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Achieving recommended daily physical activity levels through commuting by public transportation: Unpacking individual and contextual influences

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ABSTRACT

This paper estimates the amount of daily walking associated with using public transportation in a large metropolitan area and examines individual and contextual characteristics associated with walking distances. Total walking distance to and from transit was calculated from a travel diary survey for 6913 individuals. Multilevel regression modelling was used to examine the underlying factors associated with walking to public transportation. The physical activity benefits of public transportation varied along gender and socio-economic lines. Recommended minutes of daily physical activity can be achieved for public transportation users, especially train users living in affluent suburbs.

1. Introduction

The World Health Organization (WHO) identified transportation as one of the top ten social determinants of health (Wilkinson and Marmot, 2003; Commission on social determinants of health, 2008). Physical activity associated with the use of public transportation leads to a number of health benefits including reduced rates of obesity and many chronic diseases (Brown and Werner, 2007; Jakicic and Gallagher, 2003; Sallis et al., 2004; Transport Canada, 2005; Wilkinson and Marmot, 2003; Warburton et al., 2006; Macdonald et al., 2010). Previous research has shown that walking has the potential to have widespread public health impact, mainly due to its ease and low cost (Lee and Buchner, 2008).

Walking associated with daily commuting by public transportation can have a considerable impact on public health; however, the extent to which different groups of the population can benefit from this routine activity is rarely studied. Zhao et al. (2003) measured walking distances to transit stops to forecast transit accessibility and El-Geneidy et al. (2010), measured walking distances to transit stops to estimate bus service areas around stops. Another study has looked at the number of theoretical steps 'in reserve' if non-users were to start using public transportation (Morency et al., 2007). This study, however, did not incorporate characteristics of individuals, transportation service networks nor neighborhoods in their understanding of the public health potential of public transportation.

Two studies have measured overall walking to transit, the first by Besser and Dannenberg (2005), in the United States and the second by Morency et al. (2011), in Montréal, Canada. Besser and Dannenberg (2005), used the 2001 National Household Travel Survey to examine total walking to light rail and public buses in the United States; however, they did not incorporate transit service characteristics nor were they able to differentiate trip purposes in their models. Previous research has pointed to the importance of modeling different trip purposes separately, as each trip purpose has different characteristics and interacts differently with the built environment (Saelens et al., 2003; Handy, 1996). Large variation in walking distances and durations by trip purpose were found in the 2009 National Household Travel Survey (Yang and Diez-Roux, 2012) as well as other studies in the Twin Cities (Iacono et al., 2010) and Montréal (Larsen et al., 2010).

Morency et al. (2011), used the same survey data (Montreal Origin Destination survey) that is used in our analysis to estimate total walking to public transportation. That study, however, did not focus on daily commuting (i.e., the study did not isolate trip purpose) nor did the study take into consideration contextual characteristics of neighbourhoods and transit services. The resulting

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low explanatory power of their reported model (*R*-squared value of 0.069) might be attributable to these factors.

Our paper estimates the amount of daily walking that can be achieved when commuting by public transportation by way of analyses of a travel behavior survey (Origin-Destination Survey) in Montréal, Canada. Our analyses unpack the underlying individual (e.g., age, gender, income level) and contextual factors (e.g., transportation service characteristics, land use diversity, street design, neighbourhood social characteristics) associated with this type of routine physical activity. Our research improves the current knowledge on this subject by: (1) focusing exclusively on commuting trips (work and school); (2) incorporating the influence of contextual factors of neighbourhood and transit service characteristics on daily walking in a multilevel modelling framework; (3) providing a clear replicable methodology (using widely available Geographic Information System (GIS) software) that may be adopted in other urban contexts.

2. Background

Our modern urban environments tend to promote sedentary lifestyles (Egger and Swinburn, 1997). The heavy dependence on single occupancy vehicles in North America and perceived lack of adequate time for physical activity can contribute to poor mental and physical health as well as the onset of chronic disease such as obesity, cardiovascular diseases, hypertension, osteoarthritis, some types of cancers and type 2 diabetes (Wei et al., 1999; Jakicic and Gallagher, 2003; Frank et al., 2004; Katzmarzyk, 2004). Physical inactivity is identified as the fourth leading risk factor for global mortality, estimated to contribute to 6% of deaths worldwide. It is clear that the overall burden of physical inactivity is a major public health concern and, from an economic perspective, a source of increasing health care utilization and expenditure (Sari, 2009; Finkelstein et al., 2003; Brown et al., 2008).

