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Built environment interventions and physical activity levels: a systematic review

Built environment and physical activity

Intervenciones en el ambiente construido y niveles de actividad física: una revisión sistemática

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Introduction: Non-communicable diseases are the leading cause of death worldwide and physical activity is a key preventive strategy to reduce Non-communicable diseases. There´s a relationship between the built environment and the practice of physical activity, but little evidence as to whether those built environment interventions not initially designed for promoting physical activity actually have an impact on promoting the behavior.

Objectives: This paper seeks to identify whether those built environment interventions, were able to change physical activity in adults.

Materials and methods: We conducted a systematic review of interventions that targeted modifications to the built environment changes in urban areas.

Results: Out of 5,605 articles reviewed, only 7 articles met our inclusion criteria. The seven studies found higher levels of physical activity after the interventions.

Conclusions: We recommend greater specificity regarding the study design, the timeline of interventions implementation and post-intervention measurements, and to use more objective measures. Finally, we point out the need to make more explicit the mechanisms of change related to the interventions assessed.

Keywords: built environment; physical activity; health promotion.

Introducción. Las enfermedades no transmisibles son la principal causa de muerte en todo el mundo y la actividad física es una estrategia preventiva clave para reducir las enfermedades no transmisibles. Existe una relación entre el ambiente construido y la práctica de actividad física, pero hay poca evidencia de si esas intervenciones, inicialmente no diseñadas para promover actividad física, realmente tienen un impacto en la promoción del comportamiento.

Objetivo. Este estudio tiene como objetivo identificar si esas intervenciones en el ambiente construido pudieron cambiar la práctica de actividad física en adultos.

Materiales y métodos. Se realizó una revisión sistemática de las intervenciones que le apuntaban a modificaciones del ambiente construido en zonas urbanas.

Resultados. De 5,605 artículos considerados, solo 7 artículos cumplieron con nuestros criterios de inclusión. Los siete estudios encontraron niveles más altos de actividad física después de la intervención.

Conclusiones. Se recomienda ser más específicos con respecto al diseño del estudio, al cronograma de implementación de las intervenciones y mediciones posteriores, así como utilizar medidas más objetivas. Finalmente exponemos la necesidad de hacer más explícitos los mecanismos de cambio relacionados con las intervenciones evaluadas.

Palabras clave: entorno construido; actividad física; promoción de la salud.

Currently, non-communicable diseases (NCDs) are the leading cause of death in the world, responsible for 38 million of the 56 million deaths recorded in 2012, representing a 68% of total deaths worldwide (1). The majority of deaths reported as a cause of NCDs occurred in the working-age segment of the population and in low and middle-income countries (1,2). Specifically, the main four groups of diseases responsible for 80% of all NCD-related deaths are cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes (3). For the period of 2011–2025 it has been estimated that low-and-middle-income countries would have an economic loss of US $ 7 billion derived from NCDs, far exceeding the annual cost of interventions aimed at reducing the prevalence of NCDs (i.e., US $ 11.200 million) (1).

The promotion of physical activity (PA) is among the multiple interventions proposed for the reduction of morbidity and mortality of NCDs (between 20 and 30%) (1,3-5). According to the World Health Organization (1,2), for countries to increase PA levels of their population and thus have a positive effect in the reduction of morbidity and mortality related with NCDs, an intersectoral collaboration strategy is needed, including such sectors as transport, urban planning, recreation, sports and education.

There is evidence that suggests a relationship between the built environment and health behaviors such as PA (6,7). Specifically, the characteristics of the built environment can promote or inhibit PA behavior (6,7). For example, the aesthetic and security infrastructure of the neighborhoods is related to the frequency of physical activities such as walking and cycling (8). Neighborhoods with adequate pedestrian infrastructure, illumination, with green spaces and free of graffiti, have had positive effects on the practice of PA (9,10). Similarly, it has been shown that recreational and non-recreational facilities (cafes, grocery stores, food stores,

schools, and other services) are positively associated with active transportation (9,10). This suggests that even those spaces that have not been specifically built to promote PA have a relationship with its practice.

Although various studies and systematic reviews have shown a strong relationship between built environments and PA (9-11), these studies have not clearly shown whether environments not initially designed for promoting PA actually have an impact on promoting such behavior. Sustainable objective goals (United Nations, 2016) have also pointed out the importance of sustainable cities and communities. Since the world is increasingly urbanized (today, 3.5 million people live in cities) and it is expected that by 2030 60% of the population will live in urban areas (12), it is essential to understand the role of these urban environments in health. Thus, clarifying how those environments influence the practice of PA would help to encourage an intersectoral approach for promoting this behavior.

