European Commission

Health Equity Pilot Project (HEPP)

Evidence review

The impact of interventions and policies on SES differentials in physical activity

Health

Prepared for the Health Equalities Pilot Project

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Overview

This briefing paper describes the nature and extent of inequalities in physical activity participation across the European region, and outlines the evidence for approaches that may be taken to reduce these inequalities.

1. Introduction

Regular participation in health-enhancing physical activity is associated with beneficial impacts on over twenty health conditions, and reduced risk of early death. It has been estimated that physical inactivity is as important a modifiable risk factor for chronic diseases as obesity and tobacco[1].

Physical inactivity is also associated with a significant economic burden. Precise estimates are difficult because of limited data, but one study estimated the global cost of physical inactivity to health-care systems to be a minimum of $53.8 billion in 2013, with an additional $13.7 billion attributable to related productivity losses. Physical inactivity was responsible for 13.4 million disability-adjusted life years worldwide[2]. Despite strong and extensive evidence for the benefits of regular physical activity, levels of physical activity are low across most countries of the European region.

The spread and nature of physical inactivity across Europe (and beyond) has been described as a 'pandemic'[2]. Evidence from many countries shows that physical activity varies among (and between) populations, and that some population sub-groups – whether defined by social or cultural factors, education level, or income – may be more or less active than others. In many cases people on low incomes experience reduced levels of physical activity. This is likely to contribute to the substantial health burden and pervasive health inequalities experienced by these individuals across Europe[3].

This briefing paper sets out to describe the nature and extent of inequalities in physical activity participation across the European region, and to outline the evidence for approaches that may be taken to reduce these inequalities.

2. Methods

We searched the published academic literature for papers that a) described the nature and extent of inequalities in physical activity across Europe and b) provided evidence for interventions or approaches to address inequalities. To focus the review on the most appropriate evidence in the time and resources available we restricted our search to review-level articles. We also conducted a search of grey literature (see Appendix 1), reviewed authors' own files, and contacted experts for their input.

Databases searched

The following bibliographic databases and sources were searched:

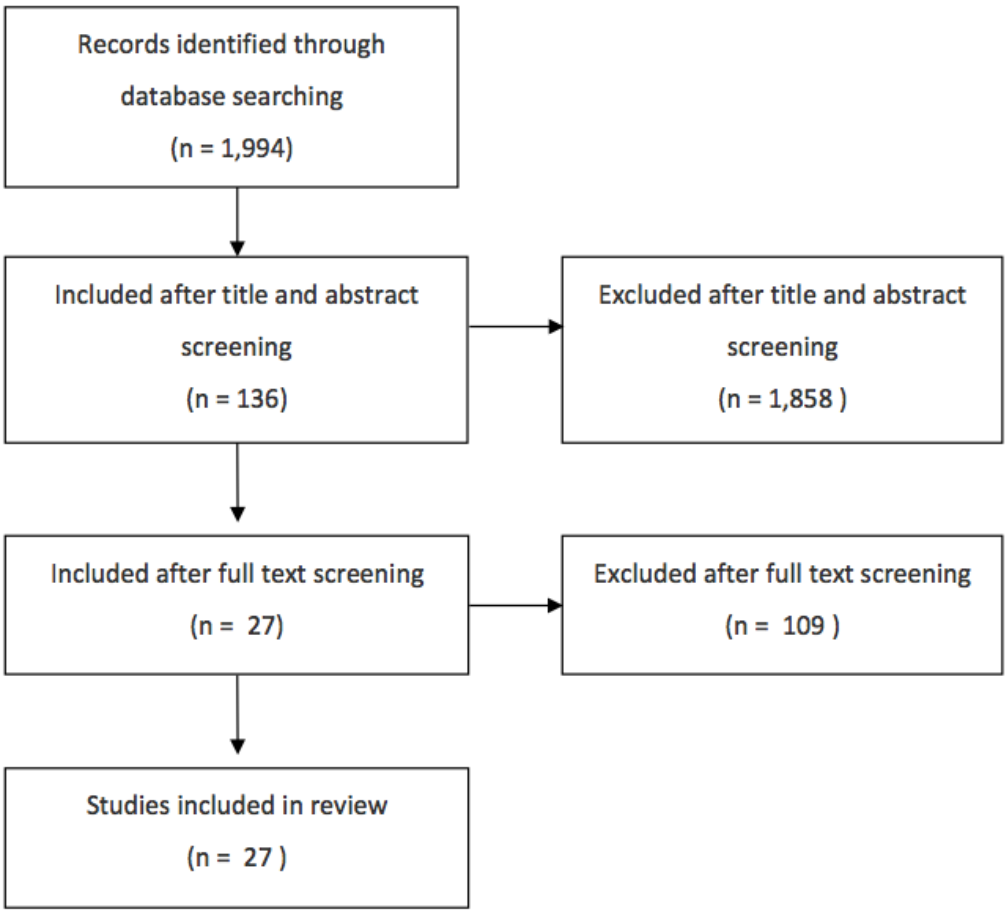
- Embase
- Medline
- Cochrane Library
- PsycInfo
- Cinahl
- Scopus
- Grey literature sources (see appendix)

Search terms

A set of search terms for EU Member State countries was used with every search. Sets of terms for either socio-economic status (SES) or geographic indicators of deprivation were used with sets of terms for topics as indicated in the summary table of results. A set of search terms was drafted for each topic, e.g. physical activity, sedentary behaviour, or active travel. Each set of terms was searched for in title and abstract, and subject headings too where available. Within each set terms were combined with the Boolean 'OR' operator e.g. Europe OR member state* OR France etc. The different sets of terms were combined with the 'AND' operator e.g. (terms for EU Member States) AND (terms for SES) AND (terms for physical activity & sedentary behaviour). Subject headings were adapted to make use of the subject headings available in each database searched.

The results of the search and screening processes are shown in Figure 1, in the overall PRISMA diagram. Detailed PRISMA diagrams are shown in Appendix 2.

Figure 1. PRISMA Search results[1] Diagram



3. Background: the nature of inequalities in physical activity

Inequalities in physical activity

Childhood socio-economic position and adult physical capacity/fitness

The strongest evidence for the existence of a socio-economic gradient in physical activity (and its impact on fitness) comes from a meta-analysis of 19 studies that examined the association between any indicator of childhood socio-economic position (e.g. parental occupation or education) and pre-specified objective measures of physical capability[4]. This study design is strengthened by measuring objective indicators of capability (such as fitness or strength) rather than self-assessed physical activity. Increased fitness is a direct outcome of regular physical activity, and is related to many aspects of health, increasing the strength of this study design.

[1] Results for each subject search in Appendix 2

The review found consistent evidence in age-adjusted models that lower childhood socio-economic position was associated with modest reductions in physical capability levels in adulthood: comparing the lowest with the highest childhood socio-economic position[2] there was a reduction in mean walking speed of 0.07 m/s (0.05, 0.10), an increase in mean chair rise time of 6% (4%, 8%), an odds ratio of an inability to balance for 5s of 1.26 (1.02, 1.55), and a reduction in grip strength of 0.13 standard deviations (95% CI: 0.06, 0.21). Adjustment for the potential mediating factors of adult socio-economic position and body weight greatly attenuated these associations. However, despite this attenuation, for walking speed and chair rise time, there was still evidence of moderate associations. The authors concluded that 'policies targeting socio-economic inequalities in childhood may have additional benefits in promoting the maintenance of independence in later life'[4].

Childhood socio-economic position and adult physical activity

A systematic review of childhood socio-economic position and adult leisure-time physical activity[5] found 22 studies showing that regular leisure-time physical activity was less prevalent among people from lower socio-economic groups in childhood, and 13 studies that found no association. Accounting for adult socio-economic position partly attenuated the associations. There was more evidence of an association in British compared with Scandinavian cohorts and in women compared with men. Results did not vary by childhood socio-economic position indicator or age at assessment of leisure time physical activity. This review found evidence of an association between less advantaged childhood socio-economic position and less frequent leisure time physical activity during adulthood[5].

Socio-economic inequalities in domains of adult physical activity

Strong evidence for the nature and extent of socio-economic inequalities in occupational, leisure-time, and transport-related physical activity among European adults comes from a recent systematic review[6]. This study reviewed the evidence pertaining to socio-economic inequalities in different domains of physical activity by European region. It found 131 studies that described physical activity participation in a European country, related to a measure of socio-economic status.

The review found that 'patterns of socio-economic inequalities in physical activity are perhaps more complex than often thought'. The authors found that the direction of socio-economic inequalities in physical activity in Europe differed considerably by the type of activity, and to some extent by European region and socio-economic indicator[6]. A summary of each domain of activity is given below.

[2] Defined in terms of parental socio-economic position

Total physical activity

Seventy studies reported associations between socio-economic position (SEP) and total physical activity (i.e. all activity, including occupational, leisure time, and active travel). Of these there were approximately equal amounts of positive (n = 28), null (n = 19), and negative (n = 23) associations. While most associations that used income as the indicator of SEP were not statistically significant, both positive and negative associations were found with education as the indicator of SEP.

