Journal of Physical Activity and Health, 2011, 8(Suppl 1), S72-S82

Commuting by Public Transit and Physical Activity: Where You Live, Where You Work, and How You Get There

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Background: Most public transit users walk to and from transit. We analyzed the relationship between transit commuting and objectively measured physical activity. ***Methods:*** Adults aged 20 to 65 working outside the home (n = 1237) were randomly selected from neighborhoods in Seattle and Baltimore regions. Neighborhoods had high or low median income and high or low mean walkability. Mean daily minutes of accelerometer-measured moderate-intensity physical activity (MPA) were regressed on frequency of commuting by transit and neighborhood walkability, adjusting for demographic factors and enjoyment of physical activity. Interaction terms and stratification were used to assess moderating effect of walkability on the relation between transit commuting and MPA. Associations between transit commuting and self-reported days walked to destinations near home and work were assessed using Chi Square tests. ***Results:*** Regardless of neighborhood walkability, those commuting by transit accumulated more MPA (approximately 5 to 10 minutes) and walked more to services and destinations near home and near the workplace than transit nonusers. Enjoyment of physical activity was not associated with more transit commute, nor did it confound the relationships between MPA and commuting. ***Conclusion:*** Investments in infrastructure and service to promote commuting by transit could contribute to increased physical activity and improved health.

Keywords: transportation, accelerometer, workplace, walkability, enjoyment of physical activity

The relationship between physical activity and the built environment is well documented,[1–5] but the use of public transit—a potential mediator, or effect modifier in this relationship—remains understudied.[6,7] Positive associations between physical activity and transit use were found in various settings, using self-reported and objective measures of physical activity, as well as network distance between home and transit location.[8–12] Many public transit users were found to achieve physical activity recommendations solely by walking to transit.[13] Transit trips always include some walking (eg, to/from stops), especially at the destination end of a trip, and may potentially be supportive of physically active lifestyles. The provision of public transit reduces auto dependence and plays a major role in meeting energy consumption, greenhouse gas emission, and air pollution reduction objectives.[14–16] Quantifying more precisely the relationship between physical activity and public transit use and exploring the mechanisms through which this relationship occurs can inform decisions about land development and transportation investments. Such investments increase the quality and convenience of a lifestyle involving public transit.

Built environments that are more walkable tend also to be supportive of public transit use.[17–19] Higher residential density, greater land use mix, and street connectivity work jointly to enable walking by providing nearby destinations that are easy to reach. A walkable built environment supports transit ridership by colocating potential users, destinations, and a higher quality of nearby transit service. Comparing the relationship between transit use and walking in different built environments can improve understanding of the independent effects of each.

Because commuting by transit inevitably involves some walking, individuals who enjoy moderate physical activity may be more prone to commuting by transit. Independent effects of enjoyment of physical activity and demographic characteristics need to be disentangled from the transit commute, built environment, and physical activity relationships.

Is the association between transit commuting and objectively measured physical activity observed in residents of both high and low walkability neighborhoods? Does this relationship hold for both frequent and infrequent commuters? Does walking and biking to commute explain the relationship, or does transit use have an additional independent effect on physical activity? Are people who enjoy moderate physical activity more prone to commute by transit? Do transit commuters also walk

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more frequently to services and destinations near home and near the workplace? Since transit commuters do not have a car available at the workplace, we expected they might also walk more to services during the workday.

Whether commuting by public transit was related to objectively-measured moderate physical activity, and whether this relationship remained across home neighborhood walkability levels was assessed in this study. Associations between commuting by transit and walking to services and amenities near home and near the workplace were tested as potential explanation for higher levels of walking of transit commuters. Finally, analyses examined whether enjoyment of moderate physical activity and levels of self-reported work-related and leisure physical activity explained the relationship between transit use and physical activity.