Besides, synthesizing evidence that provides information on whether urban planning interventions in which the main goal was not a PA intervention, although the measures taken later where PA variables or proxies of PA, can contribute to consolidating the evidence regarding the built environment and the performance of PA. In addition, this information will contribute to the body of knowledge related to evidence-based urban development, which can directly or indirectly have an impact on the prevalence of NCDs. We looked at the systematic review from the *Guide to Community Preventive Services* (13), and found that it applies only to the EUA.

Based on the above, the goal of this study was to identify whether built environment interventions, not initially designed to change PA, were able to change PA or proxies of PA in urban areas.

Materials and methods

Search strategy

This study was a systematic review of the literature that was conducted according to PRISMA criteria (14). The search of articles took place in December 2016. We searched in seven databases: MEDLINE, Web of Science, EMBASE, ProQuest, and LILACS. Those seven databases were selected to try to have a greater understanding in the sample, and to try to cover as many of the possible articles. Search terms used were as follow: “intervention” OR “natural experiment” AND “physical activity OR exercise OR walking OR cycling” OR “commute mode walking OR cycling” “active commute” OR “mode of travel” OR “proportion of trips” OR “active travel” OR “travel behavior” OR “active transport” OR “connectivity” AND “built environment” OR “built environment interventions” OR “infrastructure” OR “urban planning” OR “urban interventions” OR “transportation intervention” OR “public transportation” OR “transport infrastructure” OR “urban regeneration” OR “urban revitalization” OR “housing projects” OR “green space” OR “land use” OR “lighting” OR “traffic lights” OR “roads”.

Exclusion and inclusion criteria

The search included only papers published with adult populations in English, Spanish, or Portuguese. In order to track the most current trends studies the search was limited to papers published between 2000 and 2016. We choose this period because after the year 2000 there was an increased recognition of built environment interventions in relation with health behaviors, including PA (15). Also, at the beginning of the new century ecological models shed light on the role of the environment in the promotion of PA (15,16).

The papers included in the review were only those describing an intervention not primarily designed to promote PA but were able to measure at least one outcome

related to this behavior before or after the intervention. In this sense, we included those intervention papers related to transportation or built environment that were designed and available to the general population. For the purposes of this study, *physical activity* was defined as any muscular movement that requires energy expenditure of moderate or vigorous intensity. It can include activities such as sports, active recreation, play, wheeling, walking, or cycling (17). We included articles with self-reported measures of PA (including walking). Also, we accepted as PA proxies: commute mode walking, active commute, mode of travel, proportion of trips, active travel, and travel behavior. Likewise, the *built environment* was defined as any physical environmental characteristics in a community that could make physical activity easier or more accessible (18).

Selection of studies

The selection of papers had three different filters. *Firstly*, duplicated articles were excluded. *Secondly,* four trained researchers with English and Spanish reading skills (one of them with Portuguese reading skills) reviewed the titles and abstracts to evaluate the inclusion and exclusion criteria. *Thirdly*, pairs of researchers then reviewed each paper, which were subject to prior agreement regarding their inclusion. Possible discrepancies on whether to include a paper or not was solved based on a third reviewer of the team, guided by the inclusion and exclusion criteria previously established. Figure 1 shows a flow diagram with details about the search performed in databases.

Data extraction

Every paper included was then reviewed and categorized following these characteristics: year, language, country/region, type of study, area of knowledge, type of intervention, type of population and participants age, physical activity and other outcomes, effect estimate of PA and main results (figure 1).

Results

The results of the systematic review are organized as follows. First, we present the number of initial records identified in the databases consulted and the final number of articles included in the sample. Second, we identify and describe the study design of the papers reviewed. Third, we describe the type of population or participants in the studies reviewed. Also, we present the type of PA measures used in each paper, and finally the mechanisms underlying the interventions, in those papers where this information was available.

Sampling

A total of 5605 records were identified through the initial database search. After the removal of duplicates a total of 5273 records were screened by title and abstract. From those records, 5232 were excluded because they did not meet the inclusion criteria; the remaining 41 articles were assessed for eligibility and 7 were included in the final sample (figure 1).