In Southern Europe[3], 9 out of 12 assessed associations (75%) indicated decreasing levels of physical activity by increasing levels of SEP, while in Great Britain and Ireland, 50% of associations showed the opposite pattern.

Occupational physical activity

Of 19 reported associations between SEP and occupational physical activity, the majority (68%) were negative, indicating that people from lower socio-economic groups did more occupational physical activity. In studies in Eastern Europe, 4 out of 6 associations (66%) were non-significant, while mainly negative associations were found in other regions of Europe.

Leisure-time physical activity

Of 200 associations between total leisure-time physical activity and SEP, most studies (68% of associations) showed that people with a higher SEP were more likely to be physically active in their leisure-time, whereas one study reported that a higher SEP was associated with less leisure time physical activity. There were geographical differences: in Scandinavia and Western European countries, predominantly positive associations were observed (84% and 81% respectively). In Eastern Europe, Great Britain, and Ireland only half of the associations were positive (46% and 48% respectively), with the remaining being null associations.

Vigorous leisure-time physical activity

Of 110 associations between vigorous physical activity and SEP, 84 (76%) were positive, indicating that higher socio-economic groups were more vigorously physically active during leisure-time than lower socio-economic groups. No studies found a significant inverse association. Nearly all studies (96%) conducted in the Western European region reported that vigorous leisure time physical activity was more prevalent among people with a higher SEP. In Scandinavia, Great Britain, and Ireland the positive associations also dominated (88% positive), whereas in Southern Europe about a third of the associations were significantly positive (37%), the other 63% being non-significant.

[3] Greece, Italy, Portugal, Spain

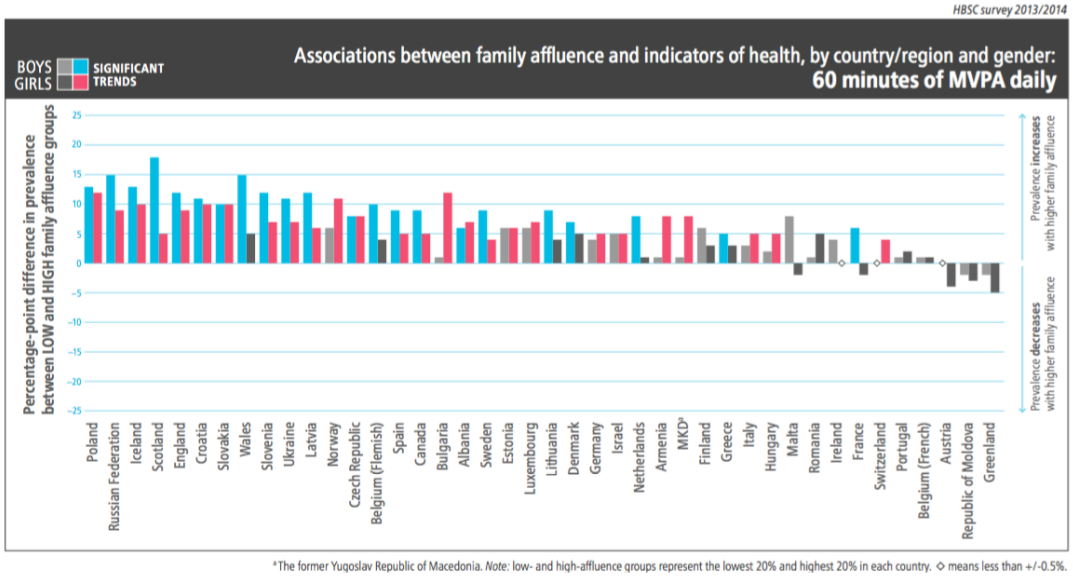
Active travel

Of 48 associations between active travel physical activity and SEP, 18 (38%) were positive, 14 (29%) were neutral, and 16 (33%) were negative. There were no clear differences by gender, SEP indicator, or geographic region.

Young people

The Health Behaviour in School-Aged Children study[7] shows that boys and girls from 'high-affluence' families are more likely than those in "low affluence" families to achieve 60 minutes of moderate-vigorous physical activity daily in more than half of countries and regions of Europe. The difference between high- and low-affluence groups was 10 percentage points or less in most. Figure 1 below shows that there is a small number of countries where a negative relation was reported (so that the prevalence of physical activity *decreased* with family affluence) but none of these were statistically significant.

Figure 2. Health Behaviour of School Children survey 2013/2014



*The former Yugoslav Republic of Macedonia. *Note:* low- and high-affluence groups represent the lowest 20% and highest 20% in each country. ◇ means less than +/-0.5%.

Socio-economic status and access to green space

WHO Europe's report on Environmental Health Inequalities in Europe[8] confirms the finding that social inequalities in access to recreational or green spaces exist, indicated by lower reported access levels among socially disadvantaged individuals. However, the report also notes that social disadvantage is not by default an indicator of lower levels of access to recreational or green areas; individuals with a high education level in all regions report a lack of access more often, as well as employed males in Member States that joined the EU

after 2004[4]. The direction and degree of social inequalities in lack of access to recreational or green areas appears to depend on the local or regional situation in a given country or region, as well as on the socio-economic indicator analysed.

As noted above, Robertson et al[9] reported data from Eurobarometer to show that people from lower socio-economic groups are less likely to take part in leisure time physical activity. They suggest that one factor may be lower access to exercise facilities and green spaces for people from low income groups.

Inequalities relating to active travel and transport systems

Recent Eurobarometer surveys have shown that adults and children from lower socio-economic groups tend to be less physically active and more sedentary than those with a higher socio-economic status[10]. The authors noted that the social and built environment, transport systems and urban design, as well as school and work environments all contribute to exacerbating inequalities in physical activity levels. Lower levels of participation among people from ,low income groups may also be due in part to them having less leisure time. People living in socio-economically deprived neighbourhoods may have few places that encourage a healthy lifestyle such as safe streets and pavements for walking or cycling, parks, paths or community gardens. When people from low income groups choose to be active they may face elevated risks of traffic danger or crime.

Geographic indicators of deprivation (neighbourhood characteristics) and physical activity

The relation between neighbourhood environment, socio-economic position, and health (and health-related behaviours) was reviewed by Schule et al[11]. They found associations between neighbourhood deprivation (socio-economic position) and individual health, independent from built environmental and individual characteristics. However, they found it difficult to disentangle the influences of socio-economic position and neighbourhood characteristics relating to participation in physical activity. They found that composite measures of 'walkability' were associated with measures of higher individual physical activity independent from the relative neighbourhood socio-economic position. Most studies analysing measures of physical activity did not find associations between neighbourhood socio-economic position and measures of physical activity. Bolte et al note in their review[12] that socially disadvantaged people and those who live in deprived areas may have limited opportunities for physical activity. This may be linked to fear of traffic (as poorer children are

[4] The following countries joined the EU in 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. These were joined by Bulgaria and Romania in 2007. Croatia joined in 2013, but the WHO report referred to predates this.

more likely to live in urban areas with poor road safety and high-speed traffic) or due to lack of resources like parks or green areas, which are rare in disadvantaged residential areas, and when available, may be of low quality or subject to perceptions that they are unsafe.

Inequalities relating to ethnicity

In addition to inequalities related to socio-economic status, there is evidence of inequalities in health outcomes and participation in physical activity related to ethnicity.

An international review of obesity-related non-communicable diseases among South Asians and White Caucasians[13] notes that South Asians are at higher risk than White Caucasians for the development of obesity and obesity-related non-communicable diseases, including insulin resistance, the metabolic syndrome, type 2 diabetes mellitus, and coronary heart disease. The causes of this are multiple and complex but one factor is physical activity. The review found lower levels of physical activity in Asian Indian, Pakistani, and Bangladeshi adults and children compared to Europeans/White Caucasians. Physical activity in Indian, Pakistani, or Bangladeshi people is correlated with body mass index, waist circumference, systolic blood pressure, and plasma glucose and insulin levels. The relation between these factors, and others such as diet, is complex, and it is not possible to ascertain the direction of causation from this review.

This finding is confirmed in a review of physical activity among South Asian women[14] which found lower levels of physical activity compared to the general population and also compared to the white population of the countries in which they lived. Indian women however generally had higher levels of physical activity when compared to Bangladeshi and Pakistani women.

Gualdi-Russo et al[15] studied levels of obesity and physical activity among children of immigrants (mainly from North Africa) living in Europe. They found high levels of overweight and obesity in children and adolescents of North African origin. In several European countries, the prevalence of overweight and obesity is higher among children of Moroccan and Middle Eastern/North African immigrants than white children of both sexes. The prevalence of overweight and obesity seems to be higher in North African female children and adolescents than in males both in Europe and in North African countries, suggesting that girls are particularly at risk. The contribution of physical inactivity to this increased risk of obesity is difficult to untangle, but the authors highlight the lack of a health-conscious exercise culture among North African societies. They say "[c]hildren and adolescents are unaware of the benefits of physical activity and its role in preventing obesity. The lack of

exercise is particularly diffuse among girls of North African descent. This fact, which reveals an important aspect of the status of women within society, their place in the public space, and cultural attitudes to physical activity behaviours, is likely to be the origin of the higher prevalence of overweight and obesity found in girls living in North African countries and as immigrants in Europe."[15]

Inequalities in obesity

Law et al[16] have noted that as countries move through the epidemiological transition, rates of obesity typically rise and its societal distribution changes[17]. Thus, the positive association between wealth and obesity found among adults (particularly women) and children in low-income countries flattens out in middle-income countries before giving way to a negative association in high-income countries, where obesity risk is higher in lower socio-economic groups[18].

