Health and Place 53 (2018) 135–149

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Review Essay

The effect of infrastructural changes in the built environment on physical activity, active transportation and sedentary behavior – A systematic review

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ABSTRACT

This systematic review examined the effect of built environment infrastructural changes (BEICs) on physical activity (PA), active transportation (AT) and sedentary behavior (SB). A literature search resulted in nineteen eligible articles. On- and off-road bicycling and/or walking trails resulted in inconsistent effects on overall PA and walking, and in predominantly positive effects on bicycling. More extensive BEICs led to mixed results, with mainly non-significant effects. However, positive effects on bicycling were found for people living closer to BEICs. None of the studies assessed SB. Improved understanding of the potential of BEICs to increase PA levels and decrease SB at population level asks for more high-quality, in-depth research, that takes into account the broader system.

1. Introduction

In recent decades, the prevalence of obesity has increased in most countries and regions of the world (Wang et al., 2011). Public health experts agree that the rapid rise in obesity cannot be explained by changes in genes, biology and psychology at the individual level alone. The explanation should also be sought in broader environmental, policy and societal changes (Kaplan et al., 2000; Sallis and Glanz, 2009). As the choices people make are partially shaped by the environments in which they live, efforts to reduce obesity, type II diabetes and cardiovascular diseases by interventions at individual level need to be supported and augmented by a whole-system response that includes upstream health policies, infrastructural changes and legislation (Lakerveld and Mackenbach, 2017; Rutter et al., 2017). Hence, researchers and policy makers are increasingly interested in environmental and policy interventions as strategies for population-wide improvements in physical activity (PA) and eating habits, in order to reduce and prevent obesity and associated non-communicable diseases (Chaix, 2009; Sallis and Glanz, 2009).

In recent years, a broad range of environmental interventions have been implemented to improve PA levels, for example by installing outdoor exercise equipment, reconstructing playgrounds and increasing the amount of open green space (Cohen et al., 2012; Veitch et al., 2012). In addition, a growing number of built environment infrastructural changes (BEICs) aim to promote active transportation (AT) – walking and bicycling for transportation. An example of a BEIC is the implementation of a walking and bicycling trail, aiming to replace passive, sedentary, transportations by AT (Evenson et al., 2005). BEICs have the potential to promote and sustain behavioral changes over a longer period of time (Davies et al., 2011; Sallis and Glanz, 2009). The built environment (BE) not only promotes or inhibits PA and AT, but can also play a role in reducing sedentary behavior (SB). The SOS (Systems of Sedentary behavior) framework emphasizes the role of the built and natural environments in interrupting sedentary time (Chastin et al., 2016), which is crucial in order to reverse the global trend toward increased sedentary time (Ng and Popkin, 2012) and physical inactivity (Kohl et al., 2012). Previous studies found that presence and proximity of green spaces is negatively correlated with SB (O'donoghue et al., 2016). Also, BEICs aiming to promote AT might evoke a modal shift from sedentary motorized transportation to AT, leading to both a decrease in SB and an increase in PA.

Cross-sectional studies have found positive associations between the BE and PA, mental health, physical health and well-being (e.g., Gao et al., 2016; Sallis et al., 2016; Gubbels et al., 2016), but longitudinal and experimental studies are necessary to detect causal relationships between the BE and health outcomes. In general, it is hardly possible to perform randomized controlled trials to evaluate large-scale policy and environmental interventions, as researchers usually cannot influence such interventions and participants cannot be randomly assigned to intervention or control sites. Natural experimental studies might help to overcome these problems. In this type of studies, the exposure to the event or intervention of interest has not been manipulated by the researcher (Craig et al., 2012). In the literature, the terms "natural experiments" and "quasi-experiments" are inconsistently used. In both

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https://doi.org/10.1016/j.healthplace.2018.08.002
Received 15 December 2017; Received in revised form 24 July 2018; Accepted 3 August 2018
1353-8292/

types of experiments, researchers cannot randomly assign participants to an intervention or control condition. Typically, in quasi-experiments researchers have a certain degree of control over the intervention, while the intervention or event of a natural experiment occurs outside the reach of researchers (Cook et al., 2002).

Previous systematic reviews evaluated the effects of several types of changes in the BE on PA levels and found that infrastructural interventions targeting AT in particular can lead to increased PA (Mayne et al., 2015; Smith et al., 2017). One recent systematic review concluded that the evidence on the effect of the BE on PA is not strong enough to draw conclusions (MacMillan et al., 2018). However, these reviews included a broad range of BE interventions, such as park improvements, infrastructural changes and changes to the public transport infrastructure. The heterogeneity of these interventions makes it difficult to evaluate the actual effect on PA and/or AT. Focusing on BEICs aiming to promote PA and/or AT may lead to more clarity regarding the effectiveness of this specific type of interventions. In addition, previous systematic reviews included participants in all age ranges, while barriers and facilitators to engage in PA and/or AT are different for different age groups. Also, none of the previous reviews searched for studies reporting SB.

The current review builds on the main outcomes of Mayne's and Smith's review by assessing the specific effectiveness of different types of BEICs that aim the promotion of PA and/or AT to clarify the effectiveness of this type of interventions in adults. Therefore, the aim of this systematic review is to update and specify the evidence in this field of research by reviewing experimental studies that have examined the effects of different types of infrastructural interventions on PA, AT and SB in adults.