Methods

Survey Sampling and Participants

The Neighborhood Quality of Life Study (NQLS) is an observational epidemiologic study conducted between 2001 and 2005. Published papers present the study design, methods, and other results in more detail.[20,21] Thirty-two neighborhoods were selected based on median income and mean walkability in the metropolitan areas of Baltimore, MD and Seattle, WA. Median neighborhood income was determined using 2000 census block group level information. Both regional distributions were split into deciles, and block groups in deciles 2 to 4 and 7 to 9 were considered low- and high-income neighborhoods respectively. A walkability index was calculated at the block group level across each region using the sum of the z-scores of net residential density, intersection density, retail floor area ratio and an entropy-based measure of land use mix.[21] An index of walkability was used to classify block groups into low (deciles 1–4) and high (deciles 7–10) walkability.[21] Contiguous block groups categorized as high or low for income and walkability were used to identify study neighborhoods across both regions. Investigators used ground validation to ensure that neighborhood surroundings were consistent with the categorization (ie, a high walkability neighborhood surrounded by low walkability ones). Transit service was generally higher in high walkability neighborhoods although some low walkability neighborhoods had good service. At the time of data collection, buses, a subway, a light rail, and stations of Washington, DC subway served the Baltimore region, while bus, express bus service and trolleys served Seattle. Both regions had park-and-ride lots served by several transit routes.

Participants were randomly selected within neighborhoods using marketing company data, and after informed consent, 2 waves of surveys along with accelerometers were mailed. The physical activity outcome and transit commute were retrieved from the second wave, for which data collection began in 2003. NQLS was based on an ecological model and designed to evaluate multiple levels of potential influences on physical activity.[22] Participants were between 20 and 65 years old, did not reside in a group establishment, were able to complete the survey in English, and did not have a medical condition preventing them from walking.

Recruitment and completion rate for the first survey was 26% (returned survey/contacted), and the second survey, sent 6 months later to respondents of the first survey, had a return rate of 87%. Sociodemographics and the psychological variable were retrieved from the first wave, and items on commute modes, walk trips and other physical activity measures were taken from the second survey. There were 2199 respondents who completed the first survey (1287 in Seattle and 912 in Baltimore regions), 1735 who completed the second survey and wore accelerometer, and the final sample of respondents employed outside the home was of 1237, 717 in Seattle, and 520 in Baltimore.

Outcome: Accelerometer-Measured Moderate Physical Activity

To ensure that survey completion did not influence physical activity patterns, the survey was preceded by a 1-week accelerometer monitoring.[20] Actigraph model 7164 or 71256 (Actigraph inc; Fort Walton Beach, FL) accelerometers recorded intensity of movement each minute. Based on published cut points, variables of valid minutes and valid days (at least 5 days were needed or a total of 66 valid hours) were calculated.[23] More details on accelerometer variable construction can be found in a published paper[20] and online.[24] Moderate-intensity physical activity minutes (MPA) per valid days was chosen as the primary outcome because physical activity guidelines are based on physical activity of "at least moderate intensity"[25]. Moderate level physical activity also corresponds with active transportation. Weekdays and weekend days were not separated because of evidence that some individuals worked on weekends (more than a 100 individuals reported more than 20 work days in a month) and because survey items did not identify weekend workers. One outlier with over 4 hours of moderate physical activity per day (242 minutes) was removed. Data collection occurred throughout the year in both regions.

Main Independent Variable: Commuting by Transit

Reported percentage of commute trips taken by public transit (bus, subway, and trolley) was the main independent variable. Participants working outside the home were asked to report the number of days they commuted to work using 9 travel modes (walking, bus, subway-trolley, biking, driving, carpool driver, carpool passenger, vanpool, and taxi) across an assumed 20 workdays per month. In a few cases, participants reported 30 workdays, and others likely assumed 2 trips per day (ie, sum of trip per all modes were clustered at 20, 30, 40, and 60). As these sums of all trips seem to be logical and internally

consistent, but not comparable, we computed the percentage of all commute trips taken by public transit ($\%T_{tr}$). This continuous variable was then categorized into those who did not commute to work by public transit, no transit ($\%T_{tr} = 0\%$), those who used public transit for less than half of their commutes, infrequent transit commuters ($0 < \%T_{tr} < 50\%$), and those who used public transit on half or more of their commutes, frequent transit commuters ($\%T_{tr} \geq 50\%$).

Psychosocial Measure

The psychosocial item "I enjoy doing moderate physical activities" was developed by NQLS investigators and measured on a 5-point Likert scale (1 = strongly disagree, to 5 = strongly agree). Self-reported enjoyment of moderate physical activity was hypothesized to have an independent effect on MPA, be similar across transit commute frequency categories, and not confound the relationship between transit commute and MPA.