Studies design

All the studies identified were intervention studies not primarily designed to promote PA, as we defined first in the inclusion criteria. Specifically, three studies identified themselves as a natural experiment (19-21), one as a prospective cohort study (22), one as a two-wave study (23), one as a quasi-experimental study inside a cohort study (24). One study did not specify the research design used (25), but taking into account the information provided in the method section, we assumed that a longitudinal design was used, with pre-and-post-intervention assessments (table 1).

Characteristics of the assessed population The studies reviewed showed a total sum of 1.947 participants in the different interventions with a range of 70 and 537. Also, one study gathered information from 750 households (22).

Regarding population characteristics in the interventions reviewed, two studies recruited employees of a certain area of interest (21,24), three studies recruited people from a local community (22,23,25), one study recruited university students (20), and one study recruited low-income African American women (19).

Type and focus of interventions

Regarding the type and focus of interventions in our sample, all of them evaluated PA levels in relation with changes in the built environment like transport infrastructure, traffic calming scheme, street interventions, among others (table 1). Specifically, four studies evaluated a transport infrastructure intervention (21,23-25), one study evaluated a traffic-calming scheme (22), and two studies evaluated built environment characteristics such as land use, pedestrian networks, and street network patterns, among others (19,20).

Measures of PA and proxies

The papers reviewed used different approaches to measure PA (table 1). The measures used were walking minutes or distance (19,20,22-24), cycling minutes or distance (21,22,24), total minutes per week of total moderate to vigorous PA (hereafter MVPA) (23,25), and total minutes per week of moderate to vigorous recreational PA (24). These measures were obtained, either objectively or through self-report. Objective measures of walking were collected through accelerometry (23,25) or pedometer (19). Subjective measures were collected using validated scales (24), through part of a survey questions asking for the weekly time of PA performed during the week (21,23) or by asking directly for perceived differences in PA levels as a result of the intervention (20,22).

All the measures in the studies reviewed were obtained on a pre-and-post-intervention basis. The studies reported only one follow-up measure, right after the intervention's implementation. The follow-up measurements were made at

different time points after the intervention has become effective: three months later (20), five to seven months later (23), one year later (21). The other studies did not give exact information on this regard (19,21,22,24); although they mentioned the range of time over which the data were collected, it was not clear how much time elapsed from the implementation of the intervention to the follow-up.

Mechanisms underlying the interventions

One of the aspects analyzed in our sample was the underlying mechanism or Behavioral Change Theory (BCT) as a theoretical, methodological and analytical foundation to explain changes in PA behavior and proxies. Two studies have made explicit reference to theories of change, specifically the Theory of Planned Behavior (TPB) (21,23), the Health Belief Model and the Ecological Model (23). Nonetheless, one study measured variables that have been integrated in behavior theories and models (e.g., perceptions and attitudes) still without making any explicit reference to theory (22). We can categorize the Prins et al. study (21) as one that applies theory (26), once there was an open reference to TPB and the variables proposed in the model were measured and analyzed in conjunction with the results in physical activity and changes in the built environment. In the case of (23), it seems that it is more informed by theory, since he does not apply it sufficiently (26). Regarding the Morrison et al. study (22), although there´s some level of theory application, it failed to account for a theory in its theoretical framework.

Discussion

To our knowledge, this is the first systematic review analyzing whether built environment interventions, not initially designed to change PA, could change PA or proxies for PA in urban areas.

As systematic reviews in this area are usually interested in interventions that have been designed to impact PA levels, our focus on interventions not designed to change PA is, we believe, a unique contribution to the literature. A better understanding of how built environments can influence the practice of PA should lead to the use of an intersectoral approach in public health, particularly in efforts to promote PA in urban areas. Also, as noted above, our synthesis of evidence on whether urban planning interventions in which the main goal was not to change PA behaviors can nevertheless affect PA can contribute to consolidating our knowledge regarding built environment and the performance of PA in urban areas.

All the studies reviewed found higher levels of PA and proxies for PA at post-intervention. These results appear to be consistent with what other authors have previously described about the influence of the built environment on health behaviors, particularly in PA (6,7,27,28). The results indicate that the kinds of interventions carried out in our sample can be particularly useful in increasing walking, cycling, total MVPA and recreational MVPA in communities.

