



Foster, C., Kelly, P., Reid, H. A. B., Roberts, N., Murtagh, E. M., Humphreys, D. K., Panter, J., & Milton, K. (2018). What works to promote walking at the population level? A systematic review. *British Journal of Sports Medicine*, 52(12), 807-812.
<https://doi.org/10.1136/bjsports-2017-098953>

Peer reviewed version

Link to published version (if available):
[10.1136/bjsports-2017-098953](https://doi.org/10.1136/bjsports-2017-098953)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via BMJ at <http://bjsm.bmj.com/content/52/12/807>. Please refer to any applicable terms of use of the publisher.

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/>

What works to promote walking at the population level? A systematic review

Charlie Foster, Paul Kelly, Hamish Reid, Nia Roberts, Elaine Murtagh, David K. Humphreys, Jenna Panter, Karen Milton

Corresponding author: Charlie Foster

Centre for Exercise Nutrition and Health Sciences, School
for Policy Studies, Priory Road, University of Bristol, BS8 1TZ
charlie.foster@bristol.ac.uk
phone: +44 -1173310931

Other authors:

Paul Kelly: Physical Activity for Health Research Centre, Institute of Sport, Physical Education and Health Sciences, University of Edinburgh, Edinburgh, UK

Hamish Reid: The Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Medical Sciences Division, University of Oxford, Oxford, UK

Nia Roberts: Knowledge Centre, Nuffield Department of Population Health, University of Oxford, Oxford, UK

Elaine Murtagh: Department of Arts Education and Physical Education, Mary Immaculate College, Limerick, Ireland

David K. Humphreys: Department of Social Policy and Intervention, University of Oxford, UK

Jenna Panter: MRC Epidemiology Unit & CEDAR, University of Cambridge School of Clinical Medicine, Cambridge, UK

Karen Milton: Norwich Medical School, University of East Anglia, Norwich, UK

Key words: walking, public health, systematic review

Word count: abstract 249, main text (without tables and references)

What works to promote walking at the population level? A systematic review

Charlie Foster, Paul Kelly, Hamish Reid, Nia Roberts, Elaine Murtagh, David Humphreys, Jenna Panter, Karen Milton

Abstract

Objective. Interventions to promote walking have focused on individual or group based approaches – often via the RCT design. Walking can also be promoted using population health approaches. We systematically reviewed the effectiveness of population approaches to promote walking among individuals and populations.

Design. A systematic review

Data Sources. 10 electronic databases searched from January 1990 to March 2017

Eligibility Criteria. Pre and post or experiment studies of the effects of population interventions to change walking. Effects must have been compared with a “no intervention,” or comparison group/area/population, or variation in exposure; duration ≥ 12 months follow up; participants in free-living populations; English language articles.

Results. 12 studies were identified from mostly urban high-income countries (one focusing on using a tax – incentivising the loss of parking spaces); one using policy only (permitting off-leash dogs in city parks). Five studies used mass media with either environment (n=2) or community approaches (n=3). Four studies used environmental changes that were combined with policies. One study had scaled up school-based approaches to promote safe routes to schools. We found mass media, community initiatives and environmental change approaches increased walking (range from 9 to 75 mins/week).

Summary. Delivering mass media, community initiatives and environmental change together appears to lead to more walking at the population level. There are insufficient data to comment on effectiveness of specific activities within population experimental studies.

word count; 223

INTRODUCTION

“Walking is the only sustained dynamic aerobic activity that is at all common in the population today, so it makes good sense to build on it” (p326). This observation by Morris and Hardman reflects the two key reasons for their conclusion, *“walking is the nearest activity to perfect exercise”* (p328).¹ Walking consistently contributes the largest proportion to overall activity across age groups.² Secondly walking can be promoted through interventions targeted towards individuals and whole populations via changes in physical environments.³

The 2017 Bangkok Declaration for Physical Activity highlighted the contribution that walking and physical activity promotion can make across broad policy sectors via development and sustainability agendas as well as direct improvements to physical and mental health.⁴ Reviews of mechanistic trials report the direct impact of walking upon health parameters including improving aerobic capacity, physical functioning and reducing blood pressure, and improving metabolic and weight profiles.⁵ In England, if one in ten adults (aged 40-60 years) achieved ten minutes of brisk walking per day it would save £310 million per year.⁶

Ogilvie and colleagues identified a range of key behavioural strategies to initiate and sustain walking, with the majority of interventions targeted towards individuals, assessed using randomised controlled trials (RCTs), rather than communities or populations.⁷ One potential problem with individual approaches is that they may be resource intensive and difficult to scale-up. Additionally they do not provide national and local policy makers with feasible actions that can be implemented.