Covariates

Sociodemographics were reported by participants in the survey and controlled for in analyses. Transit ridership is typically composed of a higher proportion of lower income, minorities, women, and younger people with no car.[26] Household income (4 categories), age, gender, whether a person was married or living with partner, ethnicity (White non-Hispanic vs. others), and cars-per-adults in the household were selected as controls.

Neighborhood walkability and income design variables as well as an indicator of region (Seattle or Baltimore) were used as independent variables in the model. High walkability neighborhoods generally have better transit service, although a transit corridor may traverse a low walkability neighborhood.[19,27]

Transit service was assessed using the survey item "It is easy to walk to a transit stop (bus, train) from my home" measured on a 4-point Likert scale (1 = strongly disagree, to 4 = strongly agree). It was hypothesized to be associated with transit use but not with MPA.

Self-reported work-related and leisure physical activity (number of days × average time per day) were measured as part of the validated International Physical Activity Questionnaire (IPAQ) which assesses frequency and duration of physical activity in multiple domains.[28] These variables were included in the descriptive table to verify that they would not provide partial explanation for the association between transit use and MPA. Lower income workers form a large share of transit users and may more frequently work in manual labor positions that would be captured by accelerometers. People who are highly active in their leisure time could seek out other opportunities for physical activity, such as taking transit. Having walked or cycled to work at least once in the past month was included to isolate the effect of these nonmotorized modes from the large majority of automobile commuters.

Self-Reported Walk Trips to Destinations at Home and Work

The survey asked: "How many days in the past month have you walked to the following places (7 items, see results) from your home or work? If none, put 0." Participants responded separately for walk trips from home and walk trips from work (with the exception of possible walk trip from home to work or back, not included in analyses). Walking to transit stops or station from home and work was not included in analyses as the results would be tautological. Walking to school or daycare had low variation in response and was not used. Each walk trip item was categorized as no walking, less than 10, and 10 days or more.

Statistical Analyses

Analyses Adjusted for Neighborhood Clustering

Because individuals were clustered in neighborhoods, a Hierarchical Linear Regression Modeling approach was employed with the 32 neighborhoods entered as a random effect to control for neighborhood clustering and adjust error variances.[29,30] The differences between the 2 cities were assessed with a dichotomous variable in the model. Stratified analyses by cities were not reported but estimated MPA was provided.

Moderating Effect

The potential moderating effect of an intermediate variable, transit commute frequency, along a hypothesized causal pathway from walkability to MPA, was assessed by interacting transit commute and walkability as well by as stratifying the model by walkability and comparing the strength of transit commute coefficients of residents of high and low walkability neighborhoods.[31] Because physical activity and public transit use are both likely associated with sociodemographic and psychological factors, these were included in the model as potential confounding variables. Other potential confounding and moderating effects (ie, age, gender, neighborhood income, and region) were tested because they were part of the design but not included in final analysis. For example, perceived safety was associated with MPA, but not with transit commute.

Walk Trips to Destinations at Home and Work

Walk trips to different services and amenities near home and workplace were compared across commute categories using Chi Square tests. The analysis was stratified by high and low walkability of home neighborhood to assess if the associations occurred in both types of neighborhood.

Results

Description of Transit Commuters

Table 1 presents sample characteristics for the 3 categories of commuters: those who never used public transit to commute (81%), infrequent transit commuters (8%), and frequent transit commuters (12%). Transit commuter categories differed in composition, in distribution across built environment, and in practice and enjoyment of physical activity. Transit commuters were also distributed differently and had slightly different physical activity levels across cities. As seen by the distribution of sociodemographics within each category, transit commuter groups had a higher proportion of women (55 and 49%, vs. 43% for entire sample), a lower proportion of married individuals and white non-Hispanic, and had less access to vehicles compared with nontransit commuters. A higher percentage of both transit commuter categories was found in high walkability neighborhoods. There was little difference between transit commuters and their counterparts in distribution across neighborhood income. Frequent transit commuters reported significantly higher ease of access to transit than nontransit commuters, but not infrequent ones (2 tailed independent sample t test: $t = -4.50$, $P < .001$).