Three methodological aspects are relevant in our evaluation of the selected studies. First, although the studies reviewed used a quasi-experimental design, not all of them described the study design exhaustively, and one failed in mentioning it at all (25). We recommend that future studies should be more specific regarding the research design and how this is carried out. Second, these studies are not specific enough regarding the timeline of the intervention's implementation and when the post-intervention measures were obtained. In this sense, the time-lapse of follow-up is something very important to report since the findings of a study can be related with the period in which the subjects were observed, or when the event occurred, which in this case was the intervention

(29). In this sense, we also suggest that longer follow-up times are needed, since the ones described in the articles are carried out immediately after the implementation of the interventions. Finally, more than half of the studies reviewed used only self-reported measures, which are not as reliable as objective measures, and presents a high risk of bias (30). In this sense, we suggest that more objective measures are needed in these kinds of studies. For example, the use of accelerometry or pedometers could be considered, along with subjective measures used. Also, another possibility with potential value is the use of Ecological Momentary Assessment (EMA), which allows us to obtain information on PA behavior and its correlates in real time (31).

Another important topic revealed in our systematic review is that the studies are not discussing enough about how these interventions impact underserved communities and disadvantaged groups. In our sample, only one study discussed this issue with reference to low-income African American women (19). In addition, we did not find any studies in low- or middle-income countries that fit our inclusion criteria of containing pre- and post-intervention measures to describe the effect of urban interventions that were not originally designed to promote PA but could have had a potential effect in this behavior (e.g., BRT, cables, electric stairs, etc.). This evidence is especially needed in economically disadvantaged countries since these nations tend to experience a disproportionate burden of NCDs, explained in part by low levels of PA.

Another important issue for us in this review was the study authors understanding of the mechanisms of change related to the interventions assessed, along with the theoretical decisions that guided the selection of measures. An adequate understanding about the mechanism of action behind the interventions would allow an explanation of how a behavior changes in relation to a specific

intervention (32). Most of the studies, however, did not make an explicit reference to a theory of change, and among those that did, only one tested the theory using variables proposed in the TPB in their pre-and-post-intervention measurements (19). For that reason, we consider that the authors' conceptual frameworks of how the interventions may be working should be made more explicit. Also, theoretical decisions that guided the selection of measures should be stated more clearly and in greater detail.

According to the World Health Organization (33), to adopt a "Health in All Policies" approach is essential, since it will contribute to improve the health of the population and health equity. Accordingly, it is recommended that interventions carried out in the built environment take into account aspects that can benefit and promote the practice of physical activity, especially in low- and middle-income countries.

In this review, we did not find any study in a language other than English, and no study was carried out in Latin America and the Caribbean region, which we believe is a limitation for the study. Also, although we wanted to focus on interventions that were not initially designed to change PA, we only used health sciences databases, since we were analyzing the PA outcome measure.

Although our expectation for the study was to address studies in low-income and minority communities, only one study explicitly referred to including participants in this category, and for that reason it is not possible to draw generalizations for populations with those characteristics.

As strengths of this study, we would emphasize the value of recognizing that interventions from the outside the health field, implemented for purposes other than the promotion of healthy behaviors such as PA, but can nonetheless be effective in promoting these behaviors. In addition, our interdisciplinary and

multilingual team has broadened the scope of our review by enabling us to review abstracts in English, Spanish, and Portuguese.

This paper has discussed some important findings regarding the effect of built environment interventions that were not originally designed to promote PA but could have had a potential effect on this behavior. The findings showed that built environment interventions not designed to promote PA are potentially effective in encouraging this behavior.

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Conflicts of interest

The authors declare no conflict of interest.

