



***National Institute for
Health and Clinical Excellence***

Interventions that use the environment to encourage physical activity

Evidence review

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This work was undertaken by the Public Health Collaborating Centre on Physical Activity on behalf of the Health Development Agency (HDA), but published after the functions of the HDA were transferred to the National Institute for Health and Clinical Excellence (NICE) on 1 April 2005.

This document does not represent NICE guidance.

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Foreword

The Health Development Agency (HDA) was established in 2000 to help build the public health evidence base, with an emphasis on what works and a special focus on reducing inequalities in health. In April 2005, the functions of the HDA were transferred to the National Institute for Clinical Excellence (NICE) to form a new organisation, the National Institute for Health and Clinical Excellence (also known as NICE).

Wanless (2004) highlighted the need for appraising the effectiveness of public health interventions, not only to reduce health inequalities but also to maximise cost effectiveness. The government's white paper *Choosing Health* (Department of Health 2004) similarly reiterates the importance of building and maintaining an evidence base for public health. From April 2005 the HDA's evidence base work is continuing under the auspices of NICE.

The HDA had the task of mapping and synthesising the evidence across priority areas of public health. It developed a systematic approach to compiling the evidence, identifying gaps and making the evidence base accessible. The evidence briefing series was one of the ways used to disseminate the HDA Evidence Base (full details of the process of developing the Evidence Base and the associated methodological activities can be found in: Graham and Kelly 2004; Kelly et al. 2002, 2004a/b; Killoran and Kelly 2004; Swann et al. 2005).

The necessity for reviewing reviews, or tertiary-level research, stems from the proliferation over the last decade or more, of systematic and other types of review in medicine and public health. In addition to an evidence briefing on interventions to increasing physical activity among adults (Hillsdon et al. 2004), the HDA published evidence briefings on:

- accidental injuries in children and older people
- ante- and post-natal home-visiting programmes
- breastfeeding
- drug misuse
- health impact assessment
- HIV prevention
- housing
- management of obesity and overweight
- prevention and reduction of alcohol misuse
- prevention and reduction of exposure to second-hand smoke
- prevention of sexually transmitted infections
- prevention of low birth weight
- smoking and public health
- teenage pregnancy and parenthood
- youth suicide prevention.

Taken together, these briefings provide a comprehensive synthesis of the evidence drawn from review-level literature, including systematic reviews. They are available on the NICE website at: www.nice.org.uk

These evidence briefings have been based on evidence drawn from systematic and other kinds of reviews. This means that the type of evidence that does not traditionally find its way into reviews has not been considered in detail for these documents. In another evidence series, 'evidence reviews', of which this is one, the scope of the coverage is extended to primary research, other kinds of evidence and other types of study. This review reports on evidence of interventions that use the environment to encourage physical activity. Evidence reviews published to date include:

- drug misuse prevention among young people
- self-management of chronic illness
- worklessness and health
- work, non-work, job satisfaction and psychological health.

The construction of the Evidence Base involved collaboration with a number of partners who have an interest or expertise in practical and methodological matters concerning the drawing together of evidence and its dissemination. In particular, the HDA acknowledged the following: the Centre for Reviews and Dissemination at the University of York; the EPPI-Centre within the Institute of Education at the University of London; Health Evidence Bulletins Wales; the ESRC UK Centre for Evidence Based Policy and Practice at Queen Mary College, University of London and its nodes at the City University London and the MRC Public Health Sciences Unit at the University of Glasgow; members of the Cochrane and Campbell collaborations; the United Kingdom and Ireland Public Health Evidence Group and the Public Health Evidence Steering Group. The latter acted as overall guide for the evidence-building project.

Colleagues in these institutions and organisations have made a significant contribution to the framework used to assess the evidence.

Every effort has been made to ensure this briefing is as accurate and up-to-date as possible. We welcome readers' comments on the content – including its accuracy – and will make every effort to correct any matters of fact in subsequent editions. Comments can be made via our website at: www.nice.org.uk

This project will contribute to the evidence base for the current NICE public health programme on physical activity and the environment.

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Summary

Introduction

There is a clear link between physical inactivity and ill health. The extent of this link is set out in publications such as the Chief Medical Officer's report *At least five times a week* (Department of Health 2004a). An increase in activity levels will contribute to the prevention and management of more than 20 conditions and diseases including coronary heart disease, diabetes, cancer, positive mental health and weight management. Besides the human costs of inactivity in terms of mortality, morbidity and quality of life, the Chief Medical Officer's report highlighted an estimate for the cost of inactivity in England to be £8.2 billion annually. This excludes the contribution of physical inactivity to the prevalence of overweight and obesity, the cost of which might run to £6.6-£7.4 billion a year according to recent estimates (House of Commons Health Committee 2004).

The current level of activity recommended for achieving the basic health benefits of physical activity are for adults to carry out a minimum of 30 minutes of at least moderate activity on five or more days a week. This can be accumulated in sessions of 10 minutes or more.

A Health Development Agency (HDA) evidence briefing on interventions to promote physical activity published in 2004 looked at systematic reviews of interventions to promote physical activity (Hillsdon et al. 2004). This failed to identify any reviews that examined the effectiveness of interventions in the built environment. As a result, it was decided to carry out a review that includes primary studies, and to use broad inclusion criteria. This review therefore includes both systematic reviews and primary studies, from earliest records to May 2005, and presents the current evidence derived from the published literature on environmental interventions. This project will contribute to the evidence base for the current NICE

public health programme on physical activity and the environment.

Methods

The objective was to undertake a review of primary studies of interventions that use the environment to encourage physical activity.

Primary studies were included if:

- the study used an experimental study design
- the aim of the study was:
 - to examine the effect of changing any aspect of the environment on physical activity behaviour
 - to use a natural or man-made element of the environment as a mechanism to increase physical activity behaviour
- physical activity or physical fitness was the dependent variable
- the impact of the environmental change on the dependent variable was compared with a control, non-intervention group or a pre- and post-measure
- the age of the study population was over 18.

Findings

The review of the evidence is presented in two categories, covering two different approaches:

- interventions that made physical and policy changes to the environment
- interventions where the environment was used to host a prompt to take an active rather than a sedentary choice, for example stair vs escalator use.

The findings are as follows.

- A combination of physical changes to working practices, policies and the physical environment appears to encourage adults to maintain their vigorous physical activity and fitness. This should be treated with caution as there are insufficient numbers of well-designed studies to draw conclusions about what is effective.
- Two interventions (conducted in military settings) have shown that changing the environment might play an active role in its relationship to physical activity (Linenger et al. 1991; Peel and Booth 2001). Further studies outside the military setting are required to identify which aspects of the interventions had the most impact on particular behaviours.
- The development of new cycle and walking paths appears to encourage use of the paths. This finding should be treated with caution as there are insufficient well-designed studies to draw conclusions about what is effective. The use of paths appears to be optimised by local promotional campaigns. The effect of a path on physical activity is mediated by the proximity of users to the path (distance from home), concerns about safety, and current levels of physical activity. A path may attract more adults who are already active, rather than new exercisers.
- Using the environment as a point of active or sedentary choice (eg using stairs not the lift) with written media (eg stair posters, riser banners on steps) can have a short-term effect on stair use for up to 3 months, with one study reporting an effect at 6 months after baseline (+29%, Kerr et al. 2001c). Although there are a large number of studies in this area, without the benefit of any comparison or control groups no conclusions can be reached about the effectiveness of such interventions.
- Studies show that a variety of printed media in commercial, workplace and transport settings can increase use of stairs, but changes diminish over time. The efficacy of a stair intervention varied within the study populations, with different effects seen for different groups based on age, sex, observed body mass index and ethnicity. These effects were not consistent across the studies.

Gaps in the evidence base

- Further studies should evaluate the contribution of new cycle or walking paths on adults' overall levels and patterns of physical activity. The work should try to assess if any new physical activity is a result of the intervention rather than shifting physical activity from one exercise opportunity to another.
- Further studies into using the environment to promote stair use should use a quasi-randomised design, ie randomised matched pairs of stair use to intervention and comparison groups. Studies should focus on settings where consistent patterns of physical activity behaviour are established and are most amenable to change.

Glossary

Effectiveness – how well an intervention works compared with a similar non-intervention condition.

Efficacy – whether the intervention works in different settings and for different groups.

Efficiency – a comparison of the cost of outcomes alongside other interventions (Gray 1997).

Environment – in relation to physical activity, any aspect of the physical (natural) environment or the man-made (urban or constructed) environment that unconsciously or consciously relates to an individual and their physical activity behaviour (Foster and Hillsdon 2004).

Interventions – different approaches to the promotion of physical activity. Approaches range from population media campaigns about the benefits of physical activity, to an exercise clinic in primary healthcare.

Natural experiment – a change to the physical environment (ie building a new road, building a new housing estate), which could offer the opportunity to evaluate the impact of these changes in encouraging or discouraging population levels of physical activity.