Table 1 Sociodemographics of Commute by Transit Categories

	No transit % (n)	Infrequent transit commutes % (n)	Frequent transit commutes % (n)	Total % (n)
Total	80.7 (1000)	7.8 (95)	11.5 (142)	100 (1237)
Seattle	82.4 (591)	8.2 (57)	9.6 (69)	100 (717)
Baltimore	78.7 (409)	7.3 (38)	14.0 (73)	100 (520)
MPA mean (sd)	28.83 (19.78)	37.18 (29.30)	35.74 (17.75)	30.24 (20.63)
MPA—Seattle mean (sd)	29.68 (19.91)	36.00 (18.77)	34.84 (17.36)	30.68 (19.69)
MPA—Baltimore mean (sd)	28.22 (20.22)	33.94 (23.79)	36.79 (18.28)	29.84 (20.45)
Age (years) mean (sd)	45.1 (10.13)	44 (10.22)	45.7 (10.49)	45.1 (10.18)
Women	41.7 (417)	55.2 (53)	49.3 (70)	43.6 (540)
Married or living with partner	66.5 (665)	58.3 (56)	51.4 (73)	64.1 (794)
White non-Hispanic	77.1 (771)	71.9 (69)	67.6 (96)	75.6 (936)
Household income				
Less than $30,000	9.5 (95)	12.5 (12)	12.0 (17)	10.0 (124)
From $30,000 to $59,000	29.1 (291)	25.0 (24)	33.1 (47)	29.2 (362)
From $60,000 to $99,000	33.3 (333)	27.1 (26)	33.1 (47)	32.8 (406)
More than $100,000	28.1 (281)	35.4 (34)	21.8 (31)	28.0 (346)
Vehicles per person mean(sd)	0.91 (0.46)	0.80 (0.41)	0.67 (0.43)	0.87 (0.46)
I enjoy moderate PA mean(sd)[a]	4.28 (0.81)	4.52 (0.63)	4.22 (0.92)	4.29 (0.81)
Easy to walk to transit from home mean(sd)[a]	3.42 (0.96)	3.68 (0.79)	3.80 (0.59)	3.49(0.92)
Survey design				
Low walkability/Low income	26.2 (262)	16.8 (16)	16.9 (24)	24.4 (302)
Low walkability/High income	29.1 (291)	16.8 (16)	14.8 (21)	26.5 (328)
High walkability/Low income	21.5 (215)	30.5 (29)	31.0 (44)	23.2 (288)
High walkability/ High income	23.2 (232)	35.7 (34)	53.0 (37.32)	25.7 (319)
Walking and cycling to work (at least once)				
Walking	10.2 (102)	32.6 (31)	10.6 (15)	12.0 (148)
Cycling	3.5 (35)	16.8 (16)	2.8 (4)	4.5 (55)
Walking or cycling	12.3 (123)	42.1 (40)	13.4 (19)	14.7 (182)
Self-reported physical activity mean (sd)				
Work-related physical activity	626.35 (1132.83)	313.70 (942.63)	429.54 (890.60)	579.60 (1097.90)
Leisure physical activity	188.57 (288.83)	233.16 (346.29)	184.08 (244.37)	191.49 (288.98)

[a] 1= Strongly disagree; 4 = Strongly agree.

Note. No transit = 0%; Infrequent transit commutes = 1–49%; Frequent commutes = 50% or more

Abbreviations: MPA, Moderate physical activity.

Transit Commuting and Enjoyment of Physical Activity

While the mean differences were small, infrequent transit commuters enjoyed moderate physical activity more than the frequent commuters (2 tailed independent sample *t* test: $t = 2.81$, $P < .005$), and more than those not commuting by transit (two tailed independent sample *t* test: $t = -2.80$, $P < .005$). Enjoyment may partially explain the level of physical activity of infrequent transit commuters. Infrequent transit commuters were wealthier than the frequent ones, had the highest proportion of women, and the highest mean MPA.

Overall, MPA was highest for infrequent transit commuters, about 10 minutes more than nontransit commuters, and slightly more than frequent commuters. Slight variations between regions were observed. Unadjusted mean MPA for commuter groups across neighborhood walkability and income categories are presented in Figure 1. First, regardless of the type of neighborhood within which a person resides, both groups of transit commuters had a higher mean MPA than nontransit commuters within their neighborhood and in most cases across all neighborhood groups. For example, nontransit commuters in high walkability neighborhoods had comparable MPA to frequent transit commuters in low walkability neighborhoods. Second, mean MPA was overall higher in high walkability neighborhoods. Third, transit commuters in low-income neighborhoods reported similar MPA levels as transit commuters living in high-income neighborhoods.