The relations between deprivation, obesity, and the physical environment have been noted elsewhere. For example, Ellaway et al[19] evaluated the relation between neighbourhood material deprivation, area socio-economic status, and obesity in four neighbourhoods in the United Kingdom. Material deprivation was measured by factors such as: housing tenure, car ownership, and weekly household income. Weights and heights were assessed among 691 adult residents aged 40 to 60 years. They found that "neighbourhood of residence was significantly associated with body mass index (BMI), waist circumference, and prevalence of obesity. For example, the prevalence of obesity was nearly double in the most materially deprived neighbourhood (29.2%) compared to that in the neighbourhood with the least material deprivation (14.2%), even after controlling for a number of individual-level demographic and SES factors"[20].

Discussion

The literature reviewed above has shown that the relation between physical activity and socio-economic status across Europe is complex, and adding in the influence of socio-economic status on overall health complicates the situation still further. In almost all European countries, rates of death and low self-rated health are substantially elevated in low socio-economic status groups, but the magnitude of the inequalities between groups of higher and lower socio-economic status varies greatly between countries. For physical activity the relation differs primarily by type of activity, with some relationships differing by country or region.

Some key aspects of the complex relation between physical activity and socio-economic status are outlined below:

Children

- Lower childhood socio-economic position is associated with modest reductions in physical capability levels in adulthood
- Most evidence shows that regular leisure-time physical activity is less prevalent in lower socio-economic groups
- Boys and girls from 'high-affluence' families are more likely to achieve 60 minutes of moderate-vigorous physical activity daily in more than half of countries and regions of Europe

Adults

- In Southern Europe, higher socio-economic groups are likely to be less active; in Great Britain and Ireland, higher socio-economic groups tend to be more active
- In most countries, people from lower socio-economic groups do more physical activity through work than those from higher socio-economic groups
- People with a higher socio-economic position are more likely to be physically active in their leisure-time
- Higher socio-economic groups engage in more vigorous physical activity during leisure time than lower socio-economic groups do
- There is no clear pattern for active travel. This may be because people from higher socio-economic groups are more likely to choose to walk or cycle, while people from the poorest groups have less choice and may have no option but to walk or cycle
- Access to recreational or green spaces is lower among socially disadvantaged individuals
- Composite measures of 'walkability' of an area may be more important than neighbourhood socio-economic position
- Lower levels of physical activity are reported among some migrant and/or non-European ethnic groups, in both adults and children, compared to Europeans/Whites

The variation and complexity of the relation between physical activity and socio-economic status is compounded by changes in the socio-cultural landscape in Europe. Social trends in recent years have included a wholesale shift away from manual work; an increase in sedentary occupations; changes in leisure time activity; changes in car ownership; changes in public transport use; and increasing urbanisation. Add to this the issue of immigration both within and from outside the EU and changing population patterns and the complexity of the social landscape around physical activity becomes clear.

These relations also vary by country and culture. For example, in high-cycling countries such as the Netherlands or Denmark, the social distribution of the use of bicycles is quite different from low-cycling countries such as France.

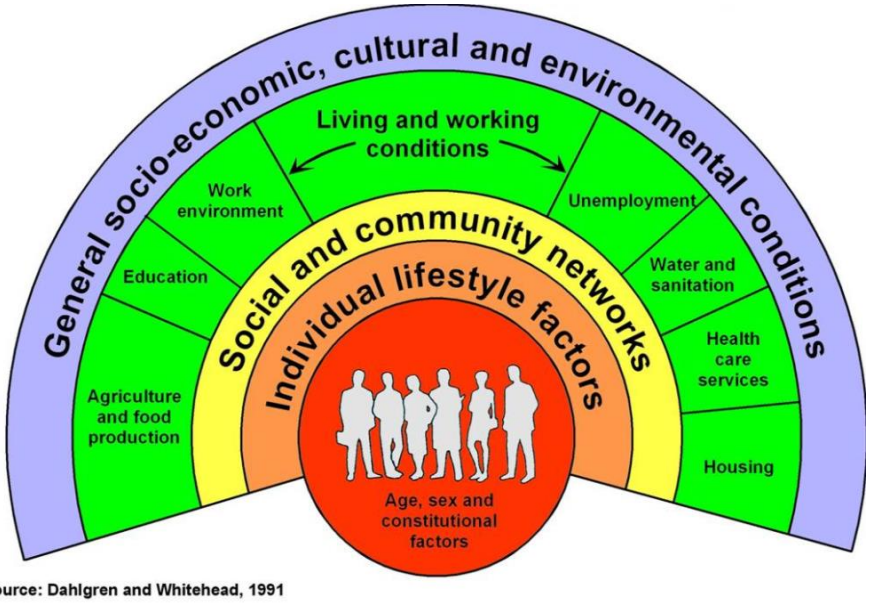
There is no simple set of generalizable measures that can be applied uniformly across Europe to narrow the inequalities gap for physical activity and obesity. Each country needs to tailor its activities and interventions depending on local circumstances in order to maximise its impact.

The next section of the report will build on this description of inequalities in physical activity participation across Europe, and consider the nature of interventions or approaches that may be taken to increasing physical activity without increasing inequalities.

4. Evidence for approaches to reduce inequalities

In this section we use Dahlgren and Whitehead's socio-ecological model[21] as a framework. This describes multiple influences on an individual's health acting at different levels, ranging from non-modifiable factors such as age and sex, through influences of social, community, and working conditions, to broader socio-economic, cultural, and environmental influences. This is not only helpful in categorising the influences on a person's health, but it also helps to group the types of interventions or actions that may be taken to influence health. In categorising and describing the studies found in this review, we start from the outside of the model and work inwards towards the individual.

Figure 3. The Dahlgren-Whitehead model of the social determinants of health



Source: Dahlgren and Whitehead, 1991

Environmental and transport approaches

The previous section highlighted the importance of walking and cycling for transport as strategies for people to integrate physical activity into their everyday lives. Cross-sectional studies show enormous variations across Europe in levels of cycling and walking: for example, 43% of people in the Netherlands cycle every day, compared to 4% in the UK[22]; while there may be many cultural, geographical, or historical factors that account for these differences, it seems likely that policies at the national or regional level have played their part.

Environmental and transport approaches include any attempt to modify the physical (or in some cases, cultural) environment to improve the conditions for walking and cycling, making it more likely that people will choose to walk or cycle for regular journeys. They include large-scale urban regeneration

programmes; changes to spatial planning policy; changes to urban design regulations and planning codes; specific (smaller-scale) interventions to create infrastructure for walking and cycling (e.g. building bike paths), access to hire bicycles and cycle parking, and environmental enhancement and conservation activity programmes.

Urban regeneration programmes

Thomson et al[23] reviewed the impact of 3 UK urban regeneration programmes on self-reported health or mortality rates, but not physical activity. These were national programmes of area-based initiatives that took place predominantly in deprived areas identified by the government.

They found one evaluation that showed 3 of 4 measures of self-reported health deteriorated, typically by 3-4%. Two other evaluations reported overall improvements in mortality rates. They concluded that "regeneration programmes may lead to some small positive impacts on health and socio-economic circumstances, but adverse impacts are also a possibility".

Impact on inequalities: The authors did not report any differential impact of these interventions by socio-economic group, but did show that most health and socio-economic outcomes assessed showed an overall improvement after regeneration investment. However, as these studies did not include a control group it was not possible to determine whether these changes were due to the area-based initiatives, as the effect size of the changes was often similar to national trends.

Urban design & land-use policies; transport policies

Heath et al[24] conducted a very large systematic review as part of the US Task Force on Community Preventive Services. One section of the review considered community-scale urban design and land-use policies and practices to increase physical activity; street-scale urban design and land-use policies to increase physical activity; and transportation and travel policies and practices. They found that physical activity could be increased through community-scale and street-scale urban design; and changes to land-use policies and practices.

These approaches usually aim to create more 'liveable' communities, using policy changes such as zoning regulations and building codes, and environmental changes brought about by government policies or builders' practices. The latter include policies encouraging development based around public transport, and policies addressing street layouts, the density of development, and the location of shops, jobs and schools within walking distance of where people live.

Impact on inequalities: The authors did not report on any differential impact of these intervention approaches by socio-economic group, but noted that 'given the diversity of populations included in this body of evidence, these results should be applicable to diverse settings and populations, provided appropriate attention is paid to adapting the intervention to the target population'.