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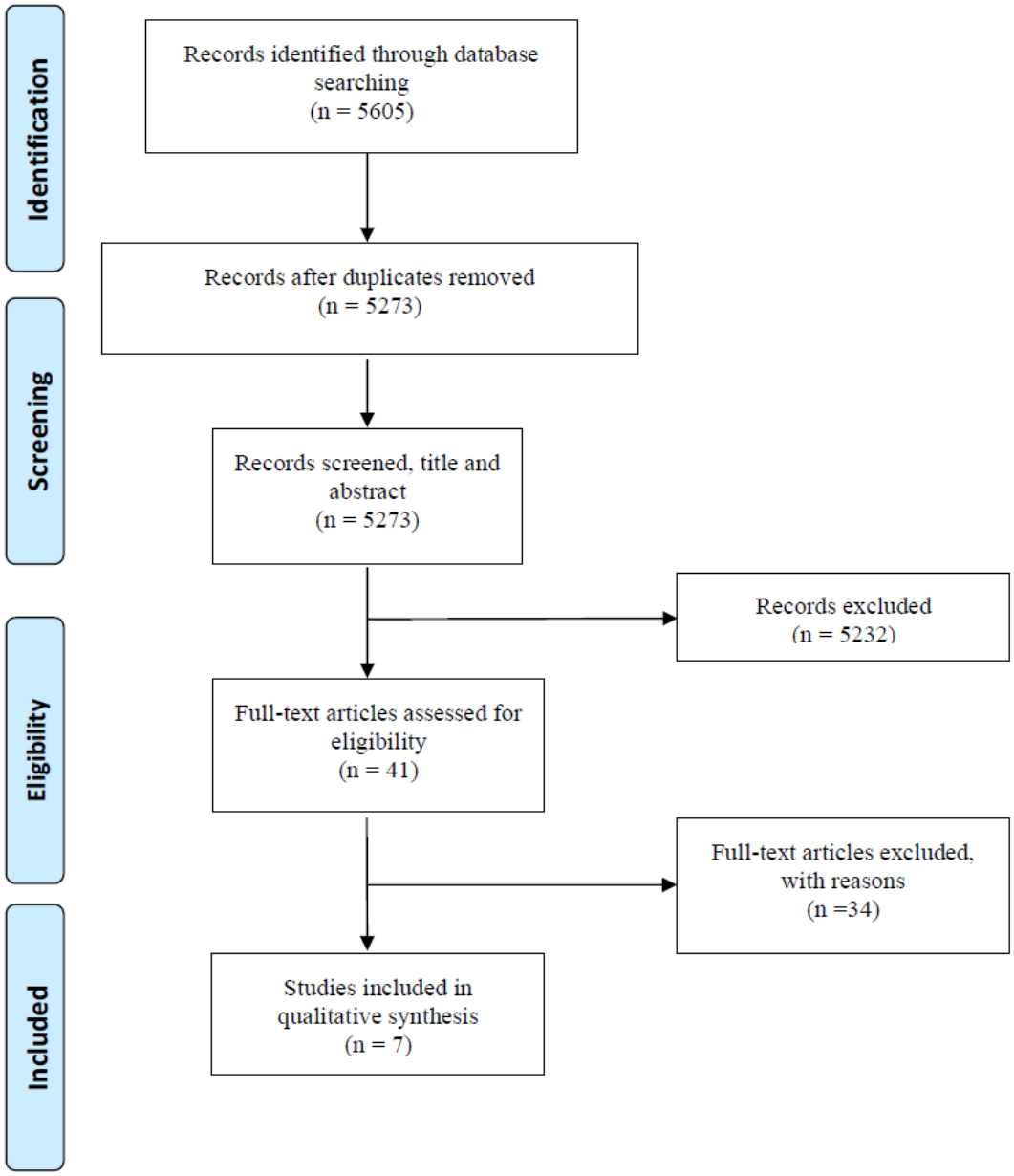

Figure 1. PRISMA flow diagram.