MPA Regression: Full Sample and Stratified

Adjusted coefficients for linear regressions of mean minutes of moderate physical activity per day (MPA) for the entire sample and for high and low walkability separately are presented in Table 2.

In the full sample regression, frequent transit commuters had significantly higher MPA than those who did not commute on transit after controlling for sociodemographics, survey design variables and enjoyment of physical activity. Neighborhood walkability was also independently and positively associated with MPA. However, the interaction term between walkability and transit commuting showed that the combined effect of frequently commuting by transit and living in high walkability was associated with lower levels of MPA.

The next 2 columns present the same MPA regression stratified by neighborhood walkability to compare the magnitude of coefficients of the frequency of commuting

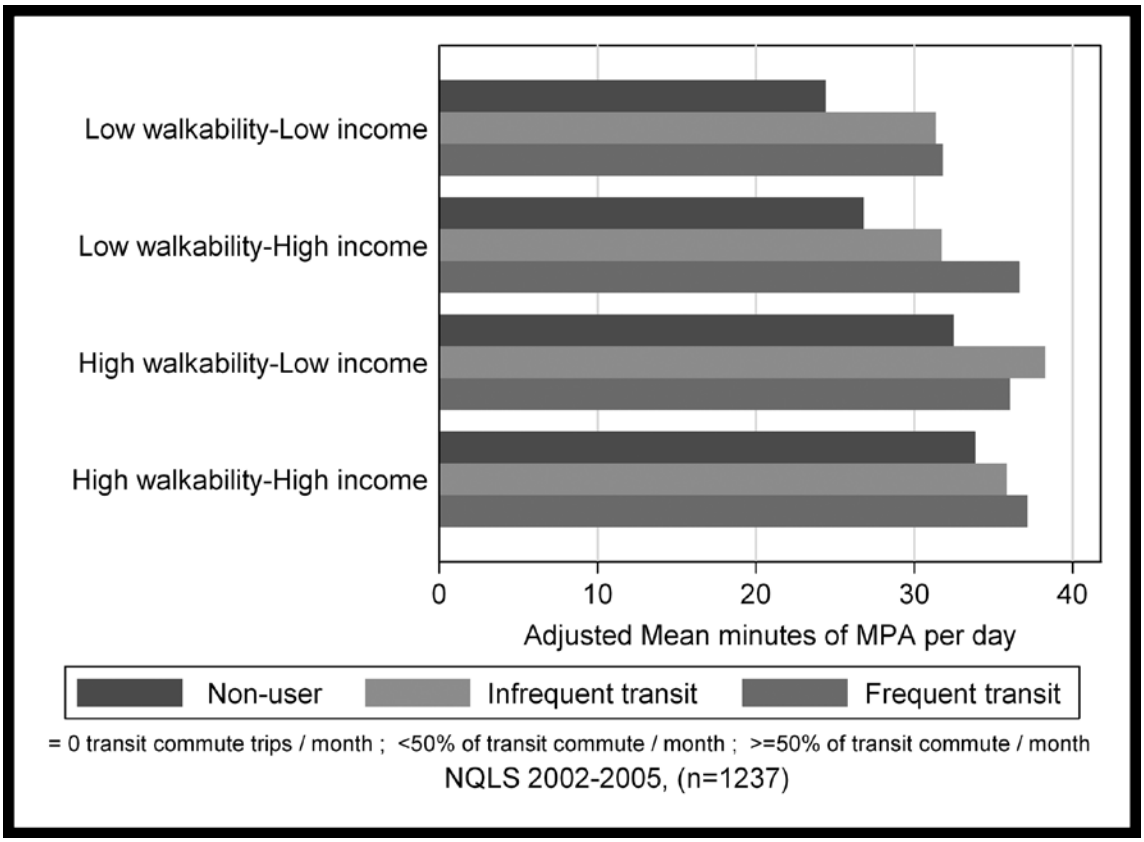

Figure 1 — Mean MPA across categories of commute and types of neighborhoods.