To increase physical activity at scale, requires population-based interventions that target entire populations. Population approaches to prevention aim to reduce key risk factors in the whole population, irrespective of individual level of risk. They achieve this by bringing about small changes in risk factor levels in the whole population, resulting in a shift in the population distribution of risk.

Development of population approaches to promote physical activity have been slow compared to other health behaviours, reflecting both the challenge of identifying what population-based approaches are, how they can be implemented, and how best to evaluate their impact.⁸ The American Heart Association identified a range of population-based approaches for diet, smoking and physical activity using six broad domains of interventions: (1) media and educational campaigns; (2) labelling and consumer information; (3) taxation, subsidies, and other economic incentives; (4) school and workplace approaches; (5) local environmental changes; and (6) direct restrictions and mandates.⁹ They reported the majority of population approaches

were found within schools, workplaces and local environment interventions categories, with none within direct restrictions and mandates. Echoing Ogilvie et al's previous findings, this suggests that the definition of a population-based approach for physical activity is a mix of *what action* and *at what scale*.⁷

The challenges to evaluating population-based approaches have been partially addressed through the increased use of "natural experiments".¹⁰ Here we bring together, for the first time, the global evidence for population-based approaches for walking, by extending our previous review of walking interventions.⁷ We aimed to review the effectiveness of population approaches to promote walking among individuals and populations. We assessed whether any population interventions have had sustained effects assessed by longer-term follow-up to see whether changes were truly sustained at scale.³

METHODS

Registration

This study is registered in PROSPERO as CRD42014013143.

Data Search

We included for consideration all studies from our earlier systematic review (1990-2006).⁷ We ran an updated searches using 10 databases: Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, MEDLINE, PubMed, EMBASE, DARE, Science Citation Index, Social Science Citations, SPORTDiscus, PsycINFO. We use the same search terms as our previous review and searched using the timeframe March 2006- March 2017. We conducted a purposive search of three additional websites (Active Living Research, Sustrans (a UK based sustainable transport charity), Transport Research Laboratory), identified possible studies from systematic reviews, and snowballed potential studies from reference lists of included studies. We also contacted authors of included studies and asked them to identify any additional studies. The full strategy is presented as "Supplementary File".

Eligibility Criteria

We selected studies based on the following inclusion criteria: randomised controlled trials and non-randomised controlled pre and post experimental, "natural" experiment or observational studies of the effects of any type of intervention which aimed to change walking. Walking was defined as commonly understood in everyday life, undertaken for any or all purposes including transport, leisure, sport, dog walking, exercise or fitness. We included studies where the outcome measures were assessed at least 12 months after the start of the intervention and where the effects of the

intervention were compared with those observed in a “no intervention,” “attention control,” or “minimal intervention” control or comparison group, area, or population, or where controlled comparisons were made (for example where variation in exposure was used as the basis for comparisons (e.g. based on distance). We excluded studies in which the ‘control’ condition consisted of an alternative intervention which was intended or likely to promote walking and which exceeded what we judged could reasonably be described as ‘standard’ or ‘usual’ care, treatment or practice. Studies had to include free-living populations (not part of any institutionalised community, e.g. prison population) within a community as defined by a geographical boundary. Participants in studies needed to be exposed to the intervention and not within a local small area (for example one park or street).¹¹ We included English language articles published in peer-reviewed journals between January 1990 and March 2017.