Citation	Data Collected	Study Design	Recruitment Strategy	Demographics	Intervention	Physical Activity Outcome
Prins et al., 2016	Cambridge, (UK). Data collected between 2009–2013.	Quasi-experimental (natural experiment).	Recruitment at workplace using a combination of strategies: emails, leaflets, recruitment stands.	N = 469 M*age* = 43.9(SD=10.8) Female = 66.4% Urbanicity: urban = 65.9%; rural = 34.1%. *Education*: lower than degree level = 25.4% degree level = 74.6%	Construction of new transport infrastructure that connects towns and villages in the northwest of Cambridge with the Cambridge Science Park, the city center and the Cambridge Biomedical Campus.	The new routes increased the use of cycling. Among all the measurements, an increase of 1.42, 95% CI = 0.86, 1.97).
Morrison et al., 2004	Glasgow, (Scotland). Data collected between 2009–2013.	Quasi-experimental (prospective cohort study)	Postal questionnaire surveys using household addresses from a commercial data company.	N = 750 (15 years and older)	The intervention consisted in a traffic calming scheme in the main road of an urban housing estate in Glasgow.	Subjective measure of physical activity showed higher levels in walking and cycling behaviors after intervention. 20% of the participants reported to walk more in the area after the intervention. Also, 3.8% reported to cycle more in the area, 12.5% allow children to walk more, 11.6% allow children to cycle more and 11.8% of the participants allow children to play out more in the area.
Sun et al., 2014	Hong Kong, (China). Data collected between 2012–2013.	Quasi-experimental (natural experiment).	Email recruitment of students from the university campus.	N = 169 M*age*=18.7 (SD = 1.2) Female = 55%	A restructuring process was carried out within the campus of the Chinese University of Hong Kong: changes in land use, pedestrian network, population density and campus bus services schedules.	Results showed that changes in the built environment led to higher levels of walking physical activity. Changes in exposure to pedestrian network increased walking ($\beta = 0.895$, $p < 0.001$). Changes in the use of recreational buildings (located further away) and exposure to increased population density were related to an increase of walking distance ($\beta = 0.187$, $p < 0.001$).
Wells et al., 2008	Georgia, Alabama,	Quasi-experimental	Women in the beneficiaries'	N = 32 M*age* = 38	Two neighborhoods were relocated to	After the relocation the number of steps in neotraditional

	and Florida (US). Data collected between 2003–2006.	(natural experiment).	neighborhoods of the Habitat for Humanity program. List of names provided by the local program organization.	Annual income = 16.425.75 USD Average body mass index = 32.09 Overweight or obese = 82% *Education*: High school graduate = 81%	neotraditional communities and conventional suburban neighborhoods.	neighborhoods were higher (62.207 steps/week) when comparing with suburban neighborhoods (58.617 steps/week), but not statistically significant (p = 0.6). However, when looking for race differences, African-American women walked less (50,320 steps/week) in comparison with non-African Americans (70.504 steps/week) and this difference was significant (p = 0.013). Also, household size predicted higher number of steps per week (5600 more steps, p = 0.008).
Hong et al., 2016	California (US). Data collected between 2012–2013.	Quasi-experimental (two-wave study)	Addresses in the area of the study were purchased from a commercial database. Invitation letters were sent to households in the area.	N = 73 M*age* = 38 Male = 39% Race (white:26%; black: 56%) *Education*: some years of College = 29%, Bachelor = 34% Employment status: not employed = 44%	Construction of a new light rail line.	In the second statistical model using total walk trip counts and the interaction term between treatment and baseline MVPA, being in the treatment group was associated with higher levels of moderate to vigorous PA (MVPA) at follow-up (β = 9.29, p = 0.06). However, when looking for the intersection between treatment and baseline MVPA, those effects were attenuated (β = −0.34, p = 0.06).
Panter et al., 2016	Cambridge (UK). Data collected between 2009–2012.	Quasi-experimental.	Recruitment at workplace using a combination of strategies: newspaper advertisements, posters, flyers by means of corporate email, staff newsletters, recruitment stands.	N = 469 M*age* = 44 (SD = 11.1) Women = 66.5% Education: degree level education: 74.8%; less than degree-level education: 25.2%. Urban-rural status: urban 67.3%; town 17.1%; village 15.6%.	Opening of a new transport infrastructure “Cambridgeshire Guided Busway”.	Positive effect of the exposure to the busway. Greater amount of weekly cycling (relative risk ratio = 1.34, 95% CI = 1.03, 1.76). Also, more time spent in active commuting (relative risk ratio = 1.76, 95% CI = 1.16, 2.67), only for those participants with less active commuting at baseline. Participants living closer to busway showed more cycling and less walking, and the greater the distance from the

				Weight status: overweight or obese: 33.9%		busway, this relationship was reversed.
Brown et al., 2015	Salt Lake, Utah (US). Data collected between 2012–2013 (one week before and after of intervention)	Quasi-experimental.	Participants were recruited door to door.	N = 537 Mage = 41.1(SD = 0.74) Female = 51% Hispanic = 25% College graduate = 37% Married = 46%.	Street intervention to extend a light-rail line.	Intervention was associated with PA levels assessed with accelerometers. Former riders showed a decrease in PA levels, in comparison with never-riders ($t = -3.30$; $p = 0.001$). New users of the light rail line performed more PA in comparison with never-riders ($t = 2.72$; $p = 0.007$).

Table 1. Summary of studies that assess urban interventions on unplanned physical activity outcomes.