to be effective

The most convincing evidence of effectiveness was for interventions delivered at the level of the individual or household or through group based approaches. Although no single method of promoting walking emerged as the most effective, and we were not able to reach any conclusions about the relative merits of different types of provider (such as doctor, nurse, exercise specialist) on the effectiveness of interventions, we were able to identify two general characteristics of those interventions found to be effective: targeting and tailoring.

Targeting—Most interventions associated with an increase in walking as a mode of transport were offered only to those individuals or households identified through prior screening as already motivated to change their behaviour.[w31-w50] Interventions to promote walking in general were often aimed at target groups such as sedentary people or patients with particular conditions. Many of the interventions found to be effective were targeted at sedentary people[w1 w2 w4 w7 w9 w11 w17 w18]; the potential value of such targeting was also shown indirectly by other studies in which significant net increases in walking were observed only in the most sedentary subgroup within the study population.[w8 w27 w28 w30] The value of targeting specific clinical populations was less clear. A group based lay mentoring intervention for patients with heart disease was effective,[w10] but studies of other approaches (brief advice or pedometers) targeted at patients with diabetes or osteoarthritis did not find them to be effective at final follow-up.[w5 w22 w23]

Tailoring—Effective interventions typically involved content tailored to participants' requirements or circumstances. Such tailoring ranged from the provision of individualised counselling[w1 w2 w8] or written materials[w17 w18] (for example, tailored to the participant's position in the transtheoretical model of behaviour change), through inviting households to choose from a menu of information resources and incentives promoting environmentally friendly modes of transport,[w32-w50] to the mapping of individual children's journeys to school.[w51]

Magnitude and social distribution of effects on walking

Magnitude of effect—Evidence from the most promising studies suggests that, among targeted participants, successful interventions could increase walking in general by up to 30-60 minutes a week on average; more robust studies were most likely to report significant net increases in walking than less robust studies (fig 2). In the transport sector, successful interventions could increase walking as a mode of transport in the general population by rather less, up to about 15-30 minutes a week on average; this estimate depends on a group of studies that are larger but less robust than the studies of walking in general (fig 3).

Social distribution of effects—In 29 studies, most of the participants were women (see http://sparcoll.org.uk/images/bmjsupp.pdf); in three studies, men were

more likely than women to increase their walking.[w5 w26 w29] Most (34/48) studies, however, did not report how the effect of interventions on walking varied between demographic or socioeconomic groups (see http://sparcoll.org.uk/images/bmjsupp.pdf).

Effects on overall physical activity and health

Twenty studies reported effects on overall measures of physical activity (see http://sparcoll.org.uk/images/bmjsupp.pdf). Of these, seven reported some evidence of a net increase in overall physical activity at final follow-up, but in each of these studies different measures of physical activity gave conflicting results.[w1 w2 w4 w10 w14 w16 w18]

Three of the studies that found a significant net increase in walking also reported effects on cardiorespiratory fitness or functional capacity in terms of maximal oxygen uptake (VOmax) or one mile (1.6 km) walking time in sedentary women or adolescent

Table 3 | Effects of interventions at individual or group level on walking in general

