

BMJ Open What interventions increase commuter cycling? A systematic review

Glenn Stewart, Nana Kwame Anokye, Subhash Pokhrel

To cite: Stewart G, Anokye NK, Pokhrel S. What interventions increase commuter cycling? A systematic review. *BMJ Open* 2015;5:e007945. doi:10.1136/bmjopen-2015-007945

► Prepublication history and additional material is available. To view please visit the journal (<http://dx.doi.org/10.1136/bmjopen-2015-007945>).

Received 13 February 2015
Revised 11 July 2015
Accepted 20 July 2015

ABSTRACT

Objective: To identify interventions that will increase commuter cycling.

Setting: All settings where commuter cycling might take place.

Participants: Adults (aged 18+) in any country.

Interventions: Individual, group or environmental interventions including policies and infrastructure.

Primary and secondary outcome measures:

A wide range of 'changes in commuter cycling' indicators, including frequency of cycling, change in workforce commuting mode, change in commuting population transport mode, use of infrastructure by defined populations and population modal shift.

Results: 12 studies from 6 countries (6 from the UK, 2 from Australia, 1 each from Sweden, Ireland, New Zealand and the USA) met the inclusion criteria. Of those, 2 studies were randomised control trials and the remainder preintervention and postintervention studies. The majority of studies (n=7) evaluated individual-based or group-based interventions and the rest environmental interventions. Individual-based or group-based interventions in 6/7 studies were found to increase commuter cycling of which the effect was significant in only 3/6 studies. Environmental interventions, however, had small but positive effects in much larger but more difficult to define populations. Almost all studies had substantial loss to follow-up.

Conclusions: Despite commuter cycling prevalence varying widely between countries, robust evidence of what interventions will increase commuter cycling in low cycling prevalence nations is sparse. Wider environmental interventions that make cycling conducive appear to reach out to hard to define but larger populations. This could mean that environmental interventions, despite their small positive effects, have greater public health significance than individual-based or group-based measures because those interventions encourage a larger number of people to integrate physical activity into their everyday lives.

INTRODUCTION

Physical activity is increasingly recognised as a fundamental prerequisite for maximal health.¹ Its opposite, physical inactivity, which has been described as a global pandemic,² was estimated to cause 9% of global premature mortality in 2008 as well as 6% of

Strengths and limitations of this study

- Ours is the first study we know of to examine the evidence of interventions to increase commuter cycling, an activity that may potentially integrate physical activity into many people's lives.
- Studies were included of any methodological design with comparison groups and/or preintervention and postintervention data but needed to include cycle commuter outcomes.
- Despite wide variation between prevalence of cycling between countries, robust evidence of what interventions will increase commuter cycling is sparse.

the global burden of coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer and 10% of colon cancer.³ This is equivalent to the global burden of mortality caused by tobacco.¹ There is strong to moderate evidence for a 20–40% reduction in many long-term conditions including cardiovascular disease, coronary heart disease, stroke, type 2 diabetes, osteoarthritis, breast and colon cancer and depression⁴ as the result of being physically active. Up to 70% of the National Health Service (NHS) budget is estimated to be spent on long-term conditions.⁵

The WHO and at least 19 countries have issued physical activity guidelines.⁶ However, translating these guidelines into action has proven difficult; increasing technology and proliferation of labour-saving devices including motor-vehicles have increasingly removed physical activity from everyday life, and elite sporting events such as the Olympics or the FIFA football world cup have not encouraged mass participation.⁷

Environmental designs have been shown to increase physical activity, particularly for stair use,⁸ playgrounds and transport to schools.⁹ However, it is possibly unlikely that many will climb the stairs for bouts of 10 min as recommended by guidelines⁴ or that travel to school will impact significantly on adult behaviour, at least in the short term. Organisations may have a financial interest



CrossMark

Health Economics Research Group (HERG), Institute of Environment, Health and Societies, Brunel University London, Uxbridge, UK

Correspondence to

Glenn Stewart;
Glenn.Stewart@brunel.ac.uk

in protecting and promoting the health of their employees, particularly if an intervention is free, but these are likely to only include those employees in organisations that are either large enough and/or are inclined to develop such plans.¹⁰

As a year-round activity that is integrated into everyday life, active commuting would appear to be one means by which physical activity might be increased and maintained. In the UK, there are some 21.5 million people who undertake a 'regular commute to a fixed onshore location' for whom 64.2% have journeys under 10 km and 42.9% have journeys under 5 km,¹¹ a cycling distance considerably less than the 8 km cited by the British Medical Association (BMA)¹² that a 'person can easily cover'. While active commuting is largely defined to include both walking and cycling, it is cycling that has been found to be of sufficient intensity to meet the criteria for Health-Enhancing Physical Activity (HEPA),¹³ to require the 4 MJ (=955 kcal) weekly energy expenditure needed to reduce all-cause and cardiovascular mortality¹⁴ and to improve performance in untrained men and women. Despite this, levels of cycling vary widely from approximately 1% in Australia, the UK and the USA to 27% in the Netherlands.¹⁵