2. Methods

2.1. Search and selection procedure

A literature search was conducted using PubMed and Web of Science to identify articles examining the effects of BEICs on PA, AT and/or SB, published up to February 2018. The following keywords/terms were included in the search: adult AND built environment OR changes in built environment OR infrastructure OR changes in infrastructure OR path OR trail OR bicycle path OR footpath AND motor activity [MeSH] OR physical activity OR active travel* OR active transport*, OR walking OR bicycling OR exercise OR sport OR sedentary OR sedentary behavior OR natural experiment* OR quasi experiment*. Searches were not restricted by date of publication.

Studies were eligible if: (1) they were a quasi- or natural experiment and had a pre-post design, (2) the BEIC directly targeted the increase of AT and/or transport-related PA (3) PA and/or AT and/or SB was reported, (4) these were assessed in adults, and (5) the articles were written in English. Studies were excluded if they (1) examined BEICs that were not directly aimed to increase transport-related PA and/or AT, such as the implementation of playgrounds, parks or public transit, the placement of fitness equipment, or other non-infrastructural interventions, (2) evaluated health promotion programs or behavior change programs, (3) concerned qualitative research, systematic reviews, conference proceedings or grey literature (4) included children or adolescents younger than 18 years. After duplicates had been removed, titles of all records were screened independently by two reviewers (XXX, XXX). Articles selected by one or both researchers were subjected to abstract screening. Again, both reviewers (XXX, XXX) performed this screening independently, and ineligible studies were removed from the sample. Disagreements between reviewers about eligibility for full-text assessment were resolved by discussion, which was necessary in five cases. The full texts of the remaining articles were assessed by one researcher (XXX). Reference lists from selected studies were hand-searched for additional articles not retrieved by the electronic search.

One reviewer (XXX) extracted the following information from each included study: author(s), publication year, study location, description of intervention, study population, study design, control sites, PA outcome measures, AT outcome measures, measuring methods, timing of the measurements and main findings.

2.2. Risk of bias assessment

The quality of the included studies was assessed using the adapted version of A Cochrane Risk of Bias Assessment Tool: for Non-Randomized Studies of Interventions (ACROBAT-NRSI), by following the detailed scoring protocol. The adapted version of the ACROBAT-NRSI, including signaling questions, was constructed and published by Benton et al. (2016). Aspects which were adapted are specific for the field of natural experiments and quasi-experiments, such as control site selection and measuring exposure to intervention. In addition, the assessment of internal validity was supplemented with the assessment of two other types of validity (statistical conclusion validity and construct validity). The following domains of bias were included in the risk of bias assessment: Bias due to confounding, bias in selection of participants into the study, bias in measurement of interventions, bias due to departures from intended interventions, bias due to missing data, bias in measurement outcome and bias in the selection of reported results (Table 1). We were aware that the ACROBAT-NRSI might set the bar of methodological acceptability too high, leading to downgrading of evidence from natural experiments (Humphreys et al., 2017), but nevertheless considered this tool suitable for comparing the included studies with each other, rather than judging them by the absolute score. A random 33% sample of the included studies were assessed for the risk of bias assessment by two researchers. The results of the assessments were compared and discussed until consensus was reached. The remaining included studies were assessed accordingly by one researcher (XXX).

3. Results

3.1. Study selection

Fig. 1 shows the numbers of publications identified, screened, assessed for eligibility and included. In total, 4163 articles were identified through database searching and checking reference lists. After removing duplicates, 3265 publications remained in the sample, 3170 of which were excluded after title screening. Ninety-five abstracts were reviewed, 47 of which were excluded (list provided in Supplementary file 1). The full texts of the remaining 48 articles were assessed, and 19 articles were included in this systematic review.

3.2. Risk of bias

The risk of bias in the included articles varied from moderate (Goodman et al., 2014; Heinen et al., 2017; Panter and Ogilvie, 2017) to serious (Crane et al., 2017; Heesch et al., 2016; Heinen et al., 2015; Panter et al., 2016; Parker et al., 2013; Rissel et al., 2015; Song et al., 2017) and critical (Dill et al., 2014; Evenson et al., 2005; Fitzhugh et al., 2010; Hirsch et al., 2017; Krizek et al., 2009; Parker et al., 2011; Pazin et al., 2016; West and Shores, 2011, 2015) (Table 1). None of the included articles scored low for risk of bias. Risk of bias was lowest in the domains of “bias due to departures from intended interventions” and “bias due to missing data”. Risk of bias was highest in the domains of “bias in the selection of participants into the study”, “bias in measurement outcome” and “bias in the selection of reported results”. A fully justified sample size calculation was missing for most of the included studies, except for Pazin et al. (2016). Outcome measurements were assessed subjectively in the vast majority of the studies. Only Goodman et al. (2014) and Crane et al. (2017) reported the results of more than one follow-up. Study protocols were published for three out of fourteen unique interventions (Rissel et al., 2013; Ogilvie et al., 2010, 2012), making it difficult to judge whether analyses and outcome