	Selected characteristics of intervention and study design								Effect on walking	
Study	How delivered or supported	Study population	Ages	Location	Sample size	Follow-up	Random allocation	Validity*	Reported net effect†	Min/week‡
Brief advice to individuals										
Purath[w1]	Nurse	Sedentary female university employees	18-65	USA	271	6 weeks	Yes	7	+26.9 min/week (P=0.001)	+27
Calfas[w2]	Doctor or nurse	Sedentary	≥18	USA	212	4-6 weeks	—	6	+13 min/week (P<0.025)	+13
Kerse[w3]	General practitioner	Community dwelling	≥65	Australia	267	12 months	Yes	6	+88 min/fortnight (95% CI 8 to 168)	+44
Halbert A[w4]	Exercise specialist	Sedentary	≥60	Australia	274	12 months	Yes	5	+1 session/week (P<0.05)	+30
Halbert B[w5] (subtrial of A)	Exercise specialist	Sedentary with osteoarthritis	≥60	Australia	69	12 months	Yes	5	+0 session/wk (NS)	0
Norris[w6]	Doctor	Workplace HMO enrollees	≥30	USA	822	6 months	Yes	5	+0.1 min/week (P=0.41)	0
Remote support to individuals										
Napolitano[w7]	Internet	Low active hospital employees	18-65	USA	52	3 months	Yes	6	+61.69 min/week (P<0.05)	+62
Jarvis[w8]	Telephone	Sedentary	≥60	USA	52	3 months	Yes	5	+50 min/week (P<0.02)§	+50
Nies[w9]	Telephone	Sedentary women	30-60	USA	160	6 months	Yes	5	+4.6 min/day (P<0.01)	+32
Group based approaches										
Coull[w10]	Lay mentored meetings	With heart disease	≥60	Scotland	289	12 months	Yes	6	+73 min/week (95% CI 1 to 137)	+73
Fisher[w11]	Led walking programme	Sedentary	≥65	USA	582	6 months	Yes	5	Effect size 0.20 (P<0.05)	—
Pereira[w12 w13]	Led walking training	Postmenopausal	50-65	USA	196	10 years	Yes	5	+420 kcal/week (P=0.01) or +7.3 miles/week (SSNR)	+146
Ferreira[w14]	Educational sessions	Physically active women	50-72	Brazil	62	12 weeks	—	3	NS change in min/week	0
Michalowski[w15]	Educational sessions	Female	28-89 (most >59)	USA	48	4 months	—	3	−0.3 h/week (NS)	−18
De Kraker[w16]	Workplace lunchtime walking coordinator	Employees in sedentary jobs	38 (9)¶	Netherlands	249	12 months	—	1	−0.2 session/fortnight (P=0.67)	−3
Pedometers										
Schofield[w17]	Group review sessions	Low active girls	15-18	Australia	68	12 weeks	Yes	7	+2591 steps/day (P=0.03)	+181
Merom[w18]	Postal support	Inactive	30-65	Australia	369	3 months	Yes	6	+54 min/week (P=0.002)	+54
Barilotti[w19 w20]	10 000 step goal	On university campus	≥18	USA	67	6 weeks	—	5	+57.5 min/week (P=0.03)	+58
Croteau[w21]	Individual review sessions	In assisted-living facility	68-95	USA	15	6 weeks	Yes	5	−1124 steps/week (NS)	−11
Talbot[w22]	Individual goal setting	With osteoarthritis	≥60	USA	34	24 weeks	Yes	5	+687 steps/day (NS)	+48
Tudor-Locke[w23]	Group review sessions	Overweight and sedentary with type 2 diabetes	40-60	Canada	38	24 weeks	Yes	5	+1367 steps/day (P=0.17)	+96
Baker[w24]	Graduated goals	On university campus	42 (11)¶	Scotland	61	12 months	Yes	4	NS change in steps/week	0

HMO=health maintenance organisation; NS=authors reported no significant difference; OR=odds ratio; SSNR=significance not reported.
*No of criteria met (maximum 7, see table 1).
†Net change in walking after adjustment for changes in control group; 95% confidence intervals or P values included if reported by authors.
‡Continuous outcome measure converted to common outcome metric (min/week) when possible. Dash indicates conversion not possible.
§Tabulated effect size is that observed in most sedentary subgroup, not across whole study population.
¶Mean (SD) age of sample.