A number of reviews have therefore sought to examine the evidence of how the prevalence of physical activity can be increased through cycling.^{16–20} However, where these reviews seek to identify how to increase the prevalence of cycling, in general this may include cycling for transport, leisure, recreation, health or sport. It may be that commuter cycling—defined following the European Network for Cycling Expertise as journeying for the sake of completing a journey as opposed to a journey that is an end in itself²¹—is more likely to be continued and to have sustainable health gains. Increased commuter cycling may also have the additional benefits of avoiding the external costs of motorised transport including injuries, pollution (including noise pollution) and community severance.²² In an age of austerity, commuter cycling has further monetary implications for the individual and their family.

The Government recognises that increasing physical activity requires 'weaving incidental activity into our daily lives' including using bicycles for transport.²³ This was echoed in the recent NHS Five Year Forward View that there needs to be a 'radical upgrade in prevention and public health'.⁵ Policymakers will find implementation of this ambition difficult unless there is good-quality evidence of interventions that have examined evidence of interventions to increase commuter cycling. The nearest such review appears to have been by Yang *et al.*²⁰ While Yang *et al.* sought to determine what interventions are successful in promoting cycling for any purpose, this may not be ideal from a public health perspective. Cycling for sport or leisure need not become habitual in the way that commuting is largely a necessary activity and indeed may increase external costs as people use

motorised transport to arrive at a location where sport/leisure cycling is desirable. The aim of this review therefore was to add to the article by Yang *et al.* by identifying and analysing interventions designed to increase commuter cycling, for example, that was intended for travel from 'place to place'. The specific review question was therefore: what interventions increase commuter cycling?

METHODS

Data sources and search strategy

In October and November 2014, eight databases were searched including Scopus, ERIC, CINAHL, the Cochrane library, Digital Dissertations, Sports Discus, PsycINFO and Web of Science. Scopus is the largest ever bibliographic database and indexes over 20 000 titles from science, technology, medicine and the social sciences, is updated daily and contains both the Medline and EMBASE databases.²⁴

In each database, a set of core key words were used: **cycl* OR bik* OR cycle AND hire OR active and commut* OR active AND travel* OR green AND commut* OR green AND transport* OR green AND travel* OR ecological AND commut* OR ecological AND transport* OR non-motor* OR non-auto.** On the returned titles, database-specific filters were then applied to narrow the search. Table 1 presents the original hits in each database on core keywords search and how attrition happened as the database-specific filters were applied.

The final set of titles after applying relevant filters (n=9825) were then imported to RefWorks reference manager software. Duplicates (n=492) were removed to obtain 9333 titles ready for screening.

Study attributes required for inclusion (population, intervention, comparators and study designs)

Outcome variable

Commuter cycling may be affected by a wide range of factors such as urban planning, congestion, safety and perception of safety, pollution, petrol, pricing, etc.²⁵ This can lead to the 'inverse evidence law' whereby that which may have the most effect on health is precisely that which is least measured due to methodological considerations.²⁶ The application of strict inclusion criteria adopted by Ogilvie *et al.*¹⁷ or Yang *et al.*²⁰ was therefore precluded in favour of the more pragmatic approach adopted by Pucher *et al.*¹⁶ To be included, studies needed to report specifically on commuter cycling as a dependent variable (rather than walking and cycling combined) and indicate quantifiable changes in commuter cycling rather than modelling or stated preference studies or other variables that may influence levels of cycling but are not direct measurements such as perceived safety, opinion, confidence on a bicycle or attitude towards active transport. This, however, included a wide range of outcome measure such as changes at an

Table 1 Search strategy and results

Database	Initial number of hits with core keywords search	Attrition as database-specific filters was applied	Final number of hits after applying all filters
Scopus	845	Filter not used	845
ERIC	11 847	Limit to: academic journals—4879 Limit to: higher education, postsecondary education, case studies, intervention, program effectiveness—1789	1789
CINAHL plus	43 324	Limit to: academic journals—37 745 Limit to: cycling—2414 Limit to: adult—1359	1359
Cochrane library	39 218	Limit to: reviews—377	377
Digital Dissertations	Just over 1 million	Limit to: scholarly journals—326 607 Limit to: American J of PH, Social Research, Health Affairs—2938	2938
PsycINFO	56 448	Limit to: academic journals—47 213 Population—human—11 366 Subject—health, physical activity—196	196
Sports Discus	95 808	Limit to: academic journals—23 166 Subject thesaurus term—cycling, exercise, physical fitness, cyclists, prevention—1494 Subject—males, comparative studies, young adults, evaluation, adulthood, women, teenagers, research, middle age, case studies—615	615
Web of Science	Just over 1 million	Limit to: engineering, behavioural sciences, public environmental occupational health, sports sciences, healthcare sciences services, sociology—371 085 Research domains—restrict to behavioural sciences, public environmental occupational health, sports sciences, healthcare sciences services, sociology, life sciences, biomedicine other topics, social issues, social sciences other types—194 675 Research areas—restrict to behavioural sciences, public environmental occupational health, engineering, social sciences other topics, urban studies, transportation—144 459 Limit to: articles—125, 612 English—114 955 Limit to: transportation, urban studies—827	827
Total databases searched=8	Total initial hits=over 2 million	Total after applying filters=9825	Total imported to RefWorks=9825

aggregate population level, number of days cycling, distance, time taken cycling and time at follow-up.