Background and policy drivers

The Chief Medical Officer's report *At least five times a week* (Department of Health 2004a) brought together the published epidemiological evidence on the impact of physical activity on health. The introduction to the report states that: 'The scientific evidence is compelling. Physical activity not only contributes to wellbeing, but is also essential for good health.' The benefits of physical activity include:

- contributing to the prevention and management of more than 20 conditions and diseases, including coronary heart disease, diabetes and cancer. Inactive and unfit people have almost double the risk of dying from coronary heart disease. Physical activity is also an independent protective factor against coronary heart disease
- benefiting musculoskeletal health by reducing the risk of osteoporosis, back pain and osteoarthritis
- reducing the risk of depression and providing positive benefits for mental health, including reduced anxiety, and enhanced mood and self-esteem
- contributing to weight management. Physical inactivity, along with unhealthy diets, has contributed to the rapid increases in obesity in both adults and children with 22% of men and 23% of women in England now obese. The prevalence of obesity has continued to increase in both sexes since 1994, but more rapidly among men, so in recent years there has been little difference between the sexes in obesity prevalence.

Following the publication of the white paper *Choosing Health* (Department of Health 2004b) an action plan, *Choosing Activity*, was produced (Department of Health 2005). This emphasised the need to achieve a cultural shift to increase levels of physical activity:

'Opportunities will be created by changing the physical and cultural landscape – and building an environment that supports people in more active lifestyles. We need to provide choice and a range of options so that people

can be active on a daily basis. Choices to build everyday activity into daily routines such as walking to the shops and cycling to school, and choice to participate in a wide variety of leisure time sport and recreation activities such as aerobics, football, mountain biking, dancing and swimming.'

A number of Public Service Agreements set out targets for increasing physical activity.

- Halt the year-on-year increase in obesity among children under 11 by 2010, in the context of a broader strategy to tackle obesity in the population as a whole. (*Department for Culture, Media and Sport; Department for Education and Skills; Department of Health*)
- By 2008, increase the take-up of cultural and sporting opportunities by adults and young people aged 16 and above from priority groups by increasing the number who participate in active sports, at least 12 times a year by 3%, and increasing the number who engage in at least 30 minutes of moderate-intensity-level sport, at least three times a week by 3%. (*Department for Culture, Media and Sport*)
- Enhance the take-up of sporting opportunities by 5 to 16 year olds so that the percentage of schoolchildren in England who spend a minimum of 2 hours each week on high-quality PE and school sport within and beyond the curriculum increases from 25% in 2002 to 75% by 2006 and 85% by 2008 in England, and to at least 75% in each school sport partnership by 2008. (*Department for Culture, Media and Sport; Department for Education and Skills*)
- Lead the delivery of cleaner, safer and greener public spaces and improvement of the quality of the built environment in deprived areas and across the country, with measurable improvement by 2008. (*Office of the Deputy Prime Minister*)

How the environment affects health

Any definition of the environment must recognise the importance of its multiple aspects and the different potential influences it can have on helping or hindering physical activity. For the purpose of this review, the environment is defined in relation to physical activity as any aspect of the physical (natural) environment or the man-made (urban or constructed) environment that unconsciously or consciously relates to an individual and their physical activity behaviour (Foster and Hillsdon 2004).

It has been suggested that an unsupportive environment – an environment that does not support activity as part of daily life – may play a part in the reduction of physical activity, and has contributed to the rapid rise of obesity levels (World Health Organization 1998). Changing the environment to influence health behaviours such as smoking and sexual health has been used as part of community interventions. Using the environment to promote physical activity could contribute to the potential impact of a community intervention.

Many reviews have been unable to show long term effectiveness of face-to-face physical activity behavioural interventions. This could be explained by a failure of these interventions to tackle environmental barriers to adopting physical activity (Hillsdon et al. 2004; Kahn et al. 2002). While psychological and ecological theories and models demonstrate the possible influences of the environment on physical activity, little is known about the effectiveness of environmental interventions.

Does the environment influence physical activity?

Psychological models of health behaviour do include some aspects of the environment in explaining behaviour choices, for example 'reciprocal determinism' in social

cognitive theory (Bandura 1986). This concept outlines a continuous interaction between our behaviours, our cognitions (thoughts, beliefs, attitudes, confidence and motives) and the environment. Recent developments in ecological theories have attempted to offer greater detail on how the environment can affect behaviour.

Ecological models of health behaviour

Ecological models of health behaviours include a broad range of influences on individuals' and communities' health behaviours. These models include the individual components of health behaviour theories, placing them within the context and influences of the environment (Marcus and Forsyth 1999; McLeroy et al. 1988; Sallis and Owen 1997; Stokols 1992).

Owen et al. (2000) have attempted to bring together the principles of ecological models using a 'behaviour settings' model (see also Barker 1968). This model acknowledges the interaction of the ingredients of a setting with the psychological components, social influences and the individual to influence someone's choice to be active or sedentary. They define behaviour settings as 'those social and physical situations in which behaviours take place, by promoting and sometimes demanding certain actions and by discouraging or prohibiting others' (Owen et al. 2000, p155).

This approach links the social learning approach, reciprocal determinism and ecological psychology by focusing on the promotion of sedentary or active choices. The model places behaviour settings as subgroups of five larger environmental contexts. These settings are linked via functions to different behaviour choices, with some settings more prone to encourage physically active or

Figure 1: Potential influences of behaviour settings and their functions on examples of activity and sedentary choices

Context	Behaviour settings	Functions	Behaviour choices	
Community	Public spaces (eg parks, beaches) Sports facilities Retail facilities Social settings (eg cafes, restaurants, community halls)	Recreation/socialising	<i>Active choice</i> Walking Jogging Participating in sports Dancing Using exercise equipment Walking groups	<i>Sedentary</i> Sitting and socialising TV viewing Spectating Eating/dining Reading Computer use Video games
		Organised recreational programmes	Walking groups Exercise classes	Reading groups Craft classes

Source: Owen et al. (2000)

sedentary behaviours (eg parks, playgrounds and shops). The behaviours are a result of the mix and interaction of the components of context, setting and function and can promote or discourage a particular behaviour. For example, a cycle path, sports field or playground might promote an active behaviour, while a busy road or lifts might discourage an active behaviour. Owen and colleagues' model allows the inclusion of the social and dynamic impact of specific contexts on the choice to be active or not within a framework of behaviour settings. An example is presented in Figure 1, for behaviour settings in the community.

The model only describes the components that contribute to active or inactive behaviour and does not explain the interaction of these elements within a setting. Owen et al. (2000) call for future studies to unpick this interaction and use methods that can objectively measure physically active and sedentary behaviour and relate specific environments to individuals.

Methodology

This evidence review is based on findings from primary studies of environmental interventions that aim to increase physical activity. In the included papers, findings were typically derived from before-and-after studies.

Identification of the literature

An extensive and systematic search was conducted to identify the relevant primary studies. The search strategy builds on work by Foster and Hillsdon (2004), taking forward searches to May 2005. The search also included additional UK public health databases.

Three search strategies were used. The strategies were an adaptation of a method used to search MEDLINE (Dickersin et al. 1995), which searched for observational and experimental studies. Searches were constructed from keywords found in appropriate studies identified in a pilot search. Each database was searched with the most appropriate search strategy.

Searches were conducted on the following electronic databases, websites and published sources:

- AMED
- BIOSIS
- CINAHL
- Clinical Evidence
- Cochrane Library
- DARE admin database
- EMBASE
- ERIC
- GEOBASE
- Health Evidence Bulletins Wales
- HTA
- National Guidelines Clearinghouse
- National Research Register
- NCCHTA website

- NICE website
- PsycINFO
- ReFeR
- SCI search
- SIGLE
- SIGN
- Sociological Abstracts
- Sport Discus
- TRIP
- TRIS online
- 'Wider Public Health' report.

Searches were carried out on AMED, CINAHL, EMBASE, GEOBASE, MEDLINE, PsychLit, SciSearch, SIGLE and Sports Discus from earliest records up to May 2005. All other databases were searched from December 2001 (the end point of searching in Foster and Hillsdon 2004) to May 2005. The search was limited to English language journals. Additional searching was carried out using the references from reviews and the papers identified during the search. The searches of the databases listed above were downloaded into Reference Manager software.

The searches identified 12,315 potentially relevant studies. The titles and abstracts of these studies were assessed for relevance using the following criteria:

- research using an experimental study design
- the aim of the study was:
 - to examine the effect of changing any aspect of the environment on physical activity behaviour
 - to use a natural or man-made element of the environment as a mechanism to increase physical activity behaviour
- physical activity or physical fitness was the dependent variable
- the impact of the environmental change was assessed or quantified.

Where no clear decision could be made on the basis of the title or abstract, studies were considered relevant and the full papers were retrieved.

Selection and appraisal of primary studies

A total of 55 papers were identified for retrieval. All papers were assessed independently by two reviewers using the critical appraisal tool in Appendix A and a joint decision was made to include a paper. Disagreements were resolved through discussion or by recourse to a third reviewer. There was no blinding of authorship of retrieved papers. Although no formal scoring assessment of quality was made, related data on study design, measures and analysis was also evaluated. Cost-effectiveness studies or economic studies were not specifically sought in this review.