Cycling interventions

Yang et al[25] conducted a systematic review of interventions to promote cycling. They found 25 studies from 7 countries. Six of these examined interventions aimed specifically at promoting cycling, of which 4 (an intensive individual intervention in obese women, high quality improvements to a cycle route network, and 2 multifaceted cycle promotion initiatives at town or city level) were found to be associated with increases in cycling. Those studies that evaluated interventions at population level reported net increases of up to 3.4% in the population prevalence of cycling or the proportion of trips made by bicycle. Sixteen studies assessing individualised marketing of "environmentally friendly" modes of transport to interested households reported modest but consistent net effects equating to an average of 8 additional cycling trips per person per year in the local population. Other interventions that targeted travel behaviour in general were not associated with a clear increase in cycling. They concluded that "community-wide promotional activities and improving infrastructure for cycling have the potential to increase cycling by modest amounts".

Impact on inequalities: The differential impact of these interventions was not reported.

Fraser and Lock[26] reviewed studies that objectively evaluated the effect of the built environment on cycling. They found 21 observational studies. Eleven studies identified objectively measured environmental factors with a significant positive association with cycling. These factors included presence of dedicated cycle routes or paths, separation of cycling from other traffic, high population density, short trip distance, proximity of a cycle path or green space and for children, projects promoting 'safe routes to school'. Negative environmental factors were: perceived and objective traffic danger; long trip distance; steep inclines; and distance from cycle paths. Of the 7 studies which focused primarily on the impact of cycle routes, 4 demonstrated a statistically significant positive association. Conclusion: Although the study identified environmental factors with positive and negative associations with cycling behaviour, many other types of environmental policies and interventions have yet to be rigorously evaluated.

Impact on inequalities: The authors concluded that "[p]olicies promoting cycle lane construction appear promising but the socio-demographic distribution of their effects on physical activity is unclear."

Walking

Ogilvie et al[27] conducted a systematic review of interventions to promote walking that had been conducted within a trial that included a control group. They included 19 randomised controlled trials and 29 non-randomised studies. They found that interventions tailored to people's needs, targeted at the most sedentary or at those most motivated to change, and delivered either at the level of the individual (brief advice, supported use of pedometers, telecommunications) or household (individualised marketing) or through groups, can encourage people to walk more, although the sustainability, generalisability, and clinical benefits of many of these approaches are uncertain. Evidence for the effectiveness of interventions applied to workplaces, schools, communities, or areas typically depends on isolated studies or subgroup analysis. The authors concluded that "[t]he most successful interventions could increase walking among targeted participants by up to 30-60 minutes a week on average, at least in the short term."

Impact on inequalities: The authors found that the majority of studies (34/48) did not report how the effect of interventions on walking varied between demographic or socio-economic groups. Six of the studies reported on differential effects of the intervention according to a factor such as education level or socio-economic status. Of these 6 studies, 2 found positive impacts on inequalities; 2 found negative impacts; and 2 found no impact.

Individual and group-based outdoor activities

Finally, Husk et al[28] conducted a Cochrane review on participation in environmental enhancement and conservation activities for health and well-being in adults. These are activities such as unpaid litter picking, tree planting, or path maintenance that may have a positive health impact.

The authors found little quantitative evidence of positive or negative health and well-being effects from participating in environmental enhancement activities. However, the qualitative research showed high levels of perceived benefit among participants.

Impact on inequalities: The authors noted that no studies reported on the differential impact of the interventions by socio-economic status, but that "initial exploration of the grey literature and scoping searches indicated that there was potential for levels of health inequality to be perpetuated across those from lower socio-economic backgrounds and those with mental ill health" by focusing on individual or group-based activities.

Community interventions

The communities in which people live, work, learn, and play can have an important impact on their ability to take action to improve their health. This can be through supportive social environments or through provision of community facilities and local environments for physical activity, or of course unsupportive or discouraging environments.

Community-based interventions usually aim to improve the health risk factors of a particular population. These strategies generally involve investment in visible infrastructure and planning initiatives with the aim of producing long-lasting benefits for the community. One systematic review has categorised these interventions into four types (Cavill and Foster 2004). These are (1) comprehensive integrated community approaches, where physical activity is part of an overall risk factor reduction programme (for example the Minnesota Heart Health Project; (2) community-wide 'campaigns' using mass media; (3) community-based approaches using person-focused techniques; and (4) community approaches to environmental change.

Baker et al[29] conducted a Cochrane review of community-wide interventions for increasing physical activity. They found 33 studies, with 25 from high-income countries and 8 from low-income countries. The interventions varied by the number of strategies included and their intensity. Almost all of the interventions included a component of building partnerships with local governments or non-governmental organisations.

The authors found overall that "the body of evidence in this review does not support the hypothesis that the multi-component community wide interventions studied effectively increased physical activity for the population, although some studies with environmental components observed more people walking."

Impact on inequalities: Although none of the studies provided results by socio-economic disadvantage or other markers of inequity, it is of note that of the studies undertaken in high-income countries, 14 were described as being provided to deprived, disadvantaged, or low socio-economic communities.

Everson-Hock et al[30] conducted a review of community-based dietary and physical activity interventions in low socio-economic groups in the UK. They found 35 relevant papers (9 quantitative, 23 qualitative and 3 mixed-methods studies) of dietary/nutritional, food retail, physical activity, and multi-component interventions. They found that these demonstrated mixed effectiveness. Qualitative studies indicated a range of barriers and facilitators, which spanned pragmatic, social, and psychological issues. The more effective

interventions used a range of techniques to address some surface-level psychological and pragmatic concerns (such as lack of time); however, many deeper-level social, psychological, and pragmatic concerns (for example, self-esteem) were not addressed.

Impact on inequalities: The authors found that overall, some dietary and physical activity interventions appeared to be effective and acceptable among low-SES groups in the UK, although others demonstrated little or no impact. There was mixed evidence of effectiveness across all categories of intervention.

Schools

Schools are an important setting that provides a number of opportunities to improve the health of children. The vast majority of children across Europe attend school on a daily basis and spend a large proportion of time each day in the school environment. School social and physical environments can be designed or modified to support health and enable health-promoting behaviours. This can be supported by school policies, as school teachers and managers have a mandate to support and improve the health of their students. Also, parents are likely to view the school as an appropriate setting for health promotion activities and may expect the school to be a healthy environment.

There is a wide variety of school-based approaches to promoting physical activity. Perhaps the most obvious is to focus on and enhance the physical education (PE) aspect of the curriculum – either by improving the quality and content of PE classes or increasing their frequency (or both). Schools may initiate policies to encourage walking or cycling to school through a number of mechanisms including: promoting the building of physical infrastructure (cycle paths, and cycle parking); policies that discourage car travel (such as parking policies around schools); walking school buses; and training in cycling skills and safety. However, some schools actively discourage walking or cycling to school because of concerns about road safety[31]. There is also a wide variety of promotions or projects encouraging physical activity such as 'the daily mile' in the UK; pedometer promotions; and school sports days[32,33].

Many of the above issues, along with others, can be brought together into a 'whole school approach' to promoting physical activity (often combined with healthy eating). This can involve many different elements, including the establishment of healthy policies across the whole school, wider social and emotional support to promote healthy behaviours, and enhancing the healthfulness of the school environment.

Two Cochrane reviews investigated approaches to whole-school health promotion. Dobbins et al[34] reviewed school-based physical activity programmes for promoting physical activity and fitness among children and adolescents aged 6-18. They found 44 studies that evaluated the impact of a diverse range of school-based interventions, from Australia, South America, Europe, China, and North America. Duration of interventions ranged from 12 weeks to 6 years.

They found 'some evidence' that school-based physical activity interventions are effective in increasing duration of physical activity by 5-45 additional minutes per day, reducing time spent watching television per day by 5-60 mins, and improving aspects of fitness (maximal oxygen uptake or aerobic capacity). The evidence also suggests that children exposed to school-based physical activity interventions are approximately 3 times more likely to engage in moderate to vigorous physical activity during the school day than those not exposed.

Impact on inequalities: This was not specifically reported; the authors noted "[r]esearch is needed to assess the impact of physical activity strategies that take into account the known barriers and facilitators of physical activity among children and adolescents, particularly among those of various socio-economic status and ethnicity and urban/rural location."

The World Health Organization has produced a framework for Health Promoting Schools that is "an holistic, settings-based approach to promoting health and educational attainment in school"[35]. Langford et al[36] conducted a Cochrane review of this framework for improving the health and well-being of students, as well as their academic achievement.

They found 67 studies that focused on a wide range of health topics, including physical activity, but also encompassing topics such as nutrition, substance use, and bullying. Eighteen studies reported outcomes related to physical activity, sedentary behaviours, or both. Interventions that combined physical activity and nutrition were effective at increasing physical activity and fitness levels in students. The effect sizes were equivalent to an increase of approximately 3 minutes of moderate-to-vigorous activity per day, or a small increase in the shuttle run fitness test. They concluded that these are "small increases that if successfully sustained have the potential to produce public health benefits at the population level".