Eligibility criteria

To be included in the review, studies needed to include comparison groups and/or preintervention and postintervention data, include adults rather than schoolchildren, include data on cycling rather than aggregated data of walking and cycling, include data relating to commuting to work and be written in English (table 2). All study designs (except correlation studies identifying determinants of commuter cycling) were eligible, as the intention was to capture wider public health interventions, noting that often such evaluations are not limited to robust study designs such as the randomised controlled trials.

Identification of studies

In level 1 screening, the titles, abstracts and keywords of 9333 non-duplicates were screened according to the criteria set out in table 2 by the lead author (GS). This screening excluded a large number of studies (n=9267), leaving only 66 studies to be retrieved for full-text screening. In level 2 screening, all 66 full texts were screened independently by two authors (GS and SP) by applying the eligibility criteria. Disagreement (n=2/66) was settled by asking the opinion of the third author (NKA) and reaching a consensus thereafter. This screening process led to 54 studies not being eligible, and therefore they were excluded from further review. The reasons for exclusion were: correlation studies (n=16); no pre-post data (n=11); did not provide the outcome

**Table 2** Eligibility criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> ▶ Evaluation studies with comparison groups and/or preintervention and postintervention data ▶ Adults rather than schoolchildren ▶ Data relating to commuting to work ▶ Written in English 	<ul style="list-style-type: none"> ▶ Correlation studies (identifying determinants of commuter cycling) ▶ No comparison groups or pre–post data available ▶ Did not provide outcome data in the format needed for this review <ul style="list-style-type: none"> – Indiscriminate data (eg, has only aggregated data of walking and cycling) – Irrelevant data (has data only on other forms of commuting, eg, walking only or cycling for recreation) ▶ Non-evaluation (eg, editorials, commentaries, opinion pieces) ▶ Others, eg <ul style="list-style-type: none"> – Temporal/trend analysis of cycling behaviour – Reviews of correlation studies – School children – Written in a language other than English

data in the format needed for this review (n=14); non-evaluation articles (n=4); and others (n=9).

A total of 12 studies were thus identified as eligible for full review. [Figure 1](#) depicts a PRISMA diagram of the study identification and inclusion process.

Quality appraisal

The first author (GS) extracted data on the 12 included studies using a predefined data extraction table, informed by the Centre for Reviews and Dissemination guidelines²⁷ and National Institute for Health and Care Excellence (NICE)²⁸ (see online supplementary appendix 1). The first author (GS) developed the data extraction table and piloted it by extracting data on one study. This was reviewed by the other two authors before finalising it.

Two authors (GS and NA) then independently applied a quality checklist extracted from NICE's public health guidance methods manual²⁸ on 25% (n=3/12) of included studies. This checklist covered several questions enabling the reviewers to judge the quality of each study. A quality rating was also given for all included studies as per the checklist guidelines. There was no disagreement in overall quality ratings between the two reviewers on those 3/12 studies. However, minor disagreement emerged in answering some questions in the checklist—which was settled by seeking the opinion of the third author and reaching a consensus. Then the first author completed quality assessment on the remaining studies. Of the 12 included studies, 1 study²⁹ was given a “++” rating (ie, study designed to minimise risk); 3 studies^{30–32} were given a “+” rating (ie, potential sources of bias not addressed in the study or not clear from the way the study was reported); and 8 studies were given a “–” rating (ie, study with significant sources of bias).

Data analysis

The data were analysed qualitatively, considering four key attributes underlying the robustness and

generalisability of included evidence: (1) the population size where the claimed effect was observed/measured; (2) the robustness of the comparator; (3) the extent to which the interventions being evaluated were able to increase commuter cycling prevalence and (4) the robustness of the study design. The information retrieved through data extraction tables, coupled with assessments in the quality appraisal checklist, was used to inform each of the above four domains. As interventions were a mixture of environmental and individual-focused/group-focused measures, no meta-analysis of data was attempted. As such, we chose to present the findings as a narrative synthesis.

RESULTS

Study characteristics

Of the 12 included studies, 6 were from the UK, 2 from Australia, 1 each from Sweden, Ireland, New Zealand and the USA. Of those, two studies were randomised control trials (RCT)^{29 31} and the remainder preintervention and postintervention studies. The majority of studies (n=7) evaluated individual-based or group-based interventions and the rest environmental interventions. [Table 3](#) includes the characteristics of included studies.