Table 2 Interaction of Neighborhood Walkability and Frequency of Commute by Transit in Relation to MPA, Adjusting for Sociodemographic Characteristics

	All sample		High walkability		Low walkability	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Age (years)	–0.24	0.000	–0.23	0.000	–0.25	0.002
Women	–8.03	0.000	–8.84	0.000	–6.82	0.000
Married or living with partner	–4.08	0.001	–4.98	0.000	–2.92	0.181
White non-Hispanic	5.86	0.000	6.44	0.001	5.84	0.000
Less than $30,000 (ref.)						
From $30,000 to $59,000	4.56	0.025	3.71	0.206	6.39	0.010
From $60,000 to $99,000	3.60	0.056	4.03	0.173	4.25	0.063
More than $100,000	4.59	0.022	4.71	0.180	5.55	0.001
Vehicles per person	–1.50	0.236	0.087	0.941	–3.02	0.182
I enjoy moderate PA	2.86	0.000	2.55	0.019	3.30	0.000
No transit (ref.)						
Infrequent transit commute	5.03	0.204	2.09	0.299	6.47	0.133
Frequent transit commute	10.50	0.000	4.72	0.028	10.17	0.000
High neighborhood walkability	5.88	0.000				
High walkability*infrequent	–2.82	0.521				
High walkability*frequent	–6.61	0.027				
Easy to walk to transit from home	–0.30	0.680	–1.34	0.358	0.01	0.994
High neighborhood income	–0.03	0.980	–0.07	0.970	–0.16	0.920
Baltimore	1.10	0.406	0.13	0.950	2.10	0.242
Walking or cycling to work at least once in the past month	5.91	0.001	8.09	0.000	–1.04	0.744
Constant	31.03	0.000	42.37	0.000	25.46	0.000
Number of observations	1237		607		630	
Neighborhood clusters	32		16		16	

Note. Coef. = Adjusted coefficients; sig. = significance level ; ref. = reference category. The reference category for the full model was a single, nonwhite male, earning less than $30,000, not using public transit, living in a Seattle low-walkability and low-income neighborhood.

Abbreviations: MPA, Moderate physical activity; PA, physical activity.

by transit. Frequent commuting by transit was significant in low walkability neighborhoods and had a smaller, but significant effect in high walkability neighborhoods.

Many demographic correlates of MPA were significant. Those earning $100,000 and more had significantly more MPA than the reference category (less than $30,000), but not in the high walkability sample. Non-Hispanic whites had more MPA than their counterparts, while other sociodemographic variables (age, women, being married) were negatively associated with MPA. The psychological variable of enjoyment of physical activity was independently and positively associated with MPA for the entire sample and for the stratified analyses.

As Sallis and colleagues[20] showed using NQLS data, neighborhood income, and study regions were not significantly associated with self-reported and objective measures of active transportation and physical activity. Example cases are estimated using full sample and per region outcome values. Table 3 shows estimated mean adjusted MPA minutes/day for variations in neighborhood walkability and commuting by transit when other variables are considered at their means. In the full sample, transit commuters had up to 8 more minutes of MPA than nontransit commuters in low walkability neighborhoods. The effects of high vs. low walkability on nontransit commuters were nearly 8 additional minutes, and lower for the 2 transit commuter groups.

Self-Reported Walk Trips to Neighborhood and Workplace Destinations

Why do transit commuters accrue higher levels of MPA than their nontransit commuter counterparts, and why is this effect stronger in low walkability neighborhoods? Table 4 compares nontransit commuters to the collapsed frequent and infrequent transit commuters in the number of days they walked to destinations from home and from work in the past month. Again, the analysis was stratified by high and low walkability to show that the differences between transit commuters and their counterparts were

Table 3 Adjusted Minutes of MPA per Day for Transit Frequency and Walkability

	n	High walkability	Low walkability
Total			
No transit commutes	1000	33.22	25.68
Infrequent transit commutes	95	36.95	31.56
Frequent transit commutes	142	36.65	34.07
Seattle			
No transit commutes	591	33.61	26.16
Infrequent transit commutes	57	37.06	31.44
Frequent transit commutes	69	37.54	35.89
Baltimore			
No transit commutes	409	32.63	25.01
Infrequent transit commutes	38	36.81	31.78
Frequent transit commutes	73	35.82	32.34