Impact on inequalities: About half of the studies (34 studies) reported an indicator of socio-economic status, for example: household income; eligibility for free or reduced price school meals; parental occupation or education

levels; or area indices of deprivation. Within the studies that did report these data, over half targeted low-income populations (usually indicated by percentage of students eligible for free school meals). In the remaining studies, the reported socio-economic data appeared broadly to reflect the make-up of the general population, with no specific emphasis on deprived populations. When analysing data on outcomes, 21 studies reported the effect of their intervention by gender, 10 reported effects by age or grade, 6 reported effects by ethnicity, but only 2 studies reported effects by level of parental education. The authors concluded "[d]ue to the paucity of data, we were unable to perform subgroup analyses by gender and socio-economic status".

Moore et al[37] conducted a systematic review of intervention studies that specifically considered socio-economic gradients in the effects of universal school-based health behaviour interventions. They found 20 studies focusing on physical activity, of which 14 measured SES in some way. However, only one of these reported a differential effect on physical activity by SES. In contrast to the 2 Cochrane reviews, they reported generally poor or non-significant outcomes on physical activity.

Impact on inequalities: Five studies that considered social gradient focused on diet and physical activity, with 4 reporting bigger effects on obesity outcomes for the higher SES group, or in one case, a negative effect on obesity in the lower SES group. They concluded: "Universal school-based interventions may narrow, widen or have no effect on inequality."

De Bourdeaudhuij et al[38] addressed the key question directly in their systematic review, asking "[a]re physical activity interventions equally effective in adolescents of low and high socio-economic status?". They found that school-based promotion programmes in Europe showed at least short-term effects on physical activity levels in the general adolescent population under investigation.

Impact on inequalities: In 3 studies, the impacts on SES differed. The first study showed an increase in objective physical activity in the low-SES group compared with no significant effects in the high-SES group. In the second study, larger effects were found in adolescents of high SES (increase of 11 min/day) compared with adolescents of lower SES (increase of 7 min/day) at the longer term. The third study showed a positive effect on school-related physical activity in adolescents of high SES and on leisure time active travel in adolescents of low SES. The authors concluded "we were not able to show a significant widening or narrowing of inequalities in European adolescents".

De Meester et al[39] conducted a systematic review of interventions for promoting physical activity among European teenagers. They found 20 relevant studies. Fifteen interventions were delivered through a school setting, of which 3 included a family component and another 3 both a family and a community component. One intervention was conducted within a community setting, 3 were delivered in primary care, and one was delivered through the internet.

They found school-based interventions generally led to short-term improvements in physical activity levels; improvements in physical activity levels by school-based interventions were limited to school-related physical activity with no conclusive transfer to leisure-time physical activity; including parents appeared to enhance school-based interventions; the support of peers and the influence of direct environmental changes increased the physical activity level of secondary school children.

Impact on inequalities: Most of the reviewed studies were conducted in diverse SES groups, but analyses were not stratified by SES. The 2 studies that included teenagers from a disadvantaged group and the study that included only vocational and technical schools did not compare the effectiveness of their programme with the results of the same intervention in a population with an average socio-economic or educational level.

Verstraeten et al[40] conducted a systematic review of the effectiveness of preventive school-based obesity interventions in low- and middle-income countries. Out of the 4 studies evaluating time spent being physically active, 3 found a significant increase in the intervention group. Overall, the effect size of the physical activity interventions ranged from trivial to large (effect size range: -0.48 to 1.61) .

Impact on inequalities: this was not addressed; the authors noted that there is a "need to understand to what extent SES and urban/rural settings within low and middle income countries modify the effectiveness of interventions."

Finally, Yildirim et al[41] reviewed school-based interventions on energy balance-related behaviour, conducting a systematic review of moderators. They found 16 studies, of which 14 resulted in significant improvements in children's physical activity levels, especially on moderate to vigorous physical activity.

Impact on inequalities: The moderation analyses looked at SES as indicated by family income and parental educational level (in 11 studies) but did not

yield "many statistically significant and consistent results" for SES (along with ethnicity, initial weight status, or health status as potential moderators).

Workplaces

Many people spend a large proportion of their waking time at work, and their health can be influenced by the work environment and by workplace policies on factors such as physical activity (travel to work; sitting breaks; gym membership), diet (canteen provision), and more 'upstream' determinants such as management style, personal autonomy, and work-related stress.

Physical activity interventions in the workplace can focus on any of these issues, and typically include efforts to encourage people to walk or cycle to work; to use the stairs when at work; to take breaks from sitting; and to enjoy additional leisure-time physical activity (e.g. gym activity paid for or subsidised by the employer).

We found one review of workplace interventions that assessed impacts on inequalities. Vuillemin et al[42] conducted a review of worksite physical activity interventions in Europe. They found 20 studies divided in 6 intervention categories. Moderate evidence of effectiveness was found for physical fitness outcomes with exercise training interventions and for physical activity outcomes with active commuting interventions. The authors concluded "[a]ctive commuting and exercise training appear as promising approaches to promote physical activity or fitness in the workplace." The impact on inequalities was not reported.

Individual approaches

Primary care-based approaches

High proportions of European citizens are registered with a general practitioner or family doctor, and across Europe, rates of visiting a GP vary between 2 and 12 visits per person per year[43]. This presents a key opportunity for primary care-based interventions aiming to increase physical activity (among other healthy behaviours). These range from opportunistic brief advice, to counselling, or referral to an exercise specialist or exercise facility.

Pavey et al[44] conducted a systematic review of the clinical effectiveness and cost-effectiveness of exercise referral schemes. They found 7 randomised controlled trials, which showed weak evidence of an increase in the number of scheme participants who achieved a self-reported 90–150 minutes of at least moderate-intensity physical activity per week at 6–12 months' follow-up. There was no consistent evidence of a difference between exercise referral schemes and the control groups who received usual care in the duration of moderate/vigorous intensity and total physical activity or other outcomes. The

authors concluded that "there remains considerable uncertainty as to the effectiveness of exercise referral schemes for increasing activity, fitness or health indicators or whether they are an efficient use of resources in sedentary people without a medical diagnosis".

Impact on inequalities was not reported. The authors noted "[n]o data were identified as part of the effectiveness review to allow for adjustment of the effect of exercise referral schemes in different populations".

Noordman et al[45] conducted a review of communication-related behaviour change techniques used in face-to-face lifestyle interventions in primary care. They found 28 studies that reported significantly favourable health outcomes following such techniques. In these studies, 'behavioural counselling' was most frequently used (15 times), followed by motivational interviewing (8 times), education, and advice (both 7 times). They concluded that "[t]here is evidence that behavioural counselling, motivational interviewing, education and advice can be used as effective communication-related behaviour change techniques by physicians and nurses."

Impact on inequalities was not reported.

Gagliardi et al[46] conducted a 'realist systematic review' of the factors contributing to the effectiveness of physical activity counselling in primary care. They found 10 studies (3 systematic reviews, 5 randomised controlled trials, and 2 observational studies) that showed that counselling provided by clinicians or counsellors alone and that explored motivation increased self-reported physical activity at least 12 months following intervention. Multiple sessions may sustain increased physical activity beyond 12 months.

Impact on inequalities was not reported. The authors noted that "studies provided few details about whether and how patient, provider and intervention characteristics influenced physical activity counselling effectiveness".

Targeted individual and group approaches

Bull et al[47] conducted a systematic review and meta-analysis of the effectiveness of behavioural interventions targeting diet, physical activity, or smoking in low-income adults. They found 35 studies containing 45 interventions across a total of 17,000 participants. These showed 'positive but small' impacts on physical activity (SMD 0.21, 95% CI 0.06 to 0.36).

Impact on inequalities: This review showed that interventions were effective in low-income groups. However, the authors noted that similar

reviews not targeting low-income participants tend to report larger effects. This implies that interventions may be less effective for low-income populations, resulting in an overall gradual widening of health inequalities. However, they also note "true comparison is not possible unless the same interventions were compared in different population groups."

Cleland et al[48] conducted a systematic review and meta-analysis of trials that looked at interventions to increase physical activity in socio-economically disadvantaged women. They found 19 studies, most of which were conducted in Europe and North America. Results showed that studies in which the intervention had a group component – such as group education meetings or practical sessions – found a greater difference between intervention and control groups.

Impact on inequalities: The review found that interventions were effective among deprived women, but did not compare the impact to other population groups.

5. Discussion

Many indicators of health, including disability-free life years and life expectancy, are positively associated with socio-economic status (SES)[49]. This has led to health inequalities across Europe as described in section 3. These socio-economic inequalities in health cannot be fully explained by behavioural factors[50], although behaviours such as physical activity play a role (alongside smoking and diet)[51,52]. Inequalities in health behaviours emerge during childhood[53], and recent international evidence indicates that these inequalities are widening, in line with growing economic inequality[54].

Addressing this issue is not straightforward. It is well acknowledged that public health interventions may increase or decrease health inequalities[55]. People from higher socio-economic groups tend to engage more in health interventions, for a number of reasons, including being more likely to hear about available interventions, having greater agency, or having fewer barriers to becoming involved and maintaining that involvement. One approach may be to ensure that interventions are delivered on a universal basis, but this does not necessarily solve the problem if deprived groups have a lower capacity to benefit[37]. The Marmot review[49] called for 'proportionate universalism' in which actions are universal, but with a scale and intensity that is proportionate to the level of disadvantage. Emerging evidence including newer technologies – such as analyses of smartphone data including built-in accelerometry – may help in the future to describe inequalities. To date, these have shown gender inequalities but data are not available on socio-economic status of phone users[56].