Individual or group interventions

The two RCTs included in this review evaluated individual interventions that were based on provision of written information or advice and a bicycle by health professionals to encourage cycling. Mutrie *et al*,³¹ a Scottish study, aimed to increase active commuting among 295 employees at three workplaces in Glasgow. Hemmingsson *et al*,²⁹ a Swedish study, intended to increase levels of physical activity through a support programme involving three aims (awareness raising, countering and helping relationships) in obese women. The Scottish study was based on the transtheoretical model of behaviour change providing self-help materials to

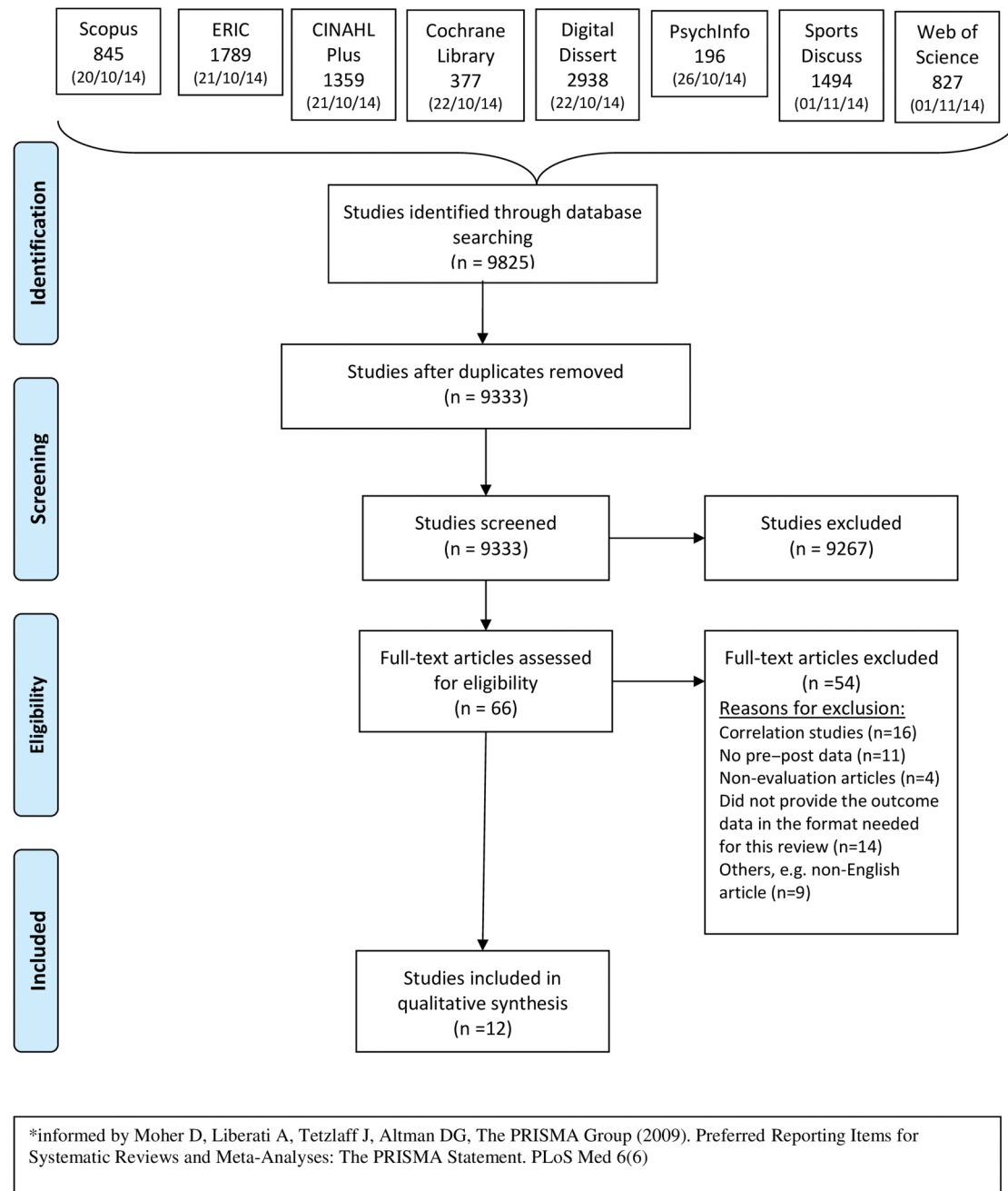


Figure 1 PRISMA diagram of the study identification and inclusion process (Digital Dissert, Digital Dissertations).

people either thinking about active commuting (contemplators) or irregular commuters (preparers). Follow-up at 6 months found that while 18% more participants in the intervention group (compared with the control group) moved to a higher stage of active commuting behaviour, the significant difference was largely attributed to walking and not cycle commuting. Only 18 people (of the 295) were cycling with no difference between the intervention and control groups. The Swedish study, however, reported an effective intervention. They compared two different support programmes to increase physical activity through active commuting. The intervention group received physician meetings,

physical activity prescriptions, group counselling and bicycles compared with the control group which received low-intensity group support and pedometers at 6 months. The mean proportion of intervention group participants (n=60) commuting with a bicycle at least once a week during months 2–18 was 29.4% compared with 8% in the control group.