Papers were included if they met the relevance criteria outlined in the previous section, plus:

- the impact of the environmental change on the dependent variable (physical activity or physical fitness) was compared with a control, non-intervention group or a pre- and post-measure
- the study population was aged over 18.

The main reason for excluding studies was that they did not evaluate the effects of an environmental intervention but used individual behavioural approaches. Studies were excluded if the environmental change was not the principle component or mechanism of the intervention – for example, community-wide physical activity promotion campaigns such as the Stanford 5 Cities Project (Young et al. 1996).

This process identified 24 primary study papers (see p8). Nineteen of these studies were included in the earlier review by Foster and Hillsdon (2004). Six new studies were found that had been published since 2001.

Details of all these studies are presented (by topic and publication date) in Tables 1 and 2. Study characteristics are described in more detail in the 'Evidence' section.

Synthesis

The evidence was brought together in a narrative synthesis. A quantitative summary, including an attempt to calculate pooled effect sizes, was not undertaken owing to the

heterogeneous nature of the studies (different time points and outcomes) and the diversity of outcome measures employed.

The studies were divided into two types of environmental interventions. In the first group of six studies, the environment was either physically altered or new opportunities for activity were developed and promoted for the intervention group (eg a new bike trail was opened). In the second group of studies, the environment provided a choice for active or sedentary behaviour. Nineteen studies were found that used health education materials to promote stair climbing in particular environments, such as commercial and commuting settings.

Any conflicting evidence was identified and gaps in the evidence concerning the reduction of health inequalities were charted. Sets of evidence summaries were derived from the results of the studies.

Primary studies identified

The following 25 papers* were identified following the critical appraisal procedure. They are listed in the same order as Tablea 1 and 2 and the Evidence section, ie by topic and study number.

ENVIRONMENTAL INTERVENTION STUDIES – PHYSICAL CHANGE

[1] Linenger JM, Chesson CV, Nice DS (1991) Physical fitness gains following simple environmental change. *American Journal of Preventive Medicine* 7:298–310.

[2] Vuori IM, Oja P, Paronen O (1994) Physically active commuting to work – testing its potential for exercise promotion. *Medicine and Science in Sports and Exercise* 26:844–50.

[3] Peel GR, Booth ML (2001) Impact evaluation of the Royal Australian Air Force health promotion program. *Aviation, Space, and Environmental Medicine* 72:44–51.

[4] Merom D, Bauman A, Vita P et al. (2003) An environmental intervention to promote walking and cycling – the impact of a newly constructed rail trail in Western Sydney. *Preventive Medicine* 36:235–42.

[5] Gordon PM, Zizzi SJ, Pauline J (2004) Use of a community trail among new and habitual exercisers: a preliminary assessment. *Preventing Chronic Disease* 1:1–11.

[6] Evenson KR, Herring AH, Huston SL (2005) Evaluating change in physical activity with the building of a multi-use trail. *American Journal of Preventive Medicine* 28 (2S2):177–85.

ENVIRONMENTAL INTERVENTION STUDIES – STAIR INTERVENTIONS

*[7] Brownell KD, Stunkard AJ, Albaum JM (1980a) Evaluation and modification of exercise patterns in the natural environment. *American Journal of Psychiatry* 137:1540–5.

*[8] Brownell KD, Stunkard AJ, Albaum JM (1980b) Evaluation and modification of exercise patterns in the natural environment. *American Journal of Psychiatry* 137:1540–5.

[9] Blamey A, Mutrie N, Aitchison T (1995) Health promotion by encouraged use of stairs. *British Medical Journal* 311:289–90.

[10] Mutrie N, Blamey A, Aitchison T (1996) Why do fewer women choose stairs? *Journal of Sports Sciences* 14:16–7.

[11] Andersen RE, Franckowiak SC, Snyder J et al. (1998) Can inexpensive signs encourage the use of stairs? Results from a community intervention. *Annals of Internal Medicine* 129:363–9.

*The paper by Brownell et al. (1980) presents findings from two separate studies, giving a total of 25 studies from 24 papers.

- [12] Russell WD, Dzewaltowski DA, Ryan GJ (1999) The effectiveness of a point-of-decision prompt in deterring sedentary behaviour. *American Journal of Health Promotion* 13:257–9.
- [13] Russell WD, Hutchinson J (2000) Comparison of health promotion and deterrent prompts in increasing use of stairs over escalators. *Perceptual and Motor Skills* 91:55–61.
- [14] Kerr J, Eves F, Carroll D (2000) Posters can prompt less active people to use the stairs. *Journal of Epidemiology and Community Health* 54:942.
- [15] Coleman KJ, Gonzalez MS (2001) Promoting stair use in a US-Mexico border community. *American Journal of Public Health* 91:2007–9.
- [16] Boutelle KN, Jeffery RW, Murray DM et al. (2001) Using signs, artwork and music to promote stair use in a public building. *American Journal of Public Health* 91:2004–6.
- [17] Titze S, Martin BM, Seiler R et al. (2001) A worksite intervention module encouraging the use of stairs: results and evaluation issues. *Sozial-und Präventivmedizin* 46:13–9.
- [18] Kerr J, Eves F, Carroll D (2001a) Can posters prompt stair use in a worksite environment? *Journal of Occupational Health* 43:205–7.
- [19] Kerr J, Eves F, Carroll D (2001b) Six-month observational study of prompted stair climbing. *Preventive Medicine* 33:422–7.
- [20] Kerr J, Eves F, Carroll D (2001c) Encouraging stair use: stair-banners are better than posters. *American Journal of Public Health* 91:1192–3.
- [21] Kerr J, Eves F, Carroll D (2001d) The influence of poster prompts on stair use: the effects of setting, poster size and content. *British Journal of Health Psychology* 6:397–405.
- [22] Kerr J, Eves F, Carroll D (2001e) Getting more people on the stairs: the impact of a new message format. *Journal of Health Psychology* 6:495–500.
- [23] Adams J, White M (2002) A systematic approach to the development and evaluation of an intervention promoting stair use. *Health Education Journal* 61:272–86.
- [24] Marshall AL, Bauman AE, Patch C et al. (2002) Can motivational signs prompt increases in incidental physical activity in an Australian health-care facility? *Health Education Research* 17:743–9.
- [25] Kerr NA, Yore MM, Ham SA et al. (2004) Increasing stair use in a worksite through environmental changes. *American Journal of Health Promotion* 18:312–5.

Table 1: Environmental intervention studies – physical change

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[1] Linenger et al. (1991) Physical fitness gains following simple environmental change	USA	Before-and-after. 12 months of follow-up from baseline. Non-intervention control site	1609 American naval personnel	To evaluate the effects of environmental change on physical fitness	The environment was altered to support an active lifestyle. Policy, access to facilities, physical changes to infrastructure and educational materials were all used to support physical activity Fitness score	Small significant increases in fitness scores for intervention site compared with others. Self-reported leisure time physical activity did not show improvement
[2] Vuori et al. (1994) Physically active commuting to work – testing its potential for exercise promotion	Finland	Before-and-after. 6 months of follow-up	1256 employees	To evaluate the impact of workplace changes to promote walking and cycling to work	New showers and changing facilities built for staff. Local authority lobbied to improve cycle routes to workplace. Travel diaries, educational events, fitness testing, lottery incentives also provided Cycling to work	7% increase in employees reporting active commuting to work after interventions
[3] Peel and Booth (2001) Impact evaluation of the Royal Australian Air Force health promotion program	Australia	Before-and-after. 6 years of follow-up	912 male RAAF pilots and navigators	To evaluate the impact of a health promotion programme	The environment was altered to support more vigorous physical activities. Included policy, access to facilities, physical changes to infrastructure, training courses, events and medical support for personnel to be more active Vigorous physical activity	Small, significant differences in physical activity between intervention and control participants. Trend difference also seen over time
[4] Merom et al. (2003) An environmental intervention to promote walking and cycling – the impact of a newly constructed rail trail in Western Sydney	Australia	Before-and-after. 3 month pre- and post-measure of bike trail use and cycle counts	Cohort of 450 adult bike owners (aged 18–55) within 1.5km and up to 5km from cycle trail	To evaluate the effects of bike trail usage supported by a media campaign on walking and cycling	Use of new cycle trail by walking or cycling Walking, cycling and cycle trail use	Mean bike counts of trail users increased post-campaign. Self-reported use of trail increased (+4%) post-campaign. Bike owners who lived closer to the trail were more likely to report using the trail

Table 1: Environmental intervention studies – physical change (cont.)