The evidence base for the differential impact of physical activity interventions is limited. While there is a moderately strong (and developing) evidence base on 'what works' to promote physical activity, studies only rarely report whether there is differential uptake of the interventions by socio-economic status. This is a clear evidence gap and needs to be filled by researchers not only collecting data on the socio-economic characteristics of their participants, but analysing and presenting these data to demonstrate the differential impact, if any, of the intervention on people from different socio-economic groups, and therefore whether the intervention had a positive or negative impact on health inequalities.

In the next section we summarise the evidence for the differential impact of the approaches and interventions reviewed, and in the absence of evidence, make an assessment of the likely differential impact of each intervention type.

Urban regeneration programmes, urban design and land use/transport policies, along with other attempts to revitalise the urban

fabric and create more amenable and liveable conditions, were seen to be effective, but there was no evidence of any differential impact. Overall it seems likely that they will reduce inequalities in health if they are applied in areas of greatest need. Such area-based initiatives are often targeted at deprived areas, aiming to regenerate areas blighted by previous industry or poor housing. The overriding principle behind such regeneration should be that new designs are based primarily around creating liveable environments in which people can safely and easily walk, cycle and use public transport, rather than being designed around motorised transport.

Cycling interventions appear to be effective at increasing rates of cycling but there was no evidence of their differential impact. It appears likely that – like town planning initiatives above – infrastructural cycling interventions (i.e. building bike paths and other infrastructure) would help to reduce inequalities if implemented in areas of greatest deprivation. However, promotional and other initiatives that are voluntary in nature are likely to perpetuate if not widen inequalities as there is evidence that in many countries, cycling is taken up by higher socio-economic groups first. In consequence, interventions cannot be applied generically, but need to be tailored to the specific circumstances of the country concerned.

Walking interventions appear to be effective at increasing rates of walking but there was no evidence of their differential impact. As with cycling and town planning it appears likely that interventions which modify the built environment to create more amenable places for walking that link to important destinations would help to reduce inequalities if implemented in areas of greatest deprivation. Across Europe, far higher numbers of people walk regularly for transport than cycle, so the effective promotion of walking has great potential for public health impact. The best approaches combine actions to support both walking and cycling, with a focus on promoting walking for shorter journeys of around 1-2km, promoting cycling for longer journeys of perhaps 2-10km, and facilitating public transport for longer trips.

Policies to promote active travel (walking and cycling) have numerous co-benefits in addition to health outcomes such as improving air quality and social cohesion [57]. However it is important to consider issues of accessibility for more disadvantaged groups or people with disabilities. While making modifications to the environment to support walking and cycling may seem difficult, it may well be that they are politically more popular than many public health actions such as nutrition-related actions. It is also important to note that they generally involve alterations to the allocation of existing budgets rather than requiring entirely new investment. Given the lower cost of walking and cycling infrastructure relative to roads this is likely to be cost-effective.

Individual and group-based environmental/conservation activities appear likely to increase health inequalities through differential uptake favouring higher SES groups, and should only be implemented with caution.

School-based interventions, including whole-school approaches, and the WHO Health Promoting School framework have a strong evidence base for their effectiveness, but only limited evidence of their differential impact. However, it seems likely that whole-school approaches can make a positive contribution to reducing inequalities in physical activity (and health outcomes) if they are planned appropriately and applied across the entire school, but targeted towards more deprived areas; and employ strategies to ensure involvement among the most deprived students.

Workplace interventions can be effective at increasing active travel and total physical activity, but there is little evidence on their differential impacts by SES. One issue is that these approaches are typically employed by larger companies, which have the time and resources to develop staff well-being strategies and employ workplace health coordinators. However, a large proportion of the EU workforce is employed in small and medium enterprises, who may not have the capacity to invest in employee health. It therefore seems likely that a blanket approach to workplace health would risk widening inequalities; efforts would need to be made to target resources at small and medium enterprises and employers in deprived communities.

Primary care-based approaches: the evidence shows that exercise referral schemes are not effective but counselling in primary care is effective at increasing physical activity in the short term. This conclusion extends to their likely impact on inequalities: referral schemes are likely to widen inequalities - they would be taken up more readily by higher socio-economic groups who have the resources (time, money, lack of barriers) to attend a leisure centre when referred. However, a well-planned and universal counselling scheme offered to everyone at risk who attends primary care would seem likely to have a more even uptake and impact according to socio-economic status.

Targeted individual and group approaches were found to be effective, but there was little or no evidence on their differential impact. Like most traditional health promotion schemes, there is concern that these types of programmes would carry a risk that they would widen health inequalities as a result of differential uptake and maintenance by people from different socio-economic groups.

This review has shown that there is sufficient evidence – combined with expert opinion – to take action on physical activity across Europe without increasing health inequalities. Physical activity interventions and approaches – particularly creating safe and appealing environments for walking and cycling – may also be practicable and politically acceptable in the current political climate. Action needs to be taken at all levels, notably at national level, where governments need to understand the relations between socio-economic status and physical activity in their own countries and take action accordingly.

6. Recommendations

An EU-wide approach to increasing physical activity without increasing health inequalities should contain the following components:

- An emphasis on the 'upstream' determinants of health rather than 'downstream' programmatic responses
- A focus on creating high-quality physical environments, emphasising the regeneration of deprived communities, and the development of infrastructure that prioritises walking and cycling over motorised transport
- Universal school-based interventions that take a 'whole school approach' to improving the health and well-being of students
- Workplace interventions in areas of greatest need and among employers of people from lower socio-economic groups
- Counselling in primary care, with an emphasis on people from lower socio-economic groups and deprived communities

There is an urgent need for improved data that describe the socio-economic distribution of physical activity (and indeed other risk factors and behaviours) across Europe. Many surveys collect such data but then either do not analyse the socio-economic components of their datasets, or do not present them in a meaningful or consistent way. In particular there is a need for country-level data that describe the social patterning of physical activity so that countries can establish their own specific strategies, addressing the most important modes of activity or specific geographical areas.

There is an ongoing need for evidence of the effectiveness of interventions and approaches to tackle physical activity, differentiated by socio-economic variable. Again, researchers often collect data on the socio-economic characteristics of their study participants, but then do not report the differential impact of their interventions. Studies tend either to ignore the socio-economic data, or to use it simply to describe their study participants. There is a need to quantify the level and direction of differential impact in studies and hence identify those interventions and approaches that are most effective in promoting physical activity while reducing, or at least not widening, health inequalities.

7. Glossary of terms

Physical activity

WHO defines physical activity as 'any bodily movement produced by skeletal muscles that requires energy expenditure'. This means that it is a global term that includes specific modes such as walking, cycling, sport, or exercise.

Exercise

Exercise is a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness.

Socio-economic position

The social and economic factors that influence what positions individuals or groups hold within the structure of a society

Active Travel

Moving from place to place using physically active means (as opposed to motorised travel). This is primarily walking/running or cycling, but can also include use of scooters or, more rarely, activities such as swimming or canoeing.

References

1. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 2012; **380**(9838): 219-29.
2. Ding D, Lawson KD, Kolbe-Alexander TL, et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *The Lancet*.
3. Marmot M. The health gap: the challenge of an unequal world. *Lancet (London, England)* 2015; **386**(10011): 2442-4.
4. Birnie K et al. Childhood socioeconomic position and objectively measured physical capability levels in adulthood : a systematic review and meta-analysis. *Public Library of Science (PLoS)* 2011.
5. Elhakeem A, Cooper R, Bann D, Hardy R. Childhood socioeconomic position and adult leisure-time physical activity: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* 2015; **12**(1).
6. Beenackers MA, Kamphuis CBM, Giskes K, et al. Socioeconomic inequalities in occupational, leisure-time, and transport related physical activity among European adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* 2012; **9**.
7. WHO Europe. Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-aged Children (HBSC) study: international report from the 2013/2014 survey. 2016.
8. World Health Organization. Environmental health inequalities in Europe: assessment report, 2012.
9. A Robertson, T Lobstein, Knai C. Obesity and socio-economic groups in Europe: Evidence review and implications for action 2007.
10. European Commission. Special Eurobarometer 412. Sport and Physical Activity, 2013.
11. Schule SA, Bolte G. Interactive and independent associations between the socioeconomic and objective built environment on the neighbourhood level and individual health: A systematic review of multilevel studies. *PLoS ONE* 2015; **10**(4).
12. Bolte G, Tamburlini G, Kohlhuber M. Environmental inequalities among children in Europe—Evaluation of scientific evidence and policy implications. *European Journal of Public Health* 2010; **20**(1): 14.
13. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. *International journal of obesity (2005)* 2011; **35**(2): 167.
14. Babakus WS, Thompson JL. Physical activity among South Asian women: A systematic, mixed-methods review. *International Journal of Behavioral Nutrition and Physical Activity* 2012; **9**.
15. Gualdi-Russo E, Zaccagni L, Manzon S, Masotti S, Rinaldo N, Khyatti M. Obesity and physical activity in children of immigrants. *European journal of public health* 2014; **24**: 40.
16. Law C, Power C, Graham H, Merrick D. Obesity and health inequalities. *Obesity Reviews* 2007; **8**(SUPPL. 1): 19-22.
17. Monteiro CA, Moura EC, Conde WL, Popkin BM. Socioeconomic status and obesity in adult populations of developing countries: a review. *Bulletin of the World Health Organization* 2004; **82**(12): 940-6.
18. Wang Y. Cross-national comparison of childhood obesity: the epidemic and the relationship between obesity and socioeconomic status. *International journal of epidemiology* 2001; **30**(5): 1129-36.
19. Ellaway A, Anderson A, Macintyre S. Does area of residence affect body size and shape? *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity* 1997; **21**(4): 304-8.