Workplace travel plans that seek to encourage active travel programmes have been promoted as having advantages to the employee (health) and employer (lower absenteeism). These may include 'bike to work' (BTW) initiatives. Three studies examined the effects of such programmes in England (Bristol),³³ Australia³⁴ and New

Table 3 Characteristics of and results from included studies

Serial number	Study	Country/setting	Intervention	Study design	Time period	Sample size	Effect
1	Brockman and fox ³³	England (University of Bristol)	Workplace travel plan(s)	Preintervention and postintervention	Surveys from 1998 to 2007	1950–2829	Percentage usually cycling to work increased from 7% to 12% but was not significant
2	Hemmingsson <i>et al</i> ²⁹	Sweden/community	Support programme (awareness raising, countering and helping relationships)	RCT	18 months	120	Proportion of participants cycling >2 km/day was 38.7% (OR 7.8)
3	Mutrie <i>et al</i> ³¹	Scotland/Hospital Trust, Health Board and University	Workplace; self-help pack including maps, activity diary, safety accessories	RCT	6 months	295 people identified as thinking about active travel	No effect
4	Telfer <i>et al</i> ³⁶	Australia (Sydney)	Cycle proficiency training	Preintervention and postintervention	2 months	113	No difference in mean frequency or duration of cycle trips
5	O'Fallon ³⁵	New Zealand—number of workplaces	Number of workplace interventions	Preintervention and postintervention	12 months	3825	675 respondents to cycle question—112 cycled less (16.6%), 347 (51.4%) about the same and 216 (32.0%) more
6	Johnson and Margolis ³⁷	London—community setting	Cycle training	Preintervention and postintervention	12 months	130	Number of days cycled to work in the last week increased from 0.66 to 1.33
7	Caulfield ³⁹	Ireland—Dublin	Whole city approach	Preintervention and postintervention	5 years	Dublin population 1.2 million	Percentage of cyclists increased from 4% to 5% (20 588 to 26 670)
8	Rose and Marfurt ³⁴	Australia (Victoria)	Ride To Work Day	Preintervention and postintervention	5 months	5577	27% of first-time riders still cycling to work after 5 months
9	McCartney <i>et al</i> ³⁸	Scotland—Glasgow	Building a bridge	Preintervention and postintervention	2007–2010	216 897 people living south of city centre	47.5% increase in the number of cyclists (n=approximately 400)
10	Goodman <i>et al</i> ³⁰	England—Cycling Cities and Towns initiative (12 locations)	Whole city approaches	Preintervention and postintervention	2008–2012	1 266 337	0.69 percentage point increase in cycling to work in intervention towns, compared with matched towns
11	Goodman <i>et al</i> ³²	England (3 cities/towns)	Changes in walking and cycle infrastructure	Preintervention and postintervention	2010–2012	22 500 (residents within 5 km of projects)	At 2 year follow-up, 18% of people who knew about project reported transport cycling compared with 7% of full sample
12	Krizek <i>et al</i> ⁴⁰	US—Minneapolis	Changes in cycle infrastructure	Preintervention and postintervention	1990–2000	4855	0.493 percentage point increase in bicycle modal share

RCT, randomised control trial.

Zealand.³⁵ Results were again mixed; in Bristol, the University travel survey indicated a non-significant rise in the cycle commuting modal share from 7% in 1998 to 11.8% following the implementation of a workplace travel plan. In Australia, in 2004, 5577 people registered for the *Ride to Work Day event* of whom baseline data was received from 1952 (35%). Of these, 17% indicated that they had not cycled to work before the event. At 5 months postevent, 27% of first-timers were still cycling to work (defined as at least once a week) compared with 67% of those who had been cycling to work before the event. In New Zealand, 40 organisations were originally recruited to the 'Bike Now' programme of which 27 (675 workers) remained in the programme at 1 year. Of these, 112 (16.6%) of 675 respondents indicated that they were cycling less, 347 (51.4%) about the same and 216 (32.0%) more. None of the above included a control group.

Two studies examined the effect of cycling training on cycling to work. Results were not consistent; in Sydney, a telephone 1-week recall interviews found no difference in either duration or frequency of cycling at 2 months (including number of days cycled to work) following a cycling proficiency training programme (n=110) although statistically significant increases in those who did not cycle before the course were found.³⁶ In London, 3-month postintervention questionnaires found that the mean number of days cycled to work increased from 0.66 to 1.33 in the past week.³⁷ Neither study included a control group. Loss to follow-up from the London study was high (104 responses from 471 participants).

