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Review Article

Impact of new rapid transit on physical activity: A meta-analysis

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ABSTRACT

New rapid transit investments have been motivated by environmental, economic, and health benefits. Given transit's potential to increase active travel, recent research leverages transit changes for natural experiment studies to examine physical activity outcomes. We aimed to quantify the association size, critically examine existing literature, and make recommendations for future studies to advance research and policies on active travel, transportation, and physical activity. Studies of physical activity impacts following transit interventions were systematically reviewed using seven health and transport databases (May–July 2017). Two investigators extracted data on sample size, intervention, pre- and post-intervention physical activity, and relevant measurement information. Inconsistency of results and estimated overall mean physical activity change post-intervention were assessed. Forest plots were created from physical activity change in each study using a general variance-based random effects model. Of 18 peer-reviewed articles examining health behaviors, 15 addressed physical activity and five were natural experiment studies with pre- and post- intervention measurements. Studies varied by intervention, duration, outcome measurement, sampling location, and spatial method. Q (201) and I^2 (98%) indicated high study heterogeneity. Among these five studies, after transit interventions, total physical activity decreased (combined mean - 80.4 min/week, 95% CI - 157.9, −2.9), but transport-related physical activity increased (mean 6.7 min/week, 95% CI - 10.1, 23.5). Following new transit infrastructure, total physical activity may decline but transport-related physical activity may increase. Positive transit benefits were location, sociodemographic, or activity-specific. Future studies should address context, ensure adequate follow-up, utilize controls, and consider non-residential environments or participants.

1. Introduction

Changing or adding to transit systems has been motivated by a multitude of potential benefits, including accommodating growing access needs for residents, reduction in environmental problems, increases in property values, and enhanced economic opportunities. Specifically, new systems with large passenger capacities that operate on a separated guideway, "Rapid Transit interventions," including Bus Rapid Transit (BRT), Light Rail Transit (LRT), and Rail Rapid Transit (RRT) are increasingly used in large cities to move growing populations more efficiently. These systems ensure that operations are not impeded by vehicle traffic or frequent stops using transit priority measures. Additional benefits of these extensions or new systems include reduced use of personal motor-vehicles, carbon emissions, air pollution, congestion, and collisions regionally (Bocarejo et al., 2012; Ding et al., 2016; Goel and Gupta, 2015; Saxe et al., 2017). For those living near rapid transit, but not necessarily regular passengers, the impacts include increased property values, higher density, and mixed land-uses (Bocarejo et al., 2013; Hurst and West, 2014; Rodriguez et al., 2016; Stokenberga, 2014; Zhu and Diao, 2016). Rapid transit can also allow regular transit users better access to economic opportunities, social and health facilities, and other desirable locations (Delmelle and Casas, 2012; Fan et al., 2012).

Beyond the many environmental, economic, and personal access benefits, rapid transit may also contribute to increased physical activity. Studies are increasingly finding associations between those who

Abbreviations: BRT, Bus Rapid Transit; LRT, Light Rail Transit; MVPA, moderate to vigorous physical activity; RRT, Rail Rapid Transit

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use transit and higher physical activity (Besser and Dannenberg, 2005; Freeland et al., 2013; Lachapelle et al., 2011; Lachapelle and Frank, 2009). Transit use may be considered an instigator of active transportation, since it often requires walking or bicycling between transit stops and destinations (Bauman et al., 2012; Lachapelle et al., 2016; Voss et al., 2015). Therefore, it follows that people who use transit may be more likely to reach their recommended daily moderate to vigorous physical activity than those who use personal motor vehicles, car sharing, or carpooling (Besser and Dannenberg, 2005; Freeland et al., 2013). This increase in physical activity can contribute to a reduction in the odds of developing a chronic disease such as obesity (Brown et al., 2015; MacDonald et al., 2010). Given this evidence that active commuting increases protection against cardiovascular disease (Hamer and Chida, 2008), public health efforts increasingly target investments in new transit infrastructure that support active travel to increase overall physical activity.

Despite the multiple drivers of investments in new transit, including the physical activity benefits, little research has directly evaluated these new investments. With cities adding new transit lines and stations, some researchers have leveraged these changes to conduct natural experiment studies that aim to measure the population-level physical activity benefits of this new infrastructure. Although this field is still rapidly growing, quantifying early natural experiment studies' findings and examining existing literature can shape recommendations for future studies and inform future transit investment. To summarize findings for research and practice, we conducted a meta-analysis of natural experiment studies examining physical activity impacts of new rapid transit interventions (BRT, LRT, RRT).