20. Taylor C, Poston SC, Jones L, Kraft MK. Environmental Justice: Obesity, Physical Activity, and Healthy Eating. *Journal of Physical Activity & Health* 2006; **3**.
21. Dahlgren G WM. Policies and Strategies to Promote Social Equity in Health. . Stockholm, Sweden: : Institute for Futures Studies; 1991.
22. European Commission. Attitudes of Europeans Towards Urban Mobility (Special Eurobarometer 406), 2013.
23. Thomson H, Atkinson R, Petticrew M, Kearns A. Do urban regeneration programmes improve public health and reduce health inequalities? A synthesis of the evidence from UK policy and practice (1980-2004). *Journal of Epidemiology & Community Health* 2006; **60**(2): 108-16.
24. Heath W, Brownson C, Kruger J, Miles R, Powell E, Ramsey T. The Effectiveness of Urban Design and Land Use and Transport Policies and Practices to Increase Physical Activity: A Systematic Review. *Journal of Physical Activity & Health* 2006; **3**.
25. Yang L, Sahlqvist S, McMinn A, Griffin SJ, Ogilvie D. Interventions to promote cycling: systematic review. *Bmj* 2010; **341**: c5293.
26. Fraser SD, Lock K. Cycling for transport and public health: a systematic review of the effect of the environment on cycling. *European journal of public health* 2011; **21**(6): 738-43.
27. Ogilvie D, Foster CE, Rothnie H, et al. Interventions to promote walking: systematic review. *Bmj* 2007; **334**(7605): 1204.
28. Husk K, Lovell R, Cooper C, Stahl-Timmins W, Garside R. Participation in environmental enhancement and conservation activities for health and well-being in adults: a review of quantitative and qualitative evidence. *Cochrane Database of Systematic Reviews*, 2016. http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD010351.pub2/abstract (accessed.
29. Baker Philip RA, Francis Daniel P, Soares J, Weightman Alison L, Foster C. Community wide interventions for increasing physical activity. *Cochrane Database of Systematic Reviews*, 2015. http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD008366.pub3/abstract http://onlinelibrary.wiley.com/store/10.1002/14651858.CD008366.pub3/asset/CD008366.pdf?v=1&t=ipzi6lrk&s=ebfab6a8dec8948b386ea4cb9d209a24a8dd1728 (accessed.
30. Everson-Hock ES, Johnson M, Jones R, et al. Community-based dietary and physical activity interventions in low socioeconomic groups in the UK: A mixed methods systematic review. *Preventive Medicine* 2013; **56**(5): 265-72.
31. Cycling UK. How to encourage cycling at schools with anti-cycling policies. http://www.cyclinguk.org/article/campaigns-guide/how-to-encourage-cycling-schools-anti-cycling-policies.
32. The Daily Mile. About the Daily Mile. http://thedailymile.co.uk/about/.
33. Ridgers ND, McNarry MA, Mackintosh KA. Feasibility and Effectiveness of Using Wearable Activity Trackers in Youth: A Systematic Review. *JMIR mHealth and uHealth* 2016; **4**(4): e129.
34. Dobbins M, Husson H, DeCorby K, LaRocca Rebecca L. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database of Systematic Reviews*, 2013. http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD007651.pub2/abstract (accessed.
35. World Health Organization. What is a health promoting school? . 2016 http://www.who.int/school_youth_health/gshi/hps/en/.
36. Langford R, Bonell P, Jones E, et al. The WHO Health Promoting School framework for improving the health and well-being of students and their academic achievement. *The Cochrane database of systematic reviews* 2014; (4).

37. Moore F, Littlecott J, Turley R, Waters E, Murphy S. Socioeconomic gradients in the effects of universal school-based health behaviour interventions: a systematic review of intervention studies. *BMC public health* 2015; **15**: 907.
38. Bourdeaudhuij I, Cauwenberghe E, Spittaels H, et al. School-based interventions promoting both physical activity and healthy eating in Europe: a systematic review within the HOPE project (Structured abstract). *Obesity Reviews*, 2011. http://onlinelibrary.wiley.com/o/cochrane/cldare/articles/DARE-12011001933/frame.html (accessed.
39. Meester F, Lenthe FJ, Spittaels H, Lien N, Bourdeaudhuij I. Interventions for promoting physical activity among European teenagers: a systematic review (Structured abstract). *International Journal of Behavioral Nutrition and Physical Activity*, 2009. http://onlinelibrary.wiley.com/o/cochrane/cldare/articles/DARE-12010001814/frame.html (accessed.
40. Verstraeten R, Roberfroid D, Lachat C, et al. Effectiveness of preventive school-based obesity interventions in low- and middle-income countries: a systematic review. *American Journal of Clinical Nutrition* 2012; **96**(2): 415-39.
41. Yildirim M, van MM, Chinapaw JM, et al. For whom and under what circumstances do school-based energy balance behavior interventions work? Systematic review on moderators. *International Journal of Pediatric Obesity* 2011; **6**(2).
42. Vuillemin A, Rostami C, Maes L, et al. Worksite physical activity interventions and obesity: a review of European studies (the HOPE project) (Provisional abstract). *Obesity Facts*, 2011. http://onlinelibrary.wiley.com/o/cochrane/cldare/articles/DARE-12012002234/frame.html (accessed.
43. European Commission. Healthcare activities statistics. Eurostat Statistics explained. 2016. http://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare_activities_statistics_-_consultations#Consultations_of_doctors.
44. Pavey TG, Anokye N, Taylor AH, et al. The clinical effectiveness and cost-effectiveness of exercise referral schemes: a systematic review and economic evaluation. *Health technology assessment (Winchester, England)* 2011; **15**(44).
45. Noordman J, van der Weijden T, van Dulmen S. Communication-related behavior change techniques used in face-to-face lifestyle interventions in primary care: a systematic review of the literature. *Patient Educ Couns* 2012; **89**(2): 227-44.
46. Gagliardi AR, Abdallah F, Faulkner G, Ciliska D, Hicks A. Factors contributing to the effectiveness of physical activity counselling in primary care: a realist systematic review. *Patient Educ Couns* 2015; **98**(4): 412-9.
47. Bull R, Dombrowski U, McCleary N, Johnston M. Are interventions for low-income groups effective in changing healthy eating, physical activity and smoking behaviours? A systematic review and meta-analysis. *BMJ open* 2014; **4**(11).
48. Cleland CL, Tully MA, Kee F, Cupples ME. The effectiveness of physical activity interventions in socio-economically disadvantaged communities: a systematic review. *Prev Med* 2012; **54**(6): 371-80.
49. Marmot MG, Allen J, Goldblatt P, Boyce T, McNeish D, M G. Fair society, healthy lives: Strategic review of health inequalities in England post-2010., 2010.
50. Marmot M. Social determinants of health inequalities. *Lancet* 2005; **365**(9464): 1099-104.
51. Law C, Power C, Graham H, Merrick D. Obesity and health inequalities. *Obes Rev* 2007; **8 Suppl 1**: 19-22.
52. Stringhini S, Sabia S, Shipley M, et al. Association of socioeconomic position with health behaviors and mortality. *Jama* 2010; **303**(12): 1159-66.
53. Hanson MD, Chen E. Socioeconomic status and substance use behaviors in adolescents: the role of family resources versus family social status. *Journal of health psychology* 2007; **12**(1): 32-5.

54. Elgar FJ, Pfortner TK, Moor I, De Clercq B, Stevens GW, Currie C. Socioeconomic inequalities in adolescent health 2002-2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study. *Lancet* 2015; **385**(9982): 2088-95.
55. Mackintyre S, editor. Evaluating the evidence on measures to reduce inequalities in health. In Oliver A, Exworthy M editor(s). Health Inequalities: Evidence, Policy and Implementation. Proceedings from a Meeting of the Health Equity Network.; 2003.
56. Althoff T, Sosic R, Hicks JL, King AC, Delp SL, Leskovec J. Large-scale physical activity data reveal worldwide activity inequality. *Nature* 2017. **547:** 336–339
57. Sallis JF, Spoon C, Cavill N, et al. Co-benefits of designing communities for active living: an exploration of literature. *The international journal of behavioral nutrition and physical activity* 2015; **12**: 30.