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[5] Gordon et al. (2004) Use of a community trail among new and habitual exercisers: a preliminary assessment	USA	Cross-sectional survey of trail users	414 adults who were using one of two new trails during the first summer they were opened	To evaluate the physical activity patterns and trail use among new and habitually active exercisers	Use of trail Physical activity, walking, running, in-line skating and cycling	23% of new trail users were new exercisers. New exercisers were more dependent on the trails as a primary source for physical activity than habitually active exercisers. New exercisers travelled shorter distances to access the trails
[6] Evenson et al. (2005) Evaluating change in physical activity with the building of a multi-use trail	USA	Before-and-after, 2 month pre- and post-measure of trail use	366 adults living within 2 miles of new trail	To evaluate the effect of a new trail on physical activity, walking, cycling and transportation physical activity	Trail use Different types of physical activity	23% had used the new trail at least once. No associations were found for different types of physical activity between adults who had and had not used the trail

Table 2: Environmental intervention studies – stair interventions

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[7] Brownell et al. (1980a) Evaluation and modification of exercise patterns in the natural environment	USA	Before-and-after	21,091 observations of stair and escalator users	To evaluate the impact of educational materials on stair use	Three different settings, shopping mall, train station and bus terminal at an upwards-choice point between stair or escalator use, with 2 day sign exposure Stair use	Increase in intervention phase of 8.1%
[8] Brownell et al. (1980a) Evaluation and modification of exercise patterns in the natural environment	USA	Before-and-after	24,603 observations of stair and escalator users	To evaluate the long-term impact of educational materials on stair use	Follow-up study in rail station only with 15 days sign exposure Stair use	Follow-up study showed a similar effect maintained but weakened over 3 months back to baseline levels
[9] Blamey et al. (1995) Health promotion by encouraged use of stairs	UK	Before-and-after	22,275 observations of stair and escalator users	To evaluate the impact of educational materials on stair use	Underground station use of stairs or escalator during mid-shopping day Stair use	7% increase during intervention period. Significantly above baseline at 12 weeks post-intervention
[10] Muttrie et al. (1996) Why do fewer women choose stairs?	UK	Before-and-after	22,275 observations of stair and escalator users	To evaluate the impact of educational materials on stair use by gender	Underground station use of stairs or escalator during mid-shopping day by different genders Stair use	Women were observed to use the stairs less than men
[11] Andersen et al. (1998) Can inexpensive signs encourage the use of stairs? Results from a community intervention	USA	Before-and-after	17,901 observations of stair and escalator users	To evaluate the effectiveness of signs to encourage stair use	Shopping mall use of stairs or escalator during mid-shopping day Stair use	2.1% small increase in stair use observed. Gender and ethnicity may mediate effect

Table 2: Environmental intervention studies – stair interventions (cont.)

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[12] Russell et al. (1999) The effectiveness of a point-of-decision prompt in deterring sedentary behaviour	USA	Before-and-after	6216 observations of stair and lift users	To evaluate the impact of educational materials on stair use	Use of escalators and stairs by university library users and staff Stair use	2.2% increase in stair use. Effect moderated by sex, age and day of the week
[13] Russell and Hutchinson (2000) Comparison of health promotion and deterrent prompts in increasing use of stairs over escalators	USA	Before-and-after	3369 observations of stair and escalator users	To compare the effects of health promoting and deterrent prompts on stair use	Use of escalator and stairs during mornings and early afternoon in an airport Stair use	Stair use increased 6.7% with health promotion signs, 6.1% with deterrent sign. Effect moderated by age
[14] Kerr et al. (2000) Posters can prompt less active people to use the stairs	UK	Before-and-after	Number of observations not stated	To assess the impact of poster prompts to use stairs not escalators on sedentary and active adults	Stairs not escalator use in two shopping centres in Birmingham Stair use	Not stated. Sub-group analysis showed less active people used the stairs during the intervention than baseline
[15] Coleman and Gonzalez (2001) Promoting stair use in a US-Mexico border community	USA	Before-and-after	53,537 observations of individual signs 61,616 observations of family signs	To compare the effects of individual and family promotion signs on stair use in a Mexican community in the USA	Bank, office building, airport and library use of stairs, escalator and lift use Stair use	3% increase in stair use across all settings. Women's stair use increased across all sites while men's increased at two sites only. No difference in type of sign or language of sign
[16] Boutelle et al. (2001) Using signs, artwork and music to promote stair use in a public building	USA	Before-and-after	35,475 observations of stair and lift users	To assess the impact of improving the attractiveness of a stairwell in addition to motivational signs	Use of stairs and lifts in university office. Improvement in the physical decor and aesthetic qualities of the stairwell Stair use	4.4% increase in stair use with signs and physical changes over baseline
[17] Titz et al. (2001) A worksite intervention module encouraging the use of stairs: results and evaluation issues	Switzerland	Before-and-after	3186 observations of stair use using observation and automatic counters	To encourage workers to use the stairs instead of the lift using written and poster materials	Stair not lift use in four Swiss federal office buildings Stair use	5.3% increase in stair use across four offices. Lift use counters underestimated use. Stair counters showed increased stairs use than observations

Table 2: Environmental intervention studies – stair interventions (cont.)

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[18] Kerr et al. (2001a) Can posters prompt stair use in a worksite environment?	UK	Before-and-after	12,288 observations in study 1 2694 observations in study 2	To assess the effectiveness of a poster prompt to increase stair use rather than lift use	Stair not lift use in two office workplaces Stair use	Study 1: no significant increase, +0.8% Study 2: no significant increase, +3.2% Stair use for descent increased in both offices: Study 1: +5% Study 2 +12%
[19] Kerr et al. (2001b) Six-month observational study of prompted stair climbing	UK	Before-and-after	45,631 observations	To assess the effects of stair riser banners to increase stair use rather than escalator use	Stair not escalator use in a shopping centre in Birmingham Stair use	Significant effect at 8, 14 weeks. Two-fold increase over first 3 months Significant effect at 6 months OR 1.29 (CI 1.14–1.47)
[20] Kerr et al. (2001c) Encouraging stair use: stair-banners are better than posters	UK	Before-and-after	11,961 at intervention site 12,018 at control site	To compare the effectiveness of two types of medium for stair use promotion, posters vs stair riser banners	Stair not escalator use in two shopping centres in Birmingham Stair use	Significant effect of poster in both sites OR 2.18 (CI 1.69–2.80) Rates of stair use were higher with the banners at the experimental site than with the poster at the control site
[21] Kerr et al. (2001d) The influence of poster prompts on stair use: the effects of setting, poster size and content	UK	Before-and-after	30,018 observations in studies 1 and 2 37,907 observations in studies 3 and 4	To examine the effects of poster size, poster message and setting on stair use	Stair not escalator use in three shopping centres and a train station in Birmingham Stair use	Studies 1 and 2: Poster size (A3, A2 or A1) had no significant effect on stair use Studies 3 and 4: both message types provoked significant increases, 2–4% over baseline levels
[22] Kerr et al. (2001e) Getting more people on the stairs: the impact of a new message format	UK	Before-and-after	23,665 observations	To assess the effectiveness of stair risers to prompt increase in stair use rather than escalator use	Stair not escalator use in a shopping centre in Birmingham Stair use	3% increase in stair use at follow-up over baseline levels
[23] Adams and White (2002) A systematic approach to the development and evaluation of an intervention promoting stair use	UK	Before-and-after	52,50 observations	To evaluate the short- and long-term effects of posters to increase stair use	Stair not lift use in a university department Stair use	No significant difference in stair use between baseline and 1 and 4 weeks

Table 2: Environmental intervention studies – stair interventions (cont.)

Author(s) (year), title	Country	Design	Sample	Study aim	Environmental change and physical activity variable	Findings
[24] Marshall et al. (2002) Can motivational signs prompt increases in incidental physical activity in an Australian health-care facility?	Australia	Before-and-after and survey data	158,350 counts	To evaluate the impact of a sign intervention on using stairs	Stair not lift use in a hospital Stair use Self-reported stair use	Stair use significantly increased after the first intervention but then decreased back to pre-intervention levels. No increase in self-reported stair use among hospital staff
[25] Kerr et al. (2004) Increasing stair use in a worksite through environmental changes	USA	Before-and-after	664 adults	To evaluate the impact of a four-staged intervention to promote stair use over a 4 year period	Stair use encouraged by decor improvements, artwork, motivational signs and music in an office Stair use	Mean trips per occupant a day using stairs gradually increased, with the overall effect of artwork, signs and music resulting in a 1% increase (3.7–4.7%). Each component of the intervention had a greater impact with a reduction in effect over time, eg music led to a 8.9% increase in the first 3 months of the intervention

Evidence

The evidence is presented in two categories covering two different approaches:

- interventions that made physical and policy changes to the environment
- interventions where the environment was used to host a prompt for an active rather than sedentary choice, ie stair vs escalator use.

The majority of the studies reviewed were found in the second group. Nineteen studies used health education materials to promote stair climbing in a variety of settings. Six studies made physical changes to an environment, with some interventions supporting this process with policy and regulatory changes. Three of these studies were conducted in the USA, two in Australia and one in Finland. Of the stair promotion studies nine were conducted in the UK, eight in the USA and one each from Australia and Switzerland.