We defined population-based approaches to promote walking as approaches involving one or more of the following approaches; (1) mass media, social media and education campaigns – for example media campaigns with technological support; (2) taxation, subsidies, and other economic incentives - for example subsidised gym membership, financial incentives to cycle/ disincentives to drive; (3) regional or federal community, school and workplace approaches (must be at scale); (4) environmental changes – for example: bike trails, cycle parking, pedestrianised city centres, new parks, improvements to existing parks, closing streets; and (5) policies with direct restrictions and mandates – for example building regulations, speed restrictions on roads.

Study Selection

Titles and abstracts were screened by three authors (KM, PK, HR), with 10% sample of exclusion decisions (other than obviously irrelevant studies) being cross-checked by another reviewer (CF). Three authors (CF, KM, PK) independently screening for eligibility against the inclusion criteria with any disagreements resolved jointly against inclusion criteria.

Data Extraction

At least two from three authors (CF, KM, PK) extracted data independently for the characteristics of included studies with the lead author (CF) extracting data from all studies. The authors reviewed all undecided data in plenary session.

Assessment of the risk of bias

We assessed study validity using seven binary criteria identical to those used in our previous systematic review. These criteria are applicable across the range of included study designs rather than applying a metric from within one study design. Indeed this approach is considered more appropriate to these types of reviews, which include a variety of study designs rather than using the assessment criteria for risk of bias within

one study type.¹² Two authors assessed these criteria independently for randomization, exposure, representativeness, comparability, attrition or sample size, period of assessment (period of time used for the measurement of walking), and whether the instrument used to assess walking was appropriate to the research question(s) of the study.

Synthesis of results

We categorised studies according to the main approach of the intervention studied. We summarised the walking outcomes 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. We examined the types of interventions, study designs, participants, and outcome metrics and the durations of follow-up. We repeated our previous analysis by plotting the relation between estimated effect size and sample size in descending order of study validity, using the common single metric across studies, net change in time spent walking (minutes/week).⁷ Given the heterogeneity of included studies we were unable to conduct a meta-analysis, nor a forest plot (i.e. intervention approaches and comparators).

RESULTS

Selection of Studies

We search 10 electronic databases from 2006 -2017 to update our previous systematic review.⁷ Our search produced 28,074 records (Figure 1). Our screening identified 404 papers for potential inclusion plus the additional 48 papers from our previous review, and 11 papers/reports from web searches. We screened 463 full text papers against our inclusion criteria with 451 excluded primarily for having the wrong aim/design, i.e. not a population approach (176), not reporting walking as an outcome (148), having no comparison group or an ineligible comparison (113), not including follow-up at of at least 12 months (11), and not being at population scale (3). Twelve studies met our inclusion criteria, including five from our original review and seven conducted since 2007.¹³⁻²⁴

INSERT FIGURE 1

Study characteristics

The characteristics of studies in terms of intervention approaches, intervention theory, population, demographics, location, study design, and types of walking outcome measure are shown in Table 1. Eleven studies were from High Income Countries (6 – USA, 2 – UK, and one each from Canada, The Netherlands, Belgium), with only one study from an Upper Middle Income Country – Brazil (UN 2017). We

found studies had utilised all five intervention approaches with only one focusing on using a taxation approaches only,¹³ and one policy only approaches.²² The majority of studies from pre 2007 had used mass media with either environment (2 studies),^{14 18} or community approaches (3 studies).¹⁵⁻¹⁷ Studies post 2007 used environmental changes plus policies.^{20 21 23 24} One study scaled up school-based approaches to promote safe routes to schools and this study was the only study to include direct measures of physical activity among children.¹⁹ McCormack et al (2016) made observations of park users and categorised them into child/teen or adult/older adult.²² Only two studies examined effects of the approaches at and beyond two years, with Goodman et al (2016) following up a longitudinal cohort at 24 months and De Cocker et al (2007) evaluating effects at 48 months.^{21 19}