Environmental interventions

Environmental interventions were either a relatively small single intervention (eg, the construction of a bridge³⁸) or a larger programme such as the English Cycling Cities and Towns (CCT) initiative that targeted 12 cities and towns with some 2.7 million residents over 3 years³⁰ or several policies taken together on cycle commuter prevalence.³⁹

The opening of a bridge in Glasgow was associated with a 47.5% increase in the number of cyclists entering the city centre from the South with almost no change in numbers of cyclists crossing other bridges. Some of this change may have been accounted for by road works associated with the construction of the M74 which was not controlled for.³⁸

The English CCT programme aimed to increase cycling through capital and revenue investment provided through competitive tendering to the respective CCTs. Changes in cycle commuting between 2001 and 2011 in the CCTs were compared with changes in matched towns using a 'difference in difference' analysis. Controls were either statistically matched towns, towns that had applied unsuccessfully for funding or a non-London national comparison group (all non-intervention urban areas outside London with a population of over 30 000). The 'difference in difference'

analysis indicated that compared with matched towns, cycling to work in the intervention towns increased by 0.69 percentage points with larger differences in differences compared with the unfunded comparison group (1.02 percentage points) and the national comparator (1.23 percentage points). Although seemingly small in effect, the size of the sample population in the 12 towns (1 266 337 in the 2011 census) indicates that the absolute percentage change in cycle commuting (0.97%) may have a large public health significance.³⁰

In Ireland, the Department of Transport set targets of increasing cycling from 2% of journeys in 2009 to 10% by 2020. In Dublin, commuter cycling was hypothesised to result from financial incentives (tax-free loans to purchase cycles), infrastructure change (traffic calming, cycle lanes including segregated lanes), promotional events such as Bike week (family rides, removing traffic from streets, repair clinics and promotion talks), a shared bike scheme and publication of the first design standards for cycling in Ireland.³⁹ Census data indicated that results were equivocal; cycle modal share fell from 6% in 1996 to 4% in 2002 and 2006 but had risen to 5% in 2011. In Cork, cycle modal share fell from 2% in 1996 to 1% from 2002 onwards, whereas in Galway it fell from 3% in 1996 to 2% from 2002. However, it is not clear as to what extent the 2008 financial crisis in Ireland might have affected the results.

In three UK cities/towns, traffic-free infrastructure (a main project plus feeder routes) were evaluated for their effects on residents living within 5 km of the respective projects.³² A total of 22 500 survey packs were distributed to which 3516 people replied of whom 53% and 43% provided data at the 1-year and 2-year follow-ups, respectively (excluding those who had moved house). Respondents were asked if they had cycled on the infrastructure for six journey purposes including commuter cycling. At the 2-year follow-up, 18% of people who knew about the project reported transport cycling compared with 7% of the full sample. However, the multivariate statistical analysis presented in the study provided data on infrastructure use for any purpose rather than commuter cycling.

One US study⁴⁰ assessed the effects of transport/cycle infrastructure on cycle commuting. Cycle commuter modal share increased in central Minnesota (from 2.8% to 3.3% at the University of Minnesota (n=4855)) and Minneapolis (from 0.788 to 0.841, n=21 111) where cycle facilities had been implemented or improved, compared with the suburbs where cycle commute share fell from 0.335% to 0.279% (n=9016). This study, however, was not immune to other external influences and, as acknowledged, the 'Lance Armstrong effect' may have been present at the time.

DISCUSSION

This review improves our understanding as to what interventions are likely to increase commuter cycling, an



activity that may potentially integrate physical activity into many people's lives. There is wide agreement that increased population levels of physical activity would make substantial improvements to health. Intuitively, the potential for commuter cycling to at least partially meet this need is large. In Europe, most car journeys are less than 5 km, most people can cycle, the financial costs are small, and for the individuals, financial savings would be made against the cost of motorised or public transport. There is also evidence of where this has been achieved—in countries such as Holland, Germany and Denmark, a substantial proportion of journeys are by bicycle, including those by people aged 65+.¹⁵ Despite all this, this review highlights how little robust research evidence exists on what may increase commuter cycle prevalence in low cycling nations.

Of the two RCTs included in the review, only one found evidence of effectiveness but in a select population of obese women—which may therefore lack external validity for the wider population. The second RCT found no evidence of effectiveness even in people assessed, through the transtheoretical model of behaviour change, as at least ready to begin to change. Other individual-based or group-based studies that assessed the effectiveness of interventions on populations opting into programmes found either no or small effect sizes, again indicating a lack of evidence for their applicability at a population level. This review also found that many studies did not include relevant control groups and had high rates of loss to follow-up, indicating a high risk of bias and that the effect of external factors cannot be discounted.