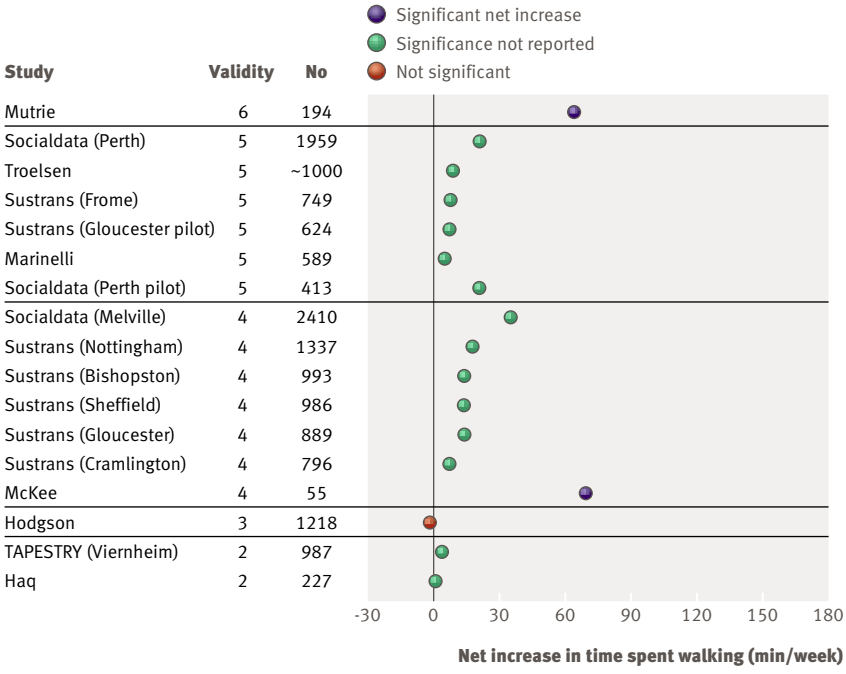

Fig 3 | Estimated net increase in walking as a mode of transport. Studies are ranked by validity (number of criteria met, see tables 1 and 2), then sample size

girls[w9 w17] or exercise tolerance in adults with ischaemic heart disease.[w10] None found a significant difference between intervention and control groups.

Two of the studies that found a significant net increase in walking also reported effects on other risk factors (anthropometry, resting heart rate, blood pressure, lipid profile, or fasting blood glucose) in specific clinical populations (adults with ischaemic heart disease[w10] or type 2 diabetes[w23]). Neither found any significant differences between intervention and control groups.

Six of the studies that found a significant net increase in walking also reported effects on self reported health, wellbeing, or quality of life measured with either a generic instrument such as the SF-36 or a more specific symptom or mood score. Three found a significant overall difference between intervention and control groups[w3 w9 w11]; two found significant differences, but only on subscales of the SF-36[w10 w31]; one found no significant difference.[w12 w13]

Adverse effects and economic evaluation

Few studies attempted to ascertain adverse effects; none reported adverse effects such as an increase in injuries clearly attributable to an intervention to promote walking. Only six studies included even a rudimentary economic evaluation.[w27 w28 w32 w37-w40 w44 w49 w54 w55] We were therefore unable to synthesise any meaningful data with which to compare these aspects of alternative approaches to promoting walking.

DISCUSSION

Principal findings

We found clear evidence that people can be encouraged to walk more by interventions tailored to their needs, targeted at the most sedentary or at those most motivated to change, and delivered either at the level of the individual or household or through group based approaches. The balance of available evidence about interventions applied at the level of the institution (workplace or school), community, or area is less convincing; evidence that these have led to a significant overall increase in walking typically depends on isolated studies or subgroup analysis.

Strengths and weaknesses of the review

The main strength of this review is its comparative inclusivity.[16 17] We searched widely for evidence in diverse fields, which enabled us to make fair comparisons across the whole range of potential approaches to promoting walking rather than selecting on the basis of study design, length or nature of follow-up, or even ideological or professional preference. We included only studies that specifically reported changes in

Table 4 | Effects of interventions at community level on walking in general

	Selected characteristics of intervention and study design								Effect on walking	
Study	How delivered or supported	Study population	Ages	Location	Sample size	Follow-up	Random allocation	Validity*	Reported net effect†	Min/week‡
Brownson (Bootheel)[w25]	Multifaceted (see text)	Rural	≥18	USA	1233	13-20 months	—	5	−1.4 min/week (P=0.91)	−1
Brownson (Ozarks)[w26]	Multifaceted (see text)	Rural	≥18	USA	1531	12 months	—	5	+5.2 min/week (NS)	+5
Reger-Nash (Wheeling)[w27 w28]	Mass media and supporting activities	Sedentary	50-65	USA	730	12 months	—	5	+75 min/week (P<0.01)§	+75
NSW Health[w29]	Park modifications and supporting activities	Suburban	25-65	Australia	840	12 months	—	2	+4.9% walking in previous fortnight (P=0.001)	—
Reger-Nash (Welch)[w30]	Mass media and supporting activities	Rural	35-65	USA	173	NR¶	—	1	+60 min/week (NS)§	+60

NS=authors reported no significant difference.
*No of criteria met (maximum 7, see table 1).
†Net change in walking after adjustment for changes in control group; 95% confidence intervals or P values included if reported by authors.
‡Continuous outcome measure converted to common outcome metric (min/week) when possible. Dash indicates conversion not possible.
§Tabulated effect size is that observed in most sedentary subgroup, not across whole study population
¶Not reported.

walking and were thus unable to examine unreported or unanalysed data on walking that may lie buried in the composite measures of physical activity used in many other trials.