Note. All other variables (age, gender, marital status, ethnicity, household income, vehicle per person, enjoyment of moderate PA, easy to walk to transit from home, neighborhood income) are kept at their mean values. MPA: Moderate physical activity; No transit = 0%; Infrequent transit commutes = 1–49%; Frequent commutes = 50% or more.

independent of the home neighborhood walkability. Transit commuters, if they lived in low walkability environments, walked significantly more frequently both near their home and near their workplace than their noncommuter counterparts. If they lived in high walkability neighborhoods, transit commuters walked significantly more than nontransit commuters to all destinations near work except food stores (carrying groceries in the bus may be avoided). Near home, they walked significantly more than nontransit commuters to retail stores, restaurants, and cafés, but not to other destinations.

Discussion

The main finding was that frequent and infrequent public transit commuters respectively accumulated approximately 8 and 4 more minutes of objectively-measured moderate physical activity per day than those who did not commute by transit (infrequent transit commute was nonsignificant). Variations by region were not significant. This association of transit commuting to MPA was stronger if participants lived in low-walkability neighborhoods as shown by negative interaction coefficient and stratification. Ten minutes per workdays would translate into almost 1 hour per week of additional physical activity for transit commuters, which is about 40% of the recommended 150 minutes of MPA per week.[25,32] The use of accelerometers to objectively measure physical activity strengthened confidence in the results. Remarkably similar results were obtained when using moderate to vigorous physical activity (MVPA) as an outcome (results not shown), which was tested to ensure that the MPA threshold captured the physical activity of those rushing to transit stops to make their connections. Logistic models using a dichotomous variable of meeting the physical activity recommendation (30 minutes a day) were also tested to verify the association from a health policy perspective (results not shown). Frequent transit commuting was associated with meeting physical activity recommendations in high walkability neighborhoods (OR = 3.1, 95% CI = 1.9, 5.3) and in low walkability neighborhoods (OR = 3.8, 95% CI = 1.9, 7.5). Living in high walkability neighborhoods (OR = 1.8, 95% CI = 1.3, 2.4), walking or cycling to work (OR = 1.93, 95% CI = 1.33, 2.8), and enjoyment of moderate PA (OR = 1.3, 95% CI = 1.1, 1.5) also increased the odds of meeting the physical activity recommendation. These additional analyses indicated that the main results are robust across different outcomes.

The findings are generally consistent with other studies comparing transit users to nontransit commuters.[8–12] Present analyses accounted for psychological influences of enjoyment of moderate physical activity to isolate the effect of environment and transit use on MPA. Enjoyment of physical activity was independently and positively associated with physical activity, but did not confound the relationship with transit commute. Transit commuters' preference for an active lifestyle was not evidenced in this analysis.

To clarify the mechanisms potentially involved in the association between commuting by public transit and MPA, public transit commuters and nontransit commuters were compared for walking to services and destinations near home and near the workplace. Transit commuters (frequent and infrequent combined) walked more often than nontransit commuters to some destinations within their home neighborhood and most destinations near their workplace. More transit commuters walked to destinations and in most cases walked more frequently,

Table 4 Walking to Destinations Near Home and Work Across Commute Categories and Neighborhood Walkability