Wider environmental interventions perhaps have the potential to have a greater though more dilute effect over a greater proportion of the population. Evaluation of environmental interventions includes several methodological issues that have been well documented,⁴¹ including defining what may be described as the denominator population (working population, working population from a particular area or the whole population). As included studies did have some of these issues present in their design, there is a clear paucity of evidence of effectiveness. NICE guidance acknowledges that a range of factors may be important in helping or restricting people from cycling⁴² and that may reflect the challenge of rigorous evaluation in this field. However, it is also noted that even small changes at a population level can have significant effects and therefore important implications for population health. For example, the 0.69 percentage point differential effect of an environmental intervention in England implies that over 8000 people started commuter cycling, following the implementation of CCT. Therefore, environmental interventions, despite showing small effect sizes, appear to have more public health significance than individual-based/group-based interventions, as they will reach out to many more people (though often harder to define populations) to encourage integration of physical activity into everyday life via commuter cycling.

This review has its own limitations which stem largely from major weaknesses of the included studies. Evaluation of real-world interventions where variables cannot be controlled by researchers can be challenging, as found in the case of all included studies. Studies suffered from high dropout rates (almost all studies had substantial loss to follow-up) and used numerous measures of outcome variables (commuter cycling) which were difficult to compare meaningfully. Most studies suffered from the lack of robust comparison groups, leading to a less robust alternative of measuring outcomes preintervention and postintervention instead. Significant aspects of potential bias in those studies therefore cannot be ruled out. Put together, this review was limited to a narrative synthesis of evidence rather than a more robust quantitative meta-analysis.

Finally, the paucity of high-quality evidence found in this review may highlight an important methodological issue related to the review itself. As noted by Pucher *et al*,¹⁶ interventions that might affect cycling prevalence are many and varied but few may be published. By restricting its focus to commuter cycling, this review may have excluded a number of interventions that increased general and commuter cycling. Given the potential for health gain, the lack of robust evidence on effective interventions may be disappointing for policymakers. More research is therefore needed to fill in this important gap as well as to further our understanding as to how lessons learnt in high cycling-prevalent countries can be applied to other countries.

CONCLUSION

Despite its potential to increase health, there is little robust evidence of effective interventions to increase commuter cycling even at a subpopulation level. Many studies lack appropriate controls, their external validity to the wider population remains unclear, and they have high rates of loss to follow-up—all indicating a high risk of bias. Wider environmental interventions that make cycling conducive appear to reach out to hard to define but larger populations. This could mean that environmental interventions, despite their small positive effects, have greater public health significance than individual-based or group-based measures because those interventions encourage a larger number of people to integrate physical activity into their everyday lives. More research is needed to establish how prevalence of commuter cycling can be increased.

Acknowledgements The authors would like to thank Professor Christina Victor and Dr Geraldine Barrett for their critical comments earlier in the review process. They hugely benefited from the comments made by the two referees who reviewed the manuscript on first submission.

Contributors This study is a part of GS doctoral thesis. GS conceptualised, designed and executed the study with significant inputs from NKA and SP throughout. GS prepared the first draft of this manuscript, which was commented on and revised by NKA and SP. All authors have read and approved the manuscript.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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