The main findings from each category are presented below in two sections, each of which includes a discussion of the strengths and limitations of the evidence and its application in the UK. Studies are identified by author and by study number, which corresponds to the number assigned in Tables 1 and 2. This 'Evidence' section is followed by sections that examine broader issues of the limitations of the review process generally, recommendations for research, and conclusions.

Interventions that made physical and policy changes to the environment

This section reviews the effectiveness of environmental intervention studies that were based in a range of different settings – military bases, factories and local communities.

- Two studies examined the effectiveness of an environmental and policy intervention in military settings (Linenger et al. 1991; Peel and Booth 2001), and one study examined a workplace setting (Vuori et al. 1994).
- Three studies examined the impact of opening and promoting a new cycle path to promote walking and cycling among adults living near or using newly constructed cycle paths (called 'rail trails' in the USA) (Merom et al. 2003; Gordon et al. 2004; Evenson et al. 2005).
- None of these studies were from the UK.

Military/workplace settings

In study 1, Linenger et al. (1991) examined the impact on staff fitness of several physical changes to the environment at a naval base in the USA. The control groups were staff at other naval bases where the environment remained unchanged. Changes were made at the intervention base to make physical activity more convenient. These included the provision of new cycle paths and exercise facilities, extending the opening hours of exercise facilities, a women-only exercise facility, and setting up running and cycle clubs. Senior officers allowed their staff to take time to be active during working hours. A small improvement in fitness over baseline in the experimental naval base was seen when compared with the control bases.

Vuori et al. (1994) (study 2) evaluated the impact of improved facilities for cycling and walking to work on 1256 employees of a large factory in Finland. New changing, showering and drying rooms were built and promoted through events to encourage employees to walk or cycle to work. Educational events, mass walking fitness tests and incentives were offered to encourage and support change. The local government authorities were also presented with information from the employees and research team about local danger spots for cycling to and from the factory. Seven per cent of employees reported changing their commuting behaviour for either cycling or walking after the intervention.

In study 3, Peel and Booth (2001) reported the results of a health promotion intervention conducted across the whole Royal Australian Air Force (RAAF). A random sample of 912 male pilots and navigators participated in a series of cross-sectional surveys and physical examinations (including aerobic fitness tests) in 1980, 1983 and 1989. The group's results were compared with a similar civilian survey conducted by the Australian National Heart Foundation (NHF) over the same period. The intervention focused on many risk factors for heart disease and included an emphasis on physical activity promotion. Physical changes to all working environments included:

- upgraded gymnasium and sporting facilities, eg installation of weight-training equipment, treadmills and squash courts
 - allocation of duty time to accomplish group and individual fitness programmes
 - periodic physical fitness assessment and an annual physical fitness test
 - official sponsorship of a diverse range of sporting pursuits and encouragement of personnel to participate.
- (GR Peel, personal communication).

At baseline, the prevalence of vigorous physical activity was similar in the RAAF and NHF samples. The proportion of RAAF participants who were taking regular vigorous physical activity increased from 46% to 55% between 1983 and 1989; in the NHF sample, the proportion increased from 44% to 48%. This increase in prevalence of vigorous physical activity among RAAF participants over time approached statistical significance in 1989 (χ^2 test, $p = 0.08$).

Cycle/walking paths

Three studies examined the impact of newly constructed cycle or walking paths using either a pre- and post-measure of physical activity behaviour or path usage, or cross-sectional surveys.

Merom et al. (2003) (study 4) used phone interviews to evaluate the impact of a promotional campaign for a new cycle trail. The campaign targeted potential cyclist and walkers living within 5km of the trail. Features of the campaign included local press advertisements; radio features; maps; distribution of colour brochures to worksites, schools, community groups and commuters at rail stations; plus a launch event. The campaign aimed to raise awareness and encourage use of the new trail. Researchers interviewed a random sample of residents who lived within 1.5km of the trail and bike owners who lived 1.5–5km from the trail before and after the launch. Bike counters were also used to measure daily cycling activity at four locations along the trail.

Cycle count usage did increase significantly in the short term (approximately 3.5 months) after the launch of the trail. Trail usage was moderated by home distance to the trail and was higher among bike owners than walkers. Impact of the campaign was only found on cycle owners who lived within 1.5km of the trail – an increase in self-reported cycling compared with cyclists who lived further away (+0.19 hour, SD 1.5 vs –0.24 hour, SD 1.6). No changes were seen in self-reported walking. Trail usage was also associated with gender (more men than women) and age (more under 34 than over 35).

In study 5, Gordon et al. (2004) surveyed adult usage of two new walking and cycling trails during the first summer the trails were open. The trails crossed a rural town and comprised 12 miles of new level and paved pathway. Researchers interviewed 414 adults using the trails and asked about trail usage and changes in physical activity. They categorised users into new and habitual exercisers. Habitual exercisers were more likely to use the trail than new exercisers (77% vs 23%). However, new exercisers were more dependent on the trail as their primary outlet for physical activity than habitual exercisers. Closer proximity to the trail was also associated with new exercisers. Habitual exercisers were likely to report more vigorous physical activities usage on the trail (eg running, in-line skating) than new exercisers (eg walking).

In study 6, Evenson et al. (2005) carried out a before-and-after survey of the physical activity behaviour of residents who lived within 2 miles of a newly-built trail. The survey was conducted on a randomly selected sample of 366 adults before the trail was built and repeated 2 months after opening. All types of physical activities were assessed, including leisure time physical activity, walking, cycling and active travel. Twenty-three per cent of respondents had used the trail at least once since opening. In multivariable logistic models, using the trail was not associated with any significant change in any type of physical activity compared with those who did not use the trail.

Evidence summary

This evidence suggests the following.

- A combination of physical changes to working practices, policies and the physical environment appears to encourage some adults to maintain their vigorous physical activity and fitness. This conclusion should be treated with caution as there are insufficient numbers of well-designed studies to draw firm conclusions about what is effective.
- Two interventions have shown that changing the environment might play an active role in its relationship to physical activity (Linenger et al. 1991; Peel and Booth 2001). Further studies outside military settings are required to identify which aspects of the interventions had the most impact on particular behaviours.
- The development of new cycle and walking paths appears to encourage use. This conclusion should be treated with caution as there are insufficient numbers of well-designed studies to draw firm conclusions about what is effective. Use appears to be optimised by support from local promotional campaigns. The effect of the path on physical activity is mediated by proximity of users to the path (distance from home), concerns about safety and current levels of physical activity. A path may attract more adults who are already active, rather than new exercisers.
- Further studies should evaluate the contribution of use of a new cycle or walking path to adults' overall levels and patterns of physical activity. These evaluations should try to assess if any new physical activity behaviour is a result of the intervention rather than the intervention shifting physical activity from one exercise opportunity to another.

Strengths and weaknesses of the studies

Five of the six studies reported a small effect of their interventions on increasing physical activity levels as a direct change in self-reported physical activity, cardiovascular fitness or trail usage (Linenger et al. 1991; Peel and Booth 2001; Vuori et al. 1994; Merom et al. 2003; Gordon et al. 2004).

Most of the included studies contained methodological limitations. Only two studies could compare their effects with a direct control or comparison group. The majority of studies used a before-and-after design, and so were unable to attribute changes to the intervention alone. All the studies were conducted within field settings and therefore were subject to systematic error, including selection bias and measurement bias (Beaglehole et al. 1993). Two studies that interviewed trail users on the trails reported high response rates and an obvious response or selection bias.

Overall, the studies did not present any power calculations so it is difficult to determine if their response rates were adequate to answer the study questions. Finally, limited information was presented on the reliability and validity of the self-reported measures used in the studies, particularly reported physical activity related to using a trail. Most studies relied on self-reported physical activity as their outcome and many did not report the validity and reliability of the method used. This is likely to lead to random misclassification of participants and therefore a possible underestimate of the true effect of the interventions.

Few studies reported the potential modification of effects by factors such as gender or social position. Other socio-demographic and socio-cultural factors may be more important in determining participation and trail usage than proximity.

Generalising results

The recruitment and selection of participants to the studies limits the applicability of these interventions to a UK context. The study participants were generally well educated and white. None of the studies were based in the UK. It is not known how well studies conducted in the USA and Australia could be transferred to the UK. However, examples of environmental interventions do exist in the UK, particularly in workplace settings and

especially with the development of the Sustrans national cycle path network. These interventions present a major opportunity to evaluate these natural experiments.

Despite the appeal of changing the environment or providing new opportunities for physical activity (eg cycle paths), the evidence base for these approaches in terms of promoting physical activity is small. Some evidence does exist of an effect on physical activity behaviour in the short term but this evidence base is weakened by poor study methodology.

Interventions where the environment was used to host a prompt for an active rather than sedentary choice, ie stair vs escalator use

This section reviews the effectiveness of environmental interventions that were based in a range of settings: public transport (rail, bus or underground stations and airports), commercial (shopping centres, banks), workplaces (offices), a university (library) and hospitals. Some studies used more than one setting for the interventions.