2. Methods

2.1. Search procedures

Methods and inclusion criteria were specified in advance and documented in a protocol (Supplemental File 1), adhering to established recommendations for meta-analyses, including PRISMA guidelines (Liberati et al., 2009; Shamseer et al., 2015) (Supplemental File 2). Studies were identified from seven health and transport databases (Academic Search Complete, CINAHL, GEOBASE, Medline, PsycINFO, TRID, Web of Science) over May to June 2017. Search terms included, but were not limited to: rapid transit, public transit, light rail, health, physical activity, mobility, longitudinal, retrospective, prospective, intervention, and pedestrian.

2.2. Inclusion criteria

Studies were considered if they were in English, published recently (≤10 years), and included a rapid transit intervention. We define rapid transit interventions as new systems with large passenger capacities that operate on a separated guideway, such as BRT, LRT, and RRT. BRT systems operate on-road within a separated guideway and with transit priority signals, so that they are not impeded by vehicle traffic. Typically, BRT systems are in the center of the roadway with stations that include pedestrian walkways. LRT systems are very similar to BRTs, but are rail-based, rather than bus-based. RRT systems are also known as subway, metro-rail, and Mass Rapid Transit systems. They are any rail-based rapid transit system that operates completely on a separated guideway, without any potential interference of vehicle transit. They typically can carry more passengers and operate faster than LRT systems.

Preliminary searches and coding revealed 101 published studies. Our current review included only those measuring physical activity pre- and post-new transit infrastructure. We used prescriptive inclusion criteria; studies were excluded if they reported insufficient physical activity details (minutes/amount) for effect size calculation (i.e., mean pre- and post-, or mean change, and standard deviations [SD] or 95% Confidence Intervals [CI]) (Brown and Werner, 2007, 2008; MacDonald et al., 2010). Of note, two of these three excluded studies (Brown and Werner, 2007, 2008) were part of a series of papers otherwise reporting on the same populations for the same transit project (Brown and Werner, 2007, 2008; Brown et al., 2015; Miller et al., 2015); our analysis includes only a single report (Miller et al., 2015).

2.3. Data extraction

Two investigators (DD, JH) independently extracted sample size, intervention, pre- and post-intervention physical activity, and measurement information relevant for descriptive purposes. To harmonize data, we converted outcomes into total and transport-related physical activity (minutes/week) by collapsing subgroups (i.e. participant subsets or specific activities such as biking and walking) or scaling to identical units (daily to weekly).

2.4. Bias assessment

Two investigators (DD, JH) assessed bias risk using the Risk of Bias in Non-randomized Studies – of Interventions (ROBINS-I) assessment tool (Sterne et al., 2016).

2.5. Statistical analysis

We assessed statistical inconsistency using Cochran's Q and I^2 (Higgins et al., 2003). We estimated overall mean change post intervention from mean and standard deviations of physical activity change in each study using a general variance-based random effect model tool in Excel (Neyeloff et al., 2012). We chose random effects because study variation existed by location, population, and intervention.

3. Results

3.1. Descriptive summary of sample studies

Of 18 peer-reviewed articles examining health behaviors, 15 were on physical activity with only five of these incorporating natural experiment designs with sufficient pre- and post-intervention measurements (Chang et al., 2017; Hong et al., 2016; Huang et al., 2017; Miller et al., 2015; Panter et al., 2016) (Supplemental File 3). The meta-analysis and subsequent results focus only on the five papers with sufficient physical activity measurements reported.

One study used a repeated cross-sectional design (Chang et al., 2017), while the others were longitudinal within the same cohort (Table 1). Only one study included a control group in the original design (Hong et al., 2016). The rapid transit interventions included two BRTs in Mexico City, MX and Cambridge, UK as well as three LRTs in Los Angeles, Salt Lake City, and Seattle, US. All studied a complete new line, except for the Los Angeles study, which only studied six stations from the first phase of a new line addition (Hong et al., 2016). Additionally, three explicitly mentioned they included concurrent investments in bicycle- and pedestrian-related infrastructure that could have influenced active travel (Hong et al., 2016; Miller et al., 2015; Panter et al., 2016). Most sampled residents living geographically close (< 2 km) to the interventions, while one sampled workers close to the intervention and living within 30 km (Panter et al., 2016). Follow-up duration ranged from one to three years. All studies examined adults; three had > 60% females (Hong et al., 2016; Huang et al., 2017; Panter et al., 2016). Three studies used accelerometry (Hong et al., 2016; Huang et al., 2017; Miller et al., 2015); four specifically measured transport-related physical activity (Chang et al., 2017; Hong et al., 2016; Miller et al., 2015; Panter et al., 2016).

Each study found positive associations with increased physical activity only within specific study subgroups. Chang et al. (2017) found an increase in walking for transport in the surveyed population near