- Das P, Horton R. Rethinking our approach to physical activity. *Lancet* 2012;380:189–90.
- Kohl HW, Craig CL, Lambert EV, *et al*. The pandemic of physical inactivity: global action for public health. *Lancet* 2012;380:294–305.
- Lee IM, Shiroma EJ, Lobelo F, *et al*. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 2012;380:219–29.
- Department of Health. *Start Active, Stay Active. A report on physical activity for health from the four home countries' Chief Medical Officers*. 2011.
- National Health Service. Five Year Forward plan. 2014.
- IHRSA. Physical Activity Guidelines International. http://download.ihrsa.org/publicpolicy/Physical_Activity_Guidelines_INTL.pdf
- Hallal PC, Bauman AE, Heath GW, *et al*. Physical activity: more of the same is not enough. *Lancet* 2012;380:190–1.
- Foster C, Hillsdon M. Changing the environment to promote health-enhancing physical activity. *J Sports Sci* 2004;22:755–69.
- Reynolds R, McKenzie S, Allender S, *et al*. Systematic review of incidental physical activity community interventions. *Prev Med* 2014;67:46–64.
- Hosking J, Macmillan A, Connor J, *et al*. Organisational travel plans for improving health. *Cochrane Database Syst Rev* 2010;3:CD005575.
- Office for National Statistics. 2011 Census Analysis—Distance Travelled to Work, 2014.
- British Medical Association. Healthy Transport=Healthy Lives. 2010.
- Oja P, Vuori I, Paronen O. Daily walking and cycling to work: their utility as health-enhancing physical activity. *Patient Educ Couns* 1998;33:S87–94.
- Shephard RJ. Is active commuting the answer to population health? *Sports Med* 2008;38:751.
- Pucher J, Buehler R. Making cycling irresistible: lessons from the Netherlands, Denmark, and Germany. *Transport Rev* 2008;28.
- Pucher J, Dill J, Handy S. Infrastructure, programs, and policies to increase bicycling: an international review. *Prev Med* 2010;50(Suppl 1):S106–25.
- Ogilvie D, Egan M, Hamilton V, *et al*. Promoting walking and cycling as an alternative to using cars: systematic review. *BMJ* 2004;329:763–6.
- Fraser SD, Lock K. Cycling for transport and public health: a systematic review of the effect of the environment on cycling. *Eur J Public Health* 2011;21:738–43.
- Krizek KJ, Forsyth A, Baum L. *Walking and Cycling International Literature Review*. Final Report. 2009.
- Yang L, Sahlqvist S, McMinn A, *et al*. Interventions to promote cycling: systematic review. *BMJ* 2010;341:c5293.
- Aldred R. A Matter of Utility? Rationalising Cycling, Cycling Rationalities. Mobilities. 2014. doi:10.1080/17450101.2014.935149
- Mindell JS, Watkins SJ, Cohen JM. Health on the Move 2. Policies for health promoting transport. Stockport: Transport and Health Study Group, 2011.
- Public Health England. Everybody active, every day. An evidence based approach to physical activity. Public Health England, 2014.
- Brunel University. Databases Webpage. Site accessed 1st November 2014.
- Heinen E, van Bee B, Kees M. Commuting by bicycle: an overview of the literature. *Transport Rev* 2010;30:59–96.
- Ogilvie D, Egan M, Hamilton V, *et al*. Systematic reviews of health effects of social interventions: 2. Best available evidence: how low should you go? *J Epidemiol Community Health* 2005;59:886–92.
- Centre for Review and Dissemination. Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health care. 2009.
- NICE. *Methods for the development of NICE public health guidance (third edition): Appendix F Quality Appraisal Checklist—quantitative intervention studies*. 3rd edn. National Institute for Health and Care Excellence, 2012.
- Hemmingsson E, Udden J, Neovius M, *et al*. Increased physical activity in abdominally obese women through support for changed commuting habits: a randomized clinical trial. *Int J Obes* 2009;33:645–52.
- Goodman A, Panter J, Sharp SJ, *et al*. Effectiveness and equity impacts of town-wide cycling initiatives in England: a longitudinal, controlled natural experimental study. *Soc Sci Med* 2013;97:228–37.
- Mutrie N, Carney C, Blamey A, *et al*. "Walk in to Work Out": a randomised controlled trial of a self help intervention to promote active commuting. *J Epidemiol Community Health* 2002;56:407–12.
- Goodman A, Sahlqvist S, Ogilvie D. Who uses new walking and cycling infrastructure and how? Longitudinal results from the UK iConnect study. *Prev Med* 2013;57:518–24.
- Brockman R, Fox KR. Physical activity by stealth? The potential health benefits of a workplace transport plan. *Public Health* 2011;125:210–16.
- Rose G, Marfurt H. Travel behaviour change impacts of a major ride to work day event. *Transportation Res Part A* 2007;41:351–64.
- O'Fallon C. Bike Now: Exploring methods of building sustained participation in cycle commuting in New Zealand. *Road and Transport Research* 2010;19(2).
- Telfer B, Rissel C, Bindon J, *et al*. Encouraging cycling through a pilot cycling proficiency training program among adults in central Sydney. *J Sci Med Sport* 2006;9:151–6.
- Johnson R, Margolis S. A review of the effectiveness of adult cycle training in Tower Hamlets, London. *Transport Policy* 2013;30:254–61.
- McCartney G, Whyte B, Livingston M, *et al*. Building a bridge, transport infrastructure and population characteristics: explaining active travel into Glasgow. *Transport Policy* 2012;21:119–25.
- Caulfield B. Re-cycling a city—examining the growth of cycling in Dublin. *Transportation Res Part A* 2014;61:216–226.
- Krizek K, Barnes G, Thompson K. Analyzing the effect of bicycle facilities on commute mode share over time. *J Urban Plann Dev* 2009;135:66–73.
- Petticrew M, Cummins S, Ferrella C, *et al*. Natural experiments: an underused tool for public health? *Public Health* 2005;119:751–7.
- National Institute for Health and Clinical Excellence (NICE). Walking and cycling: local measures to promote walking and cycling as forms of travel or recreation 2012.

What interventions increase commuter cycling? A systematic review

Glenn Stewart, Nana Kwame Anokye and Subhash Pokhrel

BMJ Open 2015 5:

doi: [10.1136/bmjopen-2015-007945](https://doi.org/10.1136/bmjopen-2015-007945)

Updated information and services can be found at:
<http://bmjopen.bmj.com/content/5/8/e007945>

These include:

Supplementary Material

Supplementary material can be found at:
<http://bmjopen.bmj.com/content/suppl/2015/08/14/bmjopen-2015-007945.DC1.html>

References

This article cites 27 articles, 5 of which you can access for free at:
<http://bmjopen.bmj.com/content/5/8/e007945#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

[Public health](#) (1113)

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/>