INSERT TABLE 1

The mix of intervention approaches shows the influence of the social ecological framework with three studies reporting this as their theoretical approach.^{14 17 18} Two early mass media and community mobilization approaches were based more on individualized theories; the Theory of Planned Behaviour and the Transtheoretical Model.^{15 16} Goodman and colleagues developed a General Theoretical Model, derived from a number of social ecological and individual theories.²⁰ Two studies did not report any established underpinning theory for their approaches.^{23 24} Droomers (2015) utilised Cozens' Crime Prevention Through Environmental Design Theory, which is based on increasing citizen surveillance and improving environmental infrastructure, leading to reductions in feelings of vulnerability and the development of social networks.²¹

Studies used designs which all attempted to present potential intervention effects against a comparison area or setting. Repeated cross sectional studies were used with independent samples or longitudinal follow up of a cohort. Most studies selected a comparison area, matched on demographic variables. Three studies analysed their outcome based on different degrees of exposure to the intervention (i.e. proximity to the new infrastructure or development).^{20 23 24} All three studies used transport network distance from home location to the nearest point of new infrastructure to define intervention exposure, making the comparisons between those who lived closer and those who lived further away from the infrastructure.

Magnitude of effects on walking by population based approach

We identified 8 studies with the common outcome metric of mins/week walking to estimate the magnitude of effects across a mix of population-based approaches, based on more robust studies (Table 2, Table 3). We found evidence from mass media and environmental infrastructure or community events, and environmental change approaches that walking could be increased (range 9 to 75 mins/week) (Figure 2).

INSERT FIGURE 2, TABLE 2, TABLE 3

Mass media, social media and education campaigns - Five studies used mass media campaigns, underpinned by environmental changes, and/or community and individual initiatives (e.g. walking groups, individual materials/advice and pedometers), all reflecting their ecological and psychological frameworks¹⁴⁻¹⁸ These studies assessed the impacts of their mix of approaches at the population level with only two reporting effects at 12 months follow up.^{16 18}

Taxation, subsidies, and other economic incentives – Only Shoup (1997) evaluated the direct effects of an incentive based approach to change workplace-parking by incentivising the loss of parking space and supporting other commuting modes, in eight Californian urban workplaces.¹³ With varying length of follow up between 12 to 36 months, the proportion of walking as the new main mode of travel to work increased from 2.3% to 3.4% ($P < 0.01$) compared with no change at a single control workplace.

Regional or federal community, school and workplace approaches – Only Macdonald (2013) reported the effects of an at scale school approach.¹⁹ The study evaluated the Oregon Safe Routes to School program with education and environmental changes (sidewalks, crossings, covered bike parking), implemented across 14 schools in urban Eugene. The approach utilised education only and education plus environmental changes compared to comparison schools and reported positive increases in the proportion of children reporting walking trips to school between 5% (education only) and 20% (education plus environmental changes) per school.

Environmental changes – The construction of new environmental infrastructure upon walking was evaluated by four recent studies.^{20 21 23 24} Goodman et al (2014) reported the effects of new cycle and walking infrastructure, with construction of traffic routes for walking and cycling (construction of traffic free bridge, riverside boardwalk) across three UK cities. They reported that mins per week of walking for transport and walking for recreation per km proximity to infrastructure at 12 months follow up did not increase, with only walking for transport significantly increasing at 24 months follow up (8.8 mins/week - 95%CI 2.8, 14.8).²⁰ Droomers et al 2015 reported no differences in walking for leisure at least once a week for residents from 24 of the most deprived neighbourhoods where parks or green space were improved, between intervention and control areas.²¹ Panter et al 2016 reported the impact of a new guided bus service and new walking and cycle routes on the residents from the environs of Cambridge, UK.²³ They reported a non-significant increase in mean walking for commuting for residents who increased walking mean 73.4, (SD 66.6), RR 0.90 (0.69 to 1.19) with a graded exposure to busway. Pazin et al (2016) examined the impact of new

environmental changes with construction of new walking and cycling infrastructure, including a new road, walking route and parking, on leisure time walking.²⁴ They reported an increase of 32 mins/week of leisure time walking for residents living within 500m of the new infrastructure compared to residents living further away (501m – 1500m).