8. Appendix 1: List of grey literature sources searched

- WHO IRIS http://apps.who.int/iris/
- Open Grey http://www.opengrey.eu/
- NYAM Grey Literature http://www.greylit.org/
- NICE Evidence Search https://www.evidence.nhs.uk/
- BL Ethos http://ethos.bl.uk/
- European Commission website http://ec.europa.eu/
- European Centre for Disease Prevention & Control http://ecdc.europa.eu/
- Eurofound https://www.eurofound.europa.eu/
- OECD iLibrary http://www.oecd-ilibrary.org/
- UK Government DH and PHE publications http://www.gov.uk
- CORDIS http://cordis.europa.eu/
- Horizon 2020 https://ec.europa.eu/programmes/horizon2020/
- Consumers Health Agriculture and Food Executive Agency http://ec.europa.eu/chafea/
- European Monitoring Centre for Drugs and Drug Addiction http://www.emcdda.europa.eu/

9. Appendix 2: Search results

(Prisma diagrams showing individual search results below)

Figure 4: Prisma diagram for SES & Physical activity & sedentary behaviour

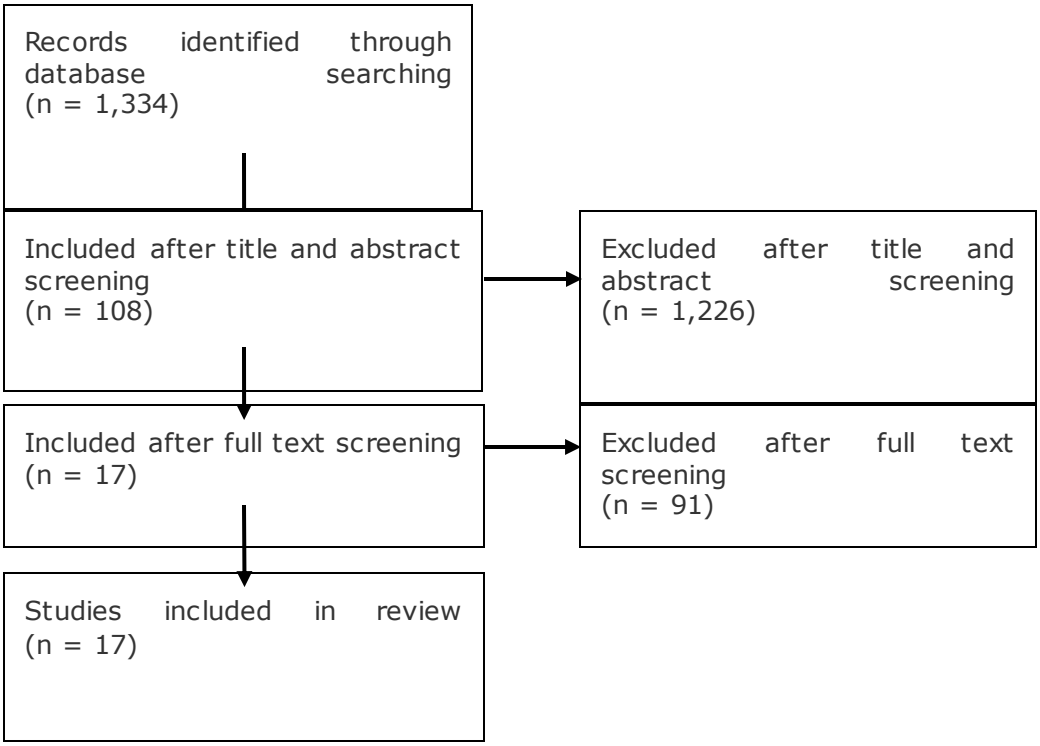


Figure 5: Prisma diagram for SES & Access to green space

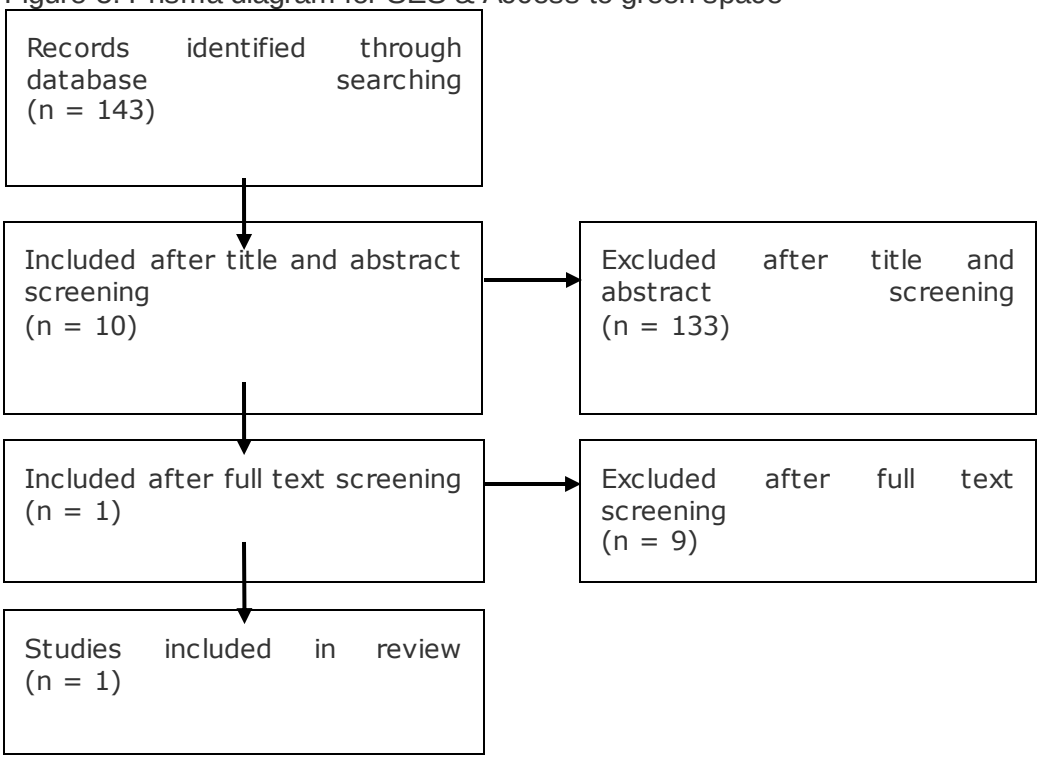


Figure 6: Prisma diagram for SES & Active travel/traffic calming

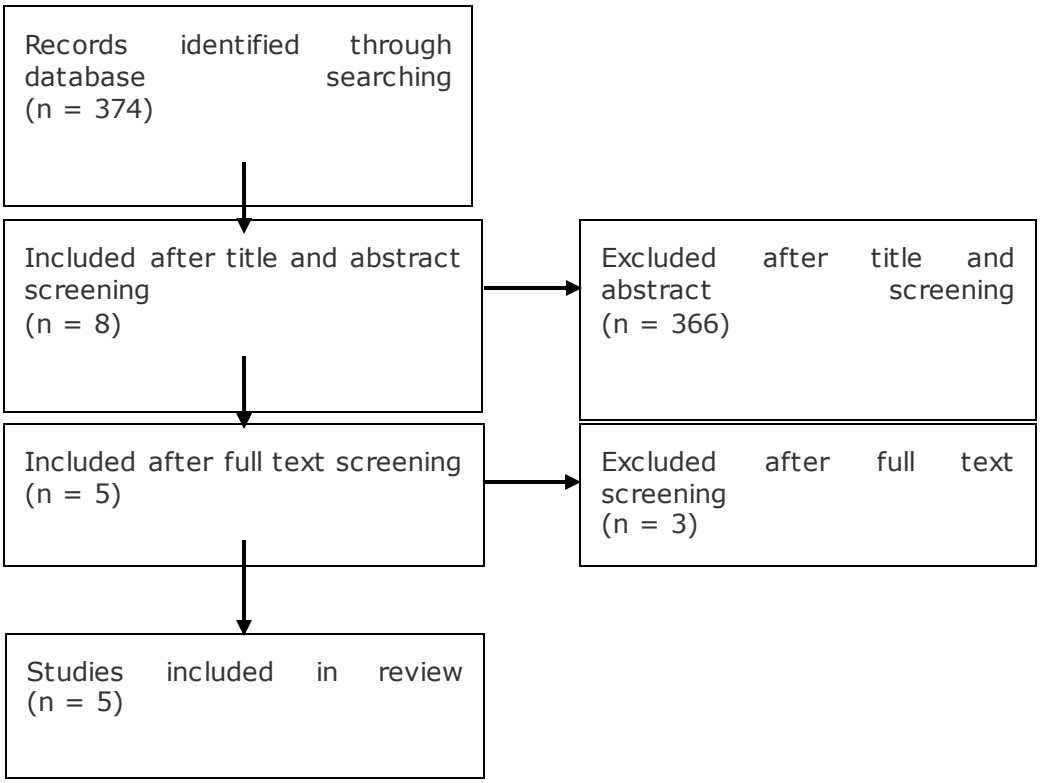


Figure 7: Prisma diagram for geographic indicators of deprivation & Physical activity & sedentary behaviour