- Seven studies examined the effectiveness of a stair intervention in a public transport setting (Brownell et al. 1980a/b; Blamey et al. 1995; Mutrie et al. 1996; Russell and Hutchinson 2000; Coleman and Gonzalez 2001; Kerr et al. 2001d).
- Eight studies examined the effectiveness of a stair intervention in a commercial setting (Andersen et al. 1998; Kerr et al. 2000; Coleman and Gonzalez 2001; Kerr et al. 2001b/c/d/e).
- Six studies examined the effectiveness of a stair intervention in a workplace setting (Coleman and Gonzalez 2001; Boutelle et al. 2001; Titze et al. 2001; Kerr et al. 2001a; Adams and White 2002; Kerr et al. 2004). Other settings include a university library (Russell et al. 1999) and a hospital (Marshall et al. 2002).
- Nine studies were from the UK.

Each stair intervention used a before-and-after study design to examine the impact of health education posters on the choice of using stairs or an escalator or lift. The studies observed the use of stairs and escalators before and after an intervention period (ie exposure to health information).

In study 7, Brownell et al. (1980a) made more than 20,000 observations of stair users in three places: a shopping mall, a train station and a bus terminal. The posters had an effect on stair use at all three sites, with about an 8% impact during the intervention phase on stair use. In a follow-up intervention (study 8), conducted at a railway station, this impact returned to baseline levels 3 months after the poster was withdrawn (Brownell et al. 1980b).

A similar intervention was conducted in the UK (Blamey et al. 1995, study 9), which repeated the studies of Brownell et al. (1980a/b), making more than 22,000 observations at a set of escalators and stairs at a Glasgow underground station. Blamey et al. (1995) reported that the poster continued to have an effect 3 months after it was withdrawn.

In study 10, a post-hoc analysis of the same data, Mutrie et al. (1996) suggested that the effect of the poster was similar for men and women; however, fewer women chose to use the stairs at all time points. The poster intervention significantly reduced and maintained the odds against using the stairs, from about 7:1 to about 4:1 against for men and from about 18:1 to 7:1 against for women, during the 4 week intervention period.

In study 11, Andersen et al. (1998) also replicated the Brownell et al. (1980a/b) studies, this time in a shopping mall in the USA, making more than 17,000 observations. The impact of posters with a health message and posters with a weight message were assessed. The impact of both posters was small during the intervention period, just under an 8% change from escalator to stair use.

In study 12, Russell et al. (1999) looked at the effect of signs on the use of a university library lift over 11 weeks. After 6216 observations, stair use only increased slightly by 2.2%. The effect of the signs was mediated by gender, age and day of the week. Stair users were younger, both men and women (n = 530), and a higher rate of use was seen on Monday to Thursday compared with Friday.

In study 13, Russell and Hutchinson (2000) compared the effect of two types of posters in a regional airport, a prompt sign for using the stairs and a deterrent sign asking for limited use of an escalator. After 3369 observations, both types of poster increased stair over escalator use by about 6% (p < 0.0001). The effect of

the posters appeared to be greater on younger (aged less than 40) adults, both men and women, but there was no difference between each type of poster.

Coleman and Gonzalez (2001) (study 15) used a Spanish version of the sign used by Brownell et al. (1980a/b) in a Hispanic community in the USA. Two versions were created, one aimed at individuals and one 'family focused'. The researchers made 53,537 observations at a bank, airport and library on the effect of the 'individual' signs and 61,616 observations at an office building, airport and library on the 'family' signs. A slight increase in total stair use (2.2%) was found for the whole intervention but this effect was not maintained after the intervention phase. Different levels of effect were found across intervention sites where baseline stair use varied considerably. Overall, the study showed a short-term, limited effect across a number of different settings and was also limited by mixing the effect of the intervention between stair use and escalator use, and stair use and lift use.

In study 16, Boutelle et al. (2001) examined the effectiveness of improving the attractiveness of a stairwell on stair use, in addition to signs encouraging stair rather than escalator use. The researchers made 35,475 observations of stair use in a university office building in the USA. Baseline measures of stair use were made, then 10 signs to encourage stair use were put up and the effects observed over a month. Later, music and artwork were added to the stairwell. The artwork was changed each week and the music played in the stairwell was changed daily; repeat observations were made. The combined effect of signs, music and artwork increased stair use by 4.4% over baseline levels after 1 month but no further follow-up was undertaken. The researchers also note that more people used the stairs to go down rather than up during the intervention period.

In study 17, Titze et al. (2001) used two approaches to encourage employees of four Swiss federal offices to use stairs rather than lifts. Written materials were sent to all employees and office workers suggesting different approaches to encouraging stair rather than lift use. These included rewards of fresh fruit, games and the symbolic closing of the lifts for a day. Observations were conducted before-and-after the 4 month intervention period, while automatic electronic counters recorded lift and stair use. Overall, the interventions increased stair use by 5.3% over baseline levels across all four offices

($p = 0.0281$). There were considerable differences in the impact of the different interventions across the four offices, with improvements in stair use from baseline to follow-up ranging from 2.8% to 13.2%. The authors suggest that these differences in rates could be explained by the attractiveness of the stairwells. The worksites with the most attractive stairs had the highest baseline and change rates of stair use.

Kerr and co-workers have published six papers (studies 14 and 18–22) covering different interventions and aspects of stair climbing (Kerr et al. 2000, Kerr et al. 2001a/b/c/d/e).

Study 14 took place in two different shopping centres in Birmingham – posters encouraged adults to climb stairs rather than use the escalators (Kerr et al. 2000). The results from two before-and-after interventions were combined and showed a significant increase in stair use during the intervention period (4 weeks) compared with the baseline period (2 weeks).

Study 18 tested the impact of posters on stair use in the workplace at two accountancy firms (worksite 1, $n = 250$; worksite 2, $n = 2694$) (Kerr et al. 2001a). Baseline stair use (ascents and descents) and lift use was established over 2 weeks by researchers counting users recorded on hidden cameras. At the first worksite, 12,288 observations were made; at the second worksite, 2694. No significant increase in stair ascents was seen in either worksite (worksite 1 = +0.8%, worksite 2 = +3.2%). However, both sites saw a significant increase in stair descents (worksite 1 = +5%, worksite 2 = +12%).

Study 19 examined the impact of prompts on stair and escalator use at a shopping centre in Birmingham (Kerr et al. 2001b). Shoppers faced a choice between a 24-step flight of stairs or an adjacent escalator. The stair prompts were stair riser banners, small signs that were placed on the vertical part of each step. The stair banners remained in place for 12 weeks, with repeat observations made for an additional 2 weeks and also 8 weeks later. Over the 24 weeks of the study, 45,631 observations of escalator/stair use were made. Differences were noted between the sexes, with women more likely to use the stairs than men during the intervention period. Stair riser banners were associated with a two-fold increase in stair use over a 3 month period. After 6 months, stair use was 29% greater than stair use at baseline (OR = 1.29, 95% CI 1.14–1.47) after adjusting for pedestrian traffic volume, sex, ethnicity and age (Kerr et al. 2001b).

Kerr and colleagues evaluated the impact of different types of media for encouraging stair use in studies 20 and 21.

Study 20 compared the impact of stair riser banners and stair posters on stair use at two shopping centre sites in Birmingham (Kerr et al. 2001c). This study compared the impact of both media with each other and a control site, adjusting the results for pedestrian traffic volume, sex, age and ethnicity. Both media increased stair use over baseline values but the stair risers had a greater impact than the posters alone after 4 weeks (net increase 4.1% vs 1.9% from baseline values).

Study 21 examined the impact of different poster sizes, messages and settings on stair use (Kerr et al. 2001d). There were significant increases in stair use with two poster sizes (A1 and A2) but not for A3. Two poster messages, 'Stay healthy, save time, use the stairs' and 'Stay healthy, use the stairs', both increased stair use but the authors report that the first message appeared to have a greater impact on women's stair use than the second message. The impact of the posters in different settings (shopping centre and railway station) also showed a difference, with the first message encouraging greater stair use in the station.

In study 22, Kerr et al. (2001e) examined the short-term impact of stair risers on stair and escalator use over an 8 week period in a shopping centre in Birmingham. As in previous studies, a significant short-term effect was observed over baseline levels (10.6% increase) after adjusting for pedestrian traffic volume (OR = 2.27, 95% CI 2.05–2.51).

Adams and White (2002) (study 23) evaluated the short and long-term impact of posters to promote stair vs lift use in a university medical department in the UK. Posters were used to encourage staff to take the stairs instead of the lift in any journey up to five floors. No significant difference in stair use was seen over 5250 observations between baseline, one and four weeks. The authors also report, in a process evaluation of the intervention, that 29 out of 39 signs were stolen during the intervention period.

In study 24, Marshall et al. (2002) evaluated the effects of a stair use promotion campaign on staff and visitors in an Australian healthcare facility. Posters and footprints leading to stairwells were used to encourage stair rather than lift use. Stair use significantly increased after the

intervention but then decreased back to pre-intervention levels. There was no increase in self-reported stair use among hospital staff.