Strengths and weaknesses of the available evidence

The available evidence (particularly that from the most robust study designs) is somewhat skewed in favour of studies of interventions that seem easier to evaluate, or perhaps easier to randomise, typically individually focused interventions such as brief advice or pedometers, often studied in small, convenience, or volunteer samples (as illustrated by the increases in walking observed in the control groups in many studies) and sometimes over short follow-up periods of only a few weeks.[17] From a perspective of improving population health, much of this research therefore constitutes, at best, evidence of efficacy rather than effectiveness. This caveat is particularly well illustrated by the case of pedometers. None of

Table 5 | Effects of interventions on walking as a mode of transport

	Selected characteristics of intervention and study design							Effect on walking	
Study	How delivered or supported	Study population	Ages	Location	Sample size	Follow-up	Validity*	Reported net effect†	Min/week‡
Targeted or individualised promotion of active travel									
Mutrie[w31]	Self help pack	Public sector employees	19-69	Scotland	194	6 months	6	+64 min/week (P<0.05)§	+64
Marinelli[w32]	Individualised marketing	Households	NR¶	Australia	589	3-11 months	5	+18 trips/year (SSNR)	+5
Socialdata (Perth pilot)[w33-w36]	Individualised marketing	Households	NR¶	Australia	413	12 months	5	+3 min/day (SSNR)	+21
Socialdata (Perth)[w37-w40]	Individualised marketing	Households	NR¶	Australia	1959	8 months	5	+3 min/day (SSNR)	+21
Sustrans (Frome)[w41]	Individualised marketing	Households	NR¶	England	749	4 months	5	+31 trips/year (SSNR)	+8
Sustrans (Gloucester pilot)[w42]	Individualised marketing	Households	NR¶	England	624	4 months	5	+25 trips/year (SSNR)	+7
Socialdata (Melville)[w43]	Individualised marketing	Households	NR¶	Australia	2410	10 months	4	+5 min/day (SSNR)	+35
Sustrans (Bishopston)[w44]	Individualised marketing	Households	NR¶	England	993	9 months	4	+2 min/day (SSNR)	+14
Sustrans (Cramlington)[w45]	Individualised marketing	Households	NR¶	England	796	9 months	4	+1 min/day (SSNR)	+7
Sustrans (Gloucester)[w46]	Individualised marketing	Households	NR¶	England	889	9 months	4	+2 min/day (SSNR)	+14
Sustrans (Nottingham)[w47]	Individualised marketing	Households	NR¶	England	1337	6 months	4	+2 min/day (in one area), +3 min/day (in another) (SSNR)	+18
Sustrans (Sheffield)[w48]	Individualised marketing	Households	NR¶	England	986	9 months	4	+2 min/day (SSNR)	+14
Haq[w49]	Individualised marketing	Households	NR¶	England	227	6 months	2	+0.1 km/week (SSNR)	+1
TAPESTRY (Viernheim)[w50]	Individualised marketing	City residents	NR¶	Germany	987	12 months	2	+16 trips/year (SSNR)	+4
School travel initiatives									
McKee[w51]	Active commuting pack	Primary schools	9-10	Scotland	55	7 weeks	4	+555 m/trip (95% CI +315 to +795)	+69
Rowland[w52]	School travel coordinator	Primary schools	6-10	England	1386	14 months	4	OR for not using car 0.98 (95% CI 0.61 to 1.59)	—
TAPESTRY (Hertfordshire)[w53]	Walk to school week	Primary schools	4-11	England	1403	3-4 weeks	2	+2% walking at least once a week (NS)	—
Miscellaneous transport interventions									
Shoup[w54 w55]	Subsidised non-car travel	Employees	NR¶	USA	1807	1-3 years	5	+1.1% in walking share of trips (P<0.01)	—
Troelsen[w56]	National cycling city	City residents	16-74	Denmark	1000	3-5 years	5	+0.1 km/day (SSNR)	+9
Hodgson[w57]	Sustainable transport campaign	Households	NR¶	England	1218	2 years	3	−0.2 trips/week (NS)	−2
Cervero[w58-w60]	Car sharing club	Members	NR¶	USA	NR¶	8-9 months	2	−3.4% in walking share of trips (NS)	—

NS=authors reported no significant difference; OR=odds ratio; SSNR=statistical significance not reported.
*Number of criteria met (maximum 7, see table 1). Only Mutrie[w31] and Rowland[w52] had random allocation.
†Net change in walking after adjustment for changes in the control group. 95% confidence intervals or P values included if reported by authors.
‡Continuous outcome measure converted to common outcome metric (min/week) where possible. Dash indicates conversion not possible.
§Tabulated effect size is that observed in the most sedentary subgroup, not across the whole study population.
¶Not reported. Most studies in the category "Targeted or individualised promotion of active travel" included travel of all household members.