At least 60% of the global population fails to achieve the minimum recommendation of 30 min of daily moderate physical activity (WHO, 2003). In Canada, two-thirds of the population are not meeting this level of physical activity (Public Health Agency of Canada, 2008; Sari, 2009; Katzmarzyk et al., 2000). Advising people to reduce sedentary time is one solution. It is notoriously difficult to change human behaviour, however, and so the general thinking is that advice must be combined with macro-scale policies that have the potential to affect entire populations. Substantial public health benefits are thought only to be possible through action directed at targets like structural modifications in the transport system and the built environment, marketing policies, and the education system (Ekelund, 2012).

The use of active transportation provides an opportunity to introduce routine, daily physical activity into the lives of large groups of people and thus can be thought of as an important population health intervention tool (Sallis et al., 2004; Transport Canada, 2005). Public transportation is considered an active mode of transportation since it involves walking to and from stations. In Canada around 15.2% of work trips are done using public transportation (Hollingworth et al., 2010), and in Montréal the figure is approximately 13.7% (Agence Métropolitaine de transport, 2003).

In this paper, total walking distances to and from transit stops for a variety of public transportation services (metro, commuter train, urban and suburban bus services) are estimated. Total distances walked to and from transit stations are further translated into minutes of physical activity in order to estimate the contribution of public transportation in achieving the public health goal of 30 min of daily physical activity. Our analyses are informed by the general hypothesis that both individual factors (age, sex, socio-economic status) and factors related to neighbourhoods and transit systems influence the amounts of physical activity that can be achieved by using public transportation. Knowledge of these factors can help inform the potential public health impacts of investments in public transportation.

3. Methods

3.1. Study area, selection and description of participants

Montréal, Québec, is the second-highest populated metropolitan region in Canada with 3.7 million residents. Participants in this study were drawn from a travel behavior survey known as the Origin-Destination (OD) Survey (Agence Métropolitaine de transport, 2003). The OD Survey is a phone survey conducted every five years in the Montréal metropolitan region by the Agence Métropolitaine de Transport (AMT)—the agency responsible for regional public transportation in Montréal. The OD Survey covers around 5% of the Montréal population (169,900 individuals). One person in every household contacted is asked to report all trips made by her/himself and every other member of the household in the previous day. Although this method might impose some error in the estimates of walking because of the proxy reporting, the Montréal OD survey has been extensively tested and several validation tools have been in place for several decades to ensure the quality of the collected data (Chapleau, 2003). For every trip, participants were asked to record the place where they started their trip (origin) and the place where they ended it (destination). Participants were also asked to record the mode of transportation used for each trip (i.e., bus, train, metro, car, cycling, walking, etc.). For participants using public transportation, additional questions were asked regarding which transit route they selected. All public transportation trips were tested against a database including all existing schedules in the region to ensure the accuracy of the reported trips.

Trips included in the analyses of this study were only trips that were made by public transportation (i.e., bus, metro and train), where participants walked to and from public transit stops or stations. They represent 13.7% of the total trips in the OD survey. Participants cycling to the train were excluded since they comprise a tiny proportion of total trips (less than 0.0001%). Additionally, participants were non-retired adults 18 years and older for whom their primary trip purpose (first trip in the day) was going to work or school (college/university)—around 45% of all reported trips in the survey. These are the main trips that people conduct on a daily basis and are the routine trips that have the potential to support frequent and enduring physical activity Fig. 1.

3.2. Calculation of variables used in the study

For each respondent, total distance walked to and from transit stops was computed in a geographic information system (GIS) environment. In the OD survey, respondents were not asked to report the actual transit stop or station they used, but were asked to report the transit route (e.g., bus number, metro line, etc). Total distance walked was measured on the street network from participants' origin location to the nearest transit stop or station of the transit route they used. Transit stop locations were obtained from different transit agencies in the region as XY locations, while origins and destinations were reported as XY coordinates in the OD Survey. The distance that participants walked at the end of their trip, from the nearest transit stop to their destination, was measured using the street network as well. Small paths and alleyways were included as part of the pedestrian network used while, freeways and any facility that did not allow pedestrians were excluded. For every transit trip, in-vehicle distance, which is