Kerr et al. (2004) (study 25) assessed the cumulative effect of improvements to the main stairway of an office building in Atlanta, USA. Improvements were:

- installing new carpet and painting the walls
- adding artwork to walls on stair landings
- displaying motivational signs to encourage stair use throughout the building
- playing music in the stairwell.

Stair use data (stair trips per day) were collected using sensors on the 664 adult workers over the time period of improvements (about 4 years). Mean trips per occupant a day using stairs gradually increased with the overall effect of artwork, signs and music resulting in a 1% increase (3.7% to 4.7%). Each component of the intervention had a greater impact but there was then a reduction in effect over time, eg music led to a 8.9% increase in the first 3 months of intervention. Overall, modest effects were seen during all stages of the improvements but there were no significant differences between improvements. Stairway use declined across the long follow-up period, but did not return to baseline levels.

Evidence summary

This evidence suggests the following.

- Using the environment as a point of active or sedentary choice (eg use of stairs not the lift) with written media (eg stair posters, riser banners on steps) can have a short-term effect on stair use for up to 3 months, with one study reporting an effect at 6 months after baseline (+29%, Kerr et al. 2001c). Although there are a large number of studies in this area, without the benefit of any comparison or control groups no conclusions can be made about the effectiveness of such interventions.
- Studies show that a variety of printed media in commercial, workplace and transport settings can increase the use of stairs, but changes diminish over time. The efficacy of the stair interventions varied within the study populations, with different effects seen for different groups based on age, sex, observed body mass index and ethnicity. These effects were not consistent across the studies.

- Further research on using the environment to promote stair use should use a quasi-randomised design, ie randomised matched pairs of stairs to intervention and comparison groups. Studies should focus on settings where consistent patterns of physical activity behaviour are established and most amenable to change.

Strengths and weaknesses of the studies

Nineteen studies reported the results of using written media (eg posters, riser banners) to prompt stair use rather than escalators or lifts. The majority saw a short-term effect for up to 3 months, with one study reporting an effect at 6 months after baseline (+29%) (Kerr et al. 2001c). Two studies reported no effect (Kerr et al. 2001a; Adams and White 2002).

A number of methodological limitations were present in the studies. Only two presented power calculations to estimate the sample required to adequately detect an effect (Adams and White 2002; Marshall et al. 2002). Some attempts were made to adjust the impact of these studies statistically for potential confounders such as pedestrian traffic volume, age, sex and ethnicity. However, this statistical adjustment still leaves other sources of bias and, without direct comparison of two randomised groups, these will remain.

The specific nature of the interventions' 'behaviour settings' (eg shopping centre, train station, library, airport, workplace) prevents any comparisons of effects between these settings. Each setting will have a different function and different 'setting-dependent' factors that may influence stair use. These factors remain unclear and may explain the different and contradictory results between studies. For example, most of the studies excluded stair or escalator users if they were carrying baggage or had children. These groups might respond differently to signs and their exclusion reduces the applicability of the results to the whole population. A number of studies used observers to classify stair users and non-users by age, ethnicity and in one case body mass, which created a potential for classification bias.

Generalising results

Nine of the studies were conducted in the UK. The feasibility of such interventions has been assessed in a wide range of UK settings, including transport and the

workplace. Eight studies demonstrated a short-term effect of different approaches to encouraging stair use. The series of studies conducted by Kerr and colleagues systematically assessed a number of different media, messages and approaches to the promotion of stair use. They also evaluated if there was differential effect of their interventions (ie a different effect of the intervention on different groups). Differential effects were examined for adults who reported they were active or inactive, and for gender, age and ethnicity. Greater effects were reported on younger men and women (Kerr et al. 2001b). However these effects were not consistent with other studies performed outside the UK.

Recent public campaigns have encouraged the use of signs to support the promotion of stair use. There is an evidence base for these approaches and the majority of studies demonstrate short-term positive effects, but this evidence base is weakened by poor study methodology. There are also a number of concerns about the impact of a relatively brief, vigorous intensity activity such as stair climbing on overall physical activity levels, and hence health. This issue is discussed further on p24.

Discussion

One limitation of this review is potential publication bias. Other types of interventions may exist but have not been submitted or accepted for publication, or only those with positive results have been published. Other reviews have commented on the lack of research in this area (Sallis et al. 1998). Only two studies had comparison or control groups using an experimental design; the other studies were unable to attribute changes to their intervention alone. All the studies were conducted within field settings and therefore are subject to systematic error, including selection bias and measurement bias (Beaglehole et al. 1993).

The evidence base for the effectiveness of interventions aimed at changing policy or the environment on physical activity is still small. This review is limited to experimental or quasi-experimental studies and so excludes a substantial amount of literature from consideration. Other types of methodological approaches, for example qualitative work, tend to be under-represented in this type of evidence (Kelly et al. 2002).

This review found only a few studies that examined the effectiveness of using the environment to promote health-enhancing physical activity. Despite this, a number of national public health bodies have publicly supported the role of the environment in promoting health-enhancing physical activity. The Centers for Disease Control and Prevention (CDC) in the USA has published a series of recommendations for the promotion of physical activity (Kahn et al. 2002). This reviewed six studies on 'point of decision' prompts for stair use, and 10 studies on environmental and policy approaches.

The CDC supported the use of point of decision prompts that encourage people to use stairs and strongly recommended creating or improving access to places for physical activity. Kahn and colleagues' review of six

studies, all of which are included in this review, suggests that point of decision prompts increased stair use by 54% (using a median net estimate of effect) (Brownell et al. 1980a/b; Blamey et al. 1995; Andersen et al. 1998; Russell et al. 1999; Kerr et al. 2000). This estimate ignores any long-term decline also seen in these studies, focusing instead on indications of short-term effects on stair use.

Kahn and colleagues' review of 10 studies that aimed to create or improve access to places for physical activity produced a median estimate of effect of a 25% increase in the proportion of people who exercise at least three times a week. The environment played a role in some of these studies, including creating walking trails and building exercise facilities. The interventions took place in a range of settings, including industrial plants, universities, federal agencies and low-income communities. Additional parts of the interventions included individual one-to-one counselling, training, physician advice, risk-factor screening and support, so it is impossible to isolate what contribution the environment played in producing an effect.

The environmental change studies relied on self-reported measures of physical activity. There are some key limitations in the measurement of physical activity. These self-reports were all typically retrospective and therefore at risk of recall bias. There is also the risk of socially desirable responses (ie the respondent may give the reply/answer they think the interviewer wants to hear). This is more likely when the follow-up period is short, and possibly in particular settings.

While these potential biases are likely to lead to some misclassification of physical activity, there is no evidence that any misclassification would be systematically different between intervention and control groups.

Therefore, the most likely outcome is an underestimate of the true effect of an intervention. This may not be the case in studies that used only a before-and-after measure, where over-reporting of physical activity might be likely.

However, stair studies often reported high reliability of their observational measures. Three studies used counters (Titze et al. 2001; Marshall et al. 2002; Kerr et al. 2004) and one used CCTV videos (Kerr et al. 2001a) as an objective measure to assess stair use. Use of objective measures may give more precise estimates of an effect of an intervention than studies that used observational measures. Three studies reported small effects and one no effect. The majority of stair studies reported a small effect of their intervention, usually a change in the proportion of stair users during an intervention period compared with baseline.

It could be argued that the size of the effect was generally small and may not be clinically meaningful (not enough of a 'dose' of exercise) or at a level equivalent to current public health recommendations. Conversely, stair climbing could add to the accumulation of daily physical activity. Further research is needed to establish how stair climbing fits into the adoption and maintenance of physical activity.

Gaps in the evidence base and recommendations for research

Future research in this area should answer the following questions, using objective measures of the environment and physical activity behaviour.

- What aspects of the environment are related to what types of physical activity behaviour for what kinds of people?
- How do these aspects of the environment impact on physical activity and sedentary behaviour?
- What is the contribution of the environment compared with other determinants of physical activity, including socio-demographic, cultural and social contexts?
- Of these aspects of the environment, which ones can be changed to impact on health-enhancing physical activity?
- What is the efficacy, effectiveness and efficiency of these interventions?
- How can these interventions be implemented in practice?
- What are the differential impacts of these interventions on disadvantaged groups?
- What is the evidence on cost effectiveness of these interventions?

Without the answers to these questions, the potential of environmental interventions to influence physical activity will remain unclear to those wishing to promote physical activity.

Reviews of broader aspects of evidence will help our understanding of effectiveness. Reviewing interventions at community, policy or environmental levels will first require criteria on the level of evidence of effectiveness that is being sought. While the randomised controlled trial is often referred to as the 'gold standard' it is not appropriate for all research questions. The evidence presented in this review is limited to two types of environmental interventions that target individuals within

particular settings, as opposed to those targeting whole communities. Evidence of effectiveness may exist in other areas such as community, policy or fiscal interventions. Physical activity will require interventions at all of these levels as it is performed within a social and physical environment. How best to combine interventions at different levels, to diverse populations, in different settings, requires further exploration.