WHAT IS ALREADY KNOWN ON THIS TOPIC

Accumulating 30 minutes of moderate intensity physical activity on most days of the week substantially reduces the risk of many chronic diseases

Walking is a popular, familiar, convenient, and free form of exercise by which many sedentary people could gain the health benefits of moderate intensity physical activity

Walking may be influenced by environmental and societal conditions as well as by interventions targeted at individuals

WHAT THIS STUDY ADDS

Interventions tailored to people's needs, targeted at the most sedentary or at those most motivated to change, and delivered either at the level of the individual or household or through groups can increase walking by up to 30-60 minutes a week on average, at least in the short term

the studies in our review found that any short term benefits associated with pedometers were sustained. The limited evidence base for the effects of attempts to change the societal or environmental determinants of walking may simply reflect the political or practical difficulties of implementing changes at the required scale to influence population patterns of activity[w25] or the scientific challenges of detecting comparatively dilute effects in whole population samples.[21]

Implications for policy and practice

About a third of adults in Britain report fewer than one episode of 30 minutes' moderate intensity physical activity of any kind each week.[3 4] Against this background, the average increase in walking of 30-60 minutes a week observed among targeted participants (typically sedentary, motivated to change, or both) in the most promising studies in this review is important. Over the longer term, or at the level of the population as a whole, the increase in walking attributable to a single intervention is likely to be substantially lower than this. Nevertheless, the successful implementation of combinations of interventions to promote walking clearly has the potential to make a substantial contribution towards increasing the activity levels of the most sedentary. In the absence of evidence to the contrary, however, we should remain alert to the possibility that targeted interventions of this kind may be preferentially taken up by better-off groups in the population and may therefore have the potential to increase health inequalities.

Our findings are consistent with (but certainly not proof of) an assumption that different types of people may respond to different approaches, tailored to their psychological characteristics or life circumstances. In other words, one size may not fit all and various approaches should be offered: some people may respond best to personal advice from their doctor, others may prefer the private feedback from a device such as a pedometer, others (perhaps those in a more advantaged socioeconomic position) may benefit from interventions delivered through the internet, others may benefit from the social support of a walking group, and others may increase their walking in response to prompts about reducing their car use on environmental grounds.

Unanswered questions and future research

Our findings illustrate an evaluative bias or "inverse evidence" law whereby to date we know least about the effects of interventions most likely to influence the health of the largest number of people.[22 23] We do not yet know whether or how the benefits of individual and group level interventions shown to be effective in selected groups or in the short term can be sustained and generalised, particularly (in many cases) to populations outside the United States and Australia. We need to establish more convincing evidence about the effects of interventions in the transport sector, which could be obtained by efforts to replicate the findings of promising but isolated studies and, more specifically, by testing the claims made for individualised marketing in an independent randomised controlled trial. We should also devote more effort to investigating the effects of large scale community level interventions, both planned health promotion activities and natural experiments involving major changes to the built environment.[15 21 24]

Few studies in this review found unequivocal improvements in health, risk factors for disease, or even overall levels of physical activity attributable to an increase in walking. Most studies did not look for (or were inadequately powered to detect) such benefits or possible adverse effects. Future intervention studies should therefore include the capacity to investigate whether increases in walking are sufficiently frequent, intense, or sustained to produce measurable improvements in anthropometric, physiological, biochemical, or clinical outcomes, or alternatively whether increases in walking might be counterbalanced or outweighed by decreases in other forms of physical activity or an increase in injuries.

At present, the epidemiological evidence for the health benefits of moderate intensity physical activity in general is not matched by a comparable degree of certainty about the effects and benefits of interventions to promote walking in particular, but the need for more intervention research does not obviate the need for those working both in and outside the health services to do something to tackle the public health problems associated with sedentary contemporary lifestyles.[1-12] Therefore, while we still have much to learn about exactly who will benefit from what type of intervention and by how much, this uncertainty should not be used as an excuse for inaction.

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VH, HR, DO, and NC screened the initial results of the literature searches. HR, DO, NC, CFF, and CEF appraised and extracted data from primary studies and analysed the findings. DO and HR drafted the manuscript. All authors contributed to the critical revision of the manuscript and approved the final version. DO is guarantor.

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