Policies with direct restrictions and mandates – Only McCormack (2016) evaluated the direct impact of the implementation of a new policy permitting off-leash dogs in city parks.²² These parks had not had any environmental modifications so the only approach was the new rule allowing dogs to run free “off-leash”. The authors reported, based on observations of park users and their activities, that in parks operating the new policy the likelihood of walking did not change in intervention parks but did increase in the control park (OR 1.79 95%CI 1.13, 2.83).

Risk of bias

A summary of validity assessment scores is presented in Table 3 and shows a consistent issue in relation to randomisation. No studies reported randomisation as this is typically an approach to distribute bias at an individual level. Instead, as suggested by Craig et al (2011), authors deployed different designs, such as random sampling and adjustment for confounders to tackle potential bias.¹⁰ However nearly all studies, with one exception, attempted to tackle these issues with loss to follow up remaining a challenge, particularly in longitudinal designs. Nearly all studies used self-report instruments to assess walking which were capable of assessing the outcome and had demonstrated measurement metrics for reliability and validity in a published or pilot study. Only one study reported using a pedometer as an objective measure of walking (De Cocker 2007).¹⁸

DISCUSSION

Key findings

Our evaluation of 12 population based approaches to promote walking identified examples across 5 types of public health mechanisms. Natural experiments that combined three approaches -- mass media, community initiatives and environmental change – increased people’s walking. Walking could be increased (range 9 to 75 mins/week) when experiments included both transport and recreation domains, but due to the heterogeneity of the small number of studies, we cannot comment on the effectiveness of specific activities within studies.

Only 4 studies evaluated impacts on walking beyond a 12-month follow-up. Although there were relatively few studies the quality of this evidence base was encouraging with robust and novel approaches adopted for sampling and data analysis.

Few studies evaluated the impact of other types of population based approaches, particularly taxation, subsidies, and other economic incentives. There is great interest in using these levers in other population approaches to public health and examples include interventions to impact on car use (e.g. congestion charging schemes), nutrition (e.g. taxes on high sugar beverages) and alcohol (e.g. minimum pricing per units), with the most established research relating to taxation of tobacco products.

Hou et al (2011) examined the associations between time-varying petrol prices and time varying levels of physical activity from 1992/3 to 2000/1.²⁵ They reported that a 25 cent increase in petrol price was significantly associated with a small (3% overall) increase in total physical activity levels, roughly equivalent to 17 mins/week walking. Green and colleagues evaluated the impact of a free bus scheme on the travel patterns of young people in London and reported an increase in use of buses but without significant reductions in walking trips and no evidence of changes in the distance walked.²⁶ Such examples are less common in physical activity but the opportunity to evaluate both fiscal incentives and disincentives is possible and should be explored further. The advance of technology based commercial products and applications (e.g. wearable physical activity trackers/monitors) at scale also remain unevaluated.

The challenges of evaluating large-scale population approaches to promoting walking reflect the practical and political issues needed to construct a robust research framework for a process where when implementation lies outside of scientific control. There were delays in the delivery of infrastructure changes, which in the case of one study delayed the timing of data collection and assessment of outcomes.^{20 23} As Baker et al (2015) suggest it would be helpful to have a greater number of measurement points spanning the pre delivery, delivery and follow up periods, which would also mitigate against any secular trends or regression to the mean.¹¹

The challenge of developing the effectiveness evidence base for population approaches is not new, and mirrors the historical development of the evidence base for individual approaches to changing behaviour. Hillsdon et al's systematic review and meta-analysis of individual focused RCTs found that studies were often conducted without a priori theory, used short term follow up, and used low quality designs and analysis.²⁷ This is likely to have restricted the implementation of this findings into practice. These issues were addressed with an increase in number, quality (theoretical basis and methods) and follow up in the conduct of walking and physical activity trials.²⁸

The limited number of evaluations of the impact of population based approaches for walking and physical activity promotion compared to individual or group based interventions is an example of "the inverse evidence law" – the situation where "we

*know least about the effects of interventions most likely to influence the health of the largest number of people”.*²⁹⁻³¹ The use of socio-ecological theoretical frameworks was more evident in the more recent studies than at the time of our earlier systematic review, reflecting a shift to the use of integrated or system theories for community interventions. However socio-ecological model may give researchers a theoretical framework that is too generic and future research might also consider models that embrace systems and complexity.