	Near home						Near workplace					
	High walkability (n = 605)			Low walkability (n = 629)			High walkability (n = 605)			Low walkability (n = 629)		
	No transit	Transit commute	Chi sq. sig.	No transit	Transit commute	Chi sq. sig.	No transit	Transit commute	Chi sq. sig.	No transit	Transit commute	Chi sq. sig.
n	446	159		551	78		446	159		551	78	
Number of days walked in past month (% in categories)												
Walking to food stores												
Never	36.8	28.3		81.7	60.3		82.7	76.1		87.3	70.5	
Less than 10 days	46	51		17	35.9	***	13.3	16.4		10.1	20.5	***
Ten days or more	17.3	20.8		1.3	3.9		4.3	7.6		2.5	9	
Total (%)	100	100		100	100		100	100		100	100	
Walking to retail stores												
Never	58.4	43.4		89	74.4		80	46.5		87.7	59	
Less than 10 days	35	46	**	10.9	23.1	***	17.8	45.9	***	10.5	34.6	***
Ten days or more	6.5	10.7		0.2	2.6		2.3	7.6		1.8	6.4	
Walking to bank or credit union												
Never	65.9	66		93.7	70.5		80.5	51.6		87.7	55.1	
Less than 10 days	31.8	32.1		6.2	29.5	***	18.4	41.5	***	11.8	41	***
Ten days or more	2.2	1.9		0.2	0		1.1	6.9		0.5	3.9	
Walking to post office												
Never	78	71.7		95.1	84.6		85.4	66		94.2	61.5	
Less than 10 days	21.5	27.7		4.7	15.4	***	14.4	34	***	5.3	38.5	***
Ten days or more	0.5	0.6		0.2	0		0.2	0		0.5	0	
Walking to restaurant or café												
Never	48.2	32.7		93.1	79.5		68.8	35.2		78.8	43.6	
Less than 10 days	40.8	57.23	***	6.5	20.5	***	21.4	42.1	***	16.9	38.5	***
Ten days or more	11	10.1		0.4	0		9.9	22.6		4.4	18	
Walking to gym, health club, or recreational facility												
Never	89.5	90.6		97.6	92.3		95.7	89.9		98.6	92.3	
Less than 10 days	7.6	4.4		1.6	6.4	*	3.4	6.9	*	0.7	5.1	***
Ten days or more	2.9	5		0.7	1.3		0.9	3.1		0.7	2.6	
Walking to park												
Never	47.8	53.5		76.4	66.7		92.4	84.9		96	83.3	
Less than 10 days	39.7	35.2		18.9	26.9		6.5	12	*	3.3	15.4	***
Ten days or more	12.6	11.3		5.1	6.4		1.1	3.1		0.7	1.3	
Total	100	100		100	100		100	100		100	100	

Note. Transit commute = frequent and infrequent transit commuters collapsed. Chi sq. sig. = significance of Chi Square test (* $P < .05$; ** $P < .01$; *** $P < .001$).

especially in low walkability neighborhoods and at the workplace. In low walkability neighborhoods, significant differences between transit commuters and nontransit commuters were found for walking trips to almost all destinations near home and near the workplace. These findings helped explain results of MPA models. The difference in walking to destinations near home between transit commuters and nontransit commuters living in high walkability neighborhood was not significant for most destinations except for retail stores and restaurants or cafés. In high walkability neighborhoods, those not commuting by transit walked as frequently to destinations as transit commuters. In addition to the walking required to access transit from home and to get to work from transit, transit commuters engaged in a lifestyle involving considerably more walking for errands and other activities near their home and, especially near the workplace. Once at the workplace, and without a car, they engaged in more walk trips than commuters not using transit.

Transit users may accrue part of their daily physical activity by walking to transit, but the present analysis suggests that their active lifestyle at home and at the workplace also involves walking to multiple destinations for utilitarian purposes. Availability of services and amenities near the workplace may partially explain why transit commuters living in low walkability environments have higher MPA. As transit stops and destinations near home may be farther in low walkability neighborhoods, trips to these services involve walking longer distances between destinations.

As lower income transit commuters are expected to more often work in manual labor positions involving more movement, models incorporating self-reported work-related physical activity were explored to see if such activities would confound the effect of transit commuting. While positive and significant relationships were found as expected, they did not confound the effect of transit commuting. Nor did the introduction of self-reported leisure physical activity confounded the association between transit commuting and MPA.

Limitations and Strengths

This analysis benefited from objective measures of physical activity and the ability to analyze the relationship between physical activity and commuting by public transit within the context of built environments of contrasting walkability. Self-reported days walked to destinations and enjoyment of physical activity items served to support the transit commute–physical activity association.

Because transit use typically has low mode shares in the United States, small sample sizes of transit commuters reduced the ability to reach statistical significance with multiple confounding variables in the models. Future studies should be sufficiently powered to overcome this limitation.

The analysis focused on the use of transit for the commute to work and did not account for other motorized travel. The survey format did not allow associating accelerometer measure with self-reported days walked to specific destinations. Combining an activity-based travel diary with the simultaneous deployment of accelerometers could support such analysis. Furthermore, accelerometers were deployed over a week, while the transit commute items assessed monthly patterns. Survey limitations precluded an accurate assessment of associations between weather and both