Many of the possible interventions to promote physical activity will also be directed at achieving other goals, such as changes in travel patterns, reduction in fossil fuel use or reductions in road danger. Where physical activity is one of several potential outcomes the difficulties in evaluation are considerable, and the level of outcome needed for 'success' may be different from a specific intervention to promote physical activity (such as brief advice in a healthcare setting). For instance, a change in road transport policy or road design to reduce danger (such as the implementation of congestion charging in London or the development of Home Zones) may be able to influence physical activity. Developing methodologies to examine such disparate outcomes across disciplines as well as developing interventions to take advantage of changing environments remains a challenge for researchers and practitioners alike.

This review has found evidence that changing the physical and policy environment can have a small effect on physical activity. However, the balance between the cost of environmental development and change, and benefit from an individual or environmental perspective, remains unclear. If users of a path must drive to use it is the environmental cost worth the benefit to the individual? If a cycle path is only used by those who already cycle then the path is supporting the already active and could be maintaining a gap between the inactive and active.

The impact of using environmental approaches to promote physical activity needs further exploration into what types of people are attracted by which types of environments and activities for what reasons. It may be the case that active people seek active environments or that only certain environments attract certain types of active people. Further research should attempt to understand the interaction of individuals, their physical activity behaviours and their views of the environment, prior to developing further environmental interventions.

Present UK physical activity policies relating to changing the physical environment (particularly transport and urban planning) are based on the belief that the environment does impact on physical activity behaviour. However, the effectiveness of policy recommendations such as traffic calming, footpath and cycle path development on promoting physical activity remains unknown. Given that it will take some time for more research to be conducted on the effectiveness of environmental changes to promote health-enhancing physical activity, it is appropriate that existing schemes that aim to change the environment should continue, given that a theoretical argument can be made to support them and there is no evidence that they do any harm. In addition, many of these interventions (such as traffic calming) are designed to meet other national or local goals or targets (such as injury reduction from road crashes), and there is frequently substantial evidence bases to support them from these points of view.

To build the physical activity evidence base, well designed, resourced and published evaluations of these interventions are vital. For example, the National Cycle Network is described by Sustrans as 'the largest environmental intervention promoting public health in the UK' (Sustrans 2002) This year it will offer over 10,000 miles of cycling and walking routes but will need to be evaluated to support any claims of effectiveness.

Any such evaluations should adopt validated and appropriate measures of physical activity, ideally objective measures, and include an assessment of other key determinants of physical activity, including individual, social and area-level variables. Evaluations of such interventions should have appropriate funding. Analysis of the impact, using appropriate multi-level statistical methods, of such interventions would then be able to distinguish the overall contribution of changing the environment beyond other possibly stronger influences.

A recent strategy statement on physical activity promotion from the Scottish Executive (2003) recommended 'the development of safe environments for active living'. Two performance indicators for monitoring progress towards changing the physical environment and provision of facilities or resources were outlined. These included miles of cycle paths (per 1000 population), pedestrianised areas (m² per 1000 population) and areas and numbers of exercise facilities (per 1000 population). Although this present review shows very little evidence to date that allows a conclusion to be made about a relationship, these indicators would prove simple to correlate against population physical activity levels. Indeed monitoring of possible supportive environmental factors (such as cycle paths) should be made at the level of the environment (ie miles of cycle paths per 1000 population).

Stair climbing has a high energy cost and is designated a vigorous physical activity (8 METs [metabolic equivalent] – see Ainsworth et al. 2000). It contributes to overall energy expenditure but its impact on other health benefits is less clear. For example, stair climbing may provoke an acute physiological response by raising heart rate but the overall effect of improving cardiovascular fitness may be limited owing to the short duration of activity.

Boreham et al. (2000), in a study of the training effects of stair climbing among sedentary young women, suggested that climbing at least six flights of stairs (approximately 200 steps) each day of the week improved indices of cardio-respiratory fitness. Fardy and Ilmarinen (1975) estimated that a 70kg man would need to climb at least 25 flights a day to result in a significant improvement in maximal aerobic power.

Most of the choices of these interventions were only one to two flights of stairs vs a lift or escalator. The potential health benefits could be great if the whole population changed to using the stairs rather than a lift. It is argued that consistent daily use of stairs will impact on health in the long term, but the impact of this review's studies was only short term. However, more than one or two flights of stairs would have to be climbed each day to achieve any potential health benefits. One recent UK study suggested that just 7 minutes of stair climbing a day reduced the chances of dying from coronary heart disease by 62% (Yu et al. 2003). It is still unknown if stair climbing is a good starting point towards active living or if it plays a part in maintaining active living.

The effectiveness of stair interventions still needs to be determined, although this review shows short-term efficacy in encouraging stair use. Further studies into using the environment to promote stair use should use a quasi-randomised design, ie randomised matched pairs of stairs to intervention and comparison groups. Similar designs have been used to evaluate health promotion interventions in schools but do suffer from bias in finding appropriate matches in populations and settings. Studies could match appropriate buildings in workplaces or airport terminals, and stations in cities. Studies should focus on settings where consistent patterns of physical activity behaviour are established and most amenable to change. Objective measures of stair use should be used. In addition, data collection should include information about patterns and levels of physical activity, and stair use in different behaviour settings. The differential effects of the interventions within different social and cultural groups should also be examined.

Policy makers should recognise that encouraging stair use in all circumstances may not achieve much for public health. The efficacy of stair interventions are small and short term, and the costs unclear (although likely to be small). It could be argued that a small population change in stair use would be a desirable gain but the evidence suggests that the gain might be short term and perhaps only reinforces the behaviour of the already active. Stair climbing is a vigorous physical activity and perhaps less appropriate than moderate activity for a physical activity recommendation. Recommendations about stair climbing might see it as a means to maintain muscle strength and an opportunity to save natural resources and energy.

The promotion of physical activity using stairs can also include technological interventions, rather than educational approaches. One example of a technological study was excluded from this review as it did not present any data on changes in physical activity level or stair use. Van Houten et al. (1981) evaluated the impact of an energy-saving campaign in a Canadian university hall of residence. The promotion of stair use was not the primary outcome of the study.

Van Houten et al. (1981) encouraged residents to reduce their use of lifts to save electricity. Weekly reductions in electricity were shared as feedback and posters were also used to support the campaign as electricity consumption fell. The researchers then altered the lift door closing times. This meant the operation time of the doors

opening and closing was slowed, increasing any time using the lift. Normal door operating time was 10 seconds from opening to closing and the increased time was 26 seconds. After a day of complaints about the lifts not working properly, lift use in the following period fell dramatically, with a corresponding increase in stair use.

A further study into the effects of different door delay times determined that 26 to 34 seconds provoked the optimal decrease in lift use and corresponding stair increase. Although the levels of stair use were not reported directly the researchers did observe a large increase in stair use during these interventions. Such an approach may be worthy of further investigation.

The current evidence reviewed here does not address issues of inequality, and research to examine the differential impact on sections of society is needed.

Although this review did not explicitly aim to search for evidence of cost effectiveness, one study (which was excluded from the review because it only had a post-intervention measure) presented data on the cost effectiveness of four bicycle/pedestrian trails (Wang et al. 2004). There is an increasing acceptance of the importance of assessing interventions in terms of their cost effectiveness as well as their effectiveness. As environmental change will have impacts beyond health, economic analyses could reasonable include costs in terms of the environment, eg use of fossil fuels, loss of green space, damage to the natural environment. Indeed this also holds true of other approaches to physical activity promotion.

Conclusions

The evidence base (in terms of high-quality experimental evidence) for environmental policy recommendations in the UK is still sparse. There is an urgent need to conduct research into the effectiveness of environmental interventions, particularly within socially-excluded sectors of the population who have the highest prevalence of physical inactivity. High-quality evaluations of natural experiments would be a good starting point.

The environment can influence physical activity, but without a systematic assessment of the nature of the relationship of specific environments to specific physical activity behaviours, it is unlikely that new broad public health interventions can be created. Current physical activity programmes have embraced the frameworks offered by the behaviour settings model, with examples of interventions aimed at the workplace, schools and the community. The lack of evidence of how to use the environment as part of an intervention within these settings is illustrated by the findings of this review. Until an evidence base is constructed, the impact of using the environment as a tool for encouraging physical activity will be based on instinct rather than good evidence.

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APPENDIX 1

Critical appraisal tool for primary studies

Paper number
First author
Reviewer
Country
Design
Study aim
Subjects (describe)
Age range
% male
% non-white
Study setting
Theoretical model of intervention
Describe intervention
Describe control condition (if applicable)
Excluded subjects
Possible confounders
Follow-up methods
Frequency and timing of observations or measures (weeks from baseline)
Outcome measure period (direct observation)
Outcome measures (measure of physical activity)
Were any outcome measures validated?
Were any adverse events described?
Numbers identified as potentially eligible in study
Numbers identified as eligible for study
Number subjects/observations
Number subjects/observations in final analysis
Main analysis
Sub group analysis
Results
Generalisability to UK
Notes