We were surprised that these approaches did not utilise aspects of the social environment as part of their intervention approaches. The social environment has been proposed as an important determinant of physical activity through different mechanisms, impacting via social support and social networks, socioeconomic position and income inequality, racial discrimination, social cohesion and social capital, and neighbourhood factors.³² We feel the potential for constructing evaluation frameworks for these approaches and rapidly improving the evidence base should be a priority for research funding.

Strengths and limitations

Our review is the first to identify the global evidence base of 12 studies investigating the long-term impact of population-based approaches to promote walking, across five public health mechanisms. This evidence base has developed slowly since our previous systematic review but we were inclusive towards study designs utilising, “natural experiments” and have also performed an appraisal of the quality of this evidence base that is pragmatic and sensitive. We have been able to characterise examples of approaches that have reported changes in walking, using three approaches of mass media, community initiatives and environmental change. One explanation for this could be that these types of population-based approaches are easier to plan and deliver and therefore more likely to appear in literature than less controllable interventions like large scale environmental or policy changes, that could be more prone to disruption (and less likely to be published).

We report several limitations. The findings of our review are limited to higher income countries, as we did not find any approaches from low middle income or low-income countries. We only included studies published in the English language. We only included studies that had walking as part of their primary outcomes and this did limit the inclusion of a number of included studies that used physical activity as their main outcome. We were unable to quantify effects of interventions in a meta-analysis due to intervention and measurement heterogeneity. Study outcomes were largely derived from self-report measures, which are prone to reporting bias. However, studies used established and often validated measures. As epidemiological evidence on the impact of walking speed and cadence on health is developed,³³ future studies

may seek more objective data by using pedometers or accelerometers, or commercial fitness monitoring devices.

SUMMARY AND CONCLUSIONS

Our evaluation of 12 population based approaches to promote walking identified examples across 5 types of public health mechanisms. For the first time we found evidence from studies utilising “natural experiments” for the overall effectiveness of approaches, particularly ones that combined three intervention approaches - mass media, community initiatives and environmental change. The precise combination of active and effective approaches within these studies will require further detailed process evaluation.

Our review is relevant to outline plans of the new draft WHO Global Physical Activity Action Plan that stresses community and citywide approaches to promoting walking for transport and recreation via active environments and policy systems.³⁴ The physical activity research community has a duty to serve the vision and legacy of Hardman and Morris. We must use “our good sense” to build on this new evidence base for walking promotion, by conducting pragmatic, responsive and high quality evaluations of future population approaches.

SUMMARY BOX (3-4 bullet points)

What is already known?

- The promotion of walking produces consistent benefits for individual in terms of physical and mental health

- But the evidence on how to promote walking has been focused on individual approaches.
- Population approaches can reach across whole populations but the effectiveness of these is needed to identify what work, at scale?

What are the new findings?

- Our review identified a new and emerging evidence base for three population approaches to promote walking, mass media and environmental infrastructure or community events, and environmental change approaches.
- The precise combination of active and effective approaches within these studies will require further detailed outcome and process evaluation.

LEGENDS FOR IMAGES

Figure 1 Study selection flow chart

Figure 2 Estimated net increase in types of walking. Studies are ranked by validity (number of criteria met, see table 3), then baseline sample size

Key Messages

1. Walking is the near to perfect form of accessible, affordable and healthy type of physical activity.
2. The evidence base for the effectiveness of intervention to promote walking has been focused on individualised approaches rather than population based interventions.
3. Population based intervention to promote walking include aim to reduce key risk factors in the whole population, irrespective of individual level of risk.
4. They use a mixture of approaches from (1) mass media, social media and education campaigns, (2) taxation, subsidies, and other economic incentives, (3) at scale regional or federal community, school and workplace approaches, (4) environmental changes, and (5) policies with direct restrictions and mandates.
5. Our review found only evidence from mass media and environmental infrastructure or community events, and environmental change approaches

that walking could be increased (range from 9 to 75 mins/week), from high/middle income countries.

6. Our review identifies that there is a new and emerging evidence base for population approaches to walking promotion but, at this stage, only limited conclusions can be drawn about effectiveness of specific activities within studies.

Competing Interests: None

Author Contributions; CF and DH conceived the idea for the study. NR, CF, KM, HR and PK conducted the review, data extraction and analysis. CF, KM, PK, DH, EM, and JP drafted the manuscript. HR contributed to the writing of the manuscript. All authors contributed to revising the final draft of the manuscript.

Acknowledgements: All the manuscript authors would like to acknowledge the intellectual support and fortitude of Dr David Ogilvie whose leadership and previous research has led the development of this manuscript.

Funding: No external funding

Ethics: No ethics needed

Data sharing: Not required

¹ Hardman AE, Morris JN. Walking to health. *Br J Sports Med* 1998;32(2):184-84.

² Roberts D, Townsend N, Foster C. Use of new guidance to profile 'equivalent minutes' of aerobic physical activity for adults in England reveals gender, geographical, and socio-economic inequalities in meeting public health guidance: A cross-sectional study. *Preventive Medicine Reports*, 2016, 4, 50-60.

³ Reis RS, Salvo D, Ogilvie D, et al. Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving. *The Lancet* 2016;388(10051):1337-48.

⁴ International Society for Physical Activity and Health ISPAH. *Br J Sports Med* 2017;0:1-3. doi:10.1136/bjsports-2017-098063

⁵ Murtagh EM, Nichols L, Mohammed MA, et al. The effect of walking on risk factors for cardiovascular disease: An updated systematic review and meta-analysis of randomised control trials. *Prev Med* 2015;72:34-43.

-
- ⁶ Brannan M, Varney J, Timpson C, Murphy M, Foster C. 10 minutes brisk walking each day in mid-life for health benefits and achievement of recommended activity levels- Evidence summary. Public Health England, London, 2017.
- ⁷ Ogilvie D, Foster C, Rothnie H, Cavill N, Hamilton V, Fitzsimons CF, Mutrie N. Scottish Physical Activity Research Collaboration. Interventions to promote walking: systematic review. *British Medical Journal* 2007;334 (7605):1204.
- ⁸ Humphreys D, Panter J, Sahlqvist S, Goodman A, Ogilvie D Changing the environment to improve population health: a framework for considering exposure in natural experimental studies. *J Epidemiol Community Health* 2016 Sep;70(9):941-6.
- ⁹ Mozaffarian D, Afshin A, Benowitz NL, et al. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. *Circulation* 2012; 126: 1514–63.
- ¹⁰ Craig P, Cooper C, Gunnell D, Haw S, Lawson K, Macintyre S, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health*. 2012;66(12):1182–1186.
- ¹¹ Baker PRA, Francis DP, Soares J, Weightman AL, Foster C. Community wide interventions for increasing physical activity. *Cochrane Database of Systematic Reviews* 2015, Issue 1. Art. No.: CD008366.
- ¹² Humphreys D, Panter J, Ogilvie D. Questioning the application of risk of bias tools in appraising evidence from natural experimental studies: critical reflections on Benton et al., *IJBNPA* 2016. *IJBNPA*, 2017;14:49.
- ¹³ Shoup D. Evaluating the effects of parking cash out: eight case studies. Sacramento: Air Resources Board Research Division, California Environmental Protection Agency, 1997.
- ¹⁴ Brownson R, Baker E, Boyd R, Caito N, Duggan K, Housemann R, et al. A community-based approach to promoting walking in rural areas. *Am J Prev Med* 2004;27:28- 34.
- ¹⁵ Reger-Nash B, Bauman A, Booth-Butterfield S, Cooper L, Smith H, Chey T, et al. Wheeling Walks: evaluation of a media-based community intervention. *Fam Community Health* 2005;28:64-78.
- ¹⁶ Reger-Nash B, Cooper L, Orren J, Cook D. Marketing used to promote walking in McDowell County. *W V Med J* 2005;101:106.
- ¹⁷ Brownson R, Hagood L, Lovegreen S, Britton B, Caito N, Elliott M, et al. A multilevel ecological approach to promoting walking in rural communities. *Prev Med* 2005;41:837–842.

-
- ¹⁸ De Cocker KA, De Bourdeaudhuij IM, Brown WJ, Cardon GM. Effects of “10,000 Steps Ghent”: a whole-community intervention. *Am J Prev Med.* 2007;33(6):455–463.
- ¹⁹ McDonad N, Yang Y, Abbott S, Bullock A. Impact of Safe Routes to School program on walking and biking: Eugene, Oregon Study. *Transport Policy*, 2013;29: 243-248.
- ²⁰ Goodman A, Sahlqvist S, Ogilvie D. New walking and cycling routes and increased physical activity: One- and 2-year findings from the UK iConnect study. *Am J Public Health.* 2014;104:e38–46.
- ²¹ Droomers M, Harting J, Jongeneel-Grimen B, Rutten L, van Kats J, Stronks K. Area-based interventions to ameliorate deprived Dutch neighborhoods in practice: does the Dutch District Approach address the social determinants of health to such an extent that future health impacts may be expected? *Prev Med*, 2014;61:122-127.
- ²² McCormack G, Graham T, Swanson K, Massolo A, Rock M. Changes in visitor profiles and activity patterns following dog supportive modifications to parks: a natural experiment on the health impact of an urban policy. *SSM Popul Health* 2016;2:237–43.
- ²³ Panter, J., Heinen, E., Mackett, R., Ogilvie, D.B., 2016. Impact of new transport infrastructure on walking, cycling and physical activity. *Am. J. Prev. Med.* 50 (2), e45–e53.
- ²⁴ Pazin J, Garcia L, Florindo A, Peres M, de Azevedo Guimarães A, Borgatto A, da Silva Duarte F. Effects of a new walking and cycling route on leisure-time physical activity of Brazilian adults: a longitudinal quasi-experiment. *Health Place*, 39 (2016), pp. 18-25.
- ²⁵ Hou N, Popkin BM, Jacobs DR Jr, Song Y, Guilkey DK, He K, Lewis CE, Gordon-Larsen P. Longitudinal trends in gasoline price and physical activity: the CARDIA study. *Prev Med.* 2011;52:365–369.
- ²⁶ Green J, Steinbach R, Jones A, Edwards P, Kelly C, Nellthorp J, et al. On the buses: a mixed-method evaluation of the impact of free bus travel for young people on the public health. *Public Health Res* 2014;2(1).
- ²⁷ Hillsdon M, Thorogood M, Foster C. Intervention for physical activity (Cochrane Review) In: *The Cochrane Library*, Issue 1, 2005. Oxford: Update Software.
- ²⁸ Foster C, Hillsdon M, Thorogood M. Interventions for physical activity (Cochrane Review) In: *The Cochrane Library*, Issue 1, 2008. Oxford: Update Software.
- ²⁹ Ogilvie D, Mitchell R, Mutrie N, Petticrew M, Platt S. Evaluating health effects of transport interventions: methodologic case study. *Am J Prev Med* 2006;31:118-26.

³⁰ Nutbeam D. How does evidence influence public health policy? Tackling health inequalities in England. *Health Promot J Aust* 2003;14:154-8.

³¹ Whitehead M, Petticrew M, Graham H, Macintyre S, Bambra C, Egan M. Evidence for public health policy on inequalities: 2: Assembling the evidence jigsaw. *J Epidemiol Community Health* 2004;58:817-21.

³² McNeill L, Subramanian S. Social Environment and Physical Activity: A review of concepts and evidence. *Social Science & Medicine* 2006;63:1011-22.

³³ Slaght J, Sénéchal M, Hrubeniuk T, Mayo A, Bouchard D. Walking Cadence to Exercise at Moderate Intensity for Adults: A Systematic Review. *Journal of Sports Medicine*, vol. 2017, Article ID 4641203.

³⁴ WHO Global Physical Activity Action Plan - draft
<http://www.who.int/ncds/governance/Global-action-plan-on-PA-DRAFT-2-Dec-2017.pdf?ua=1>
accessed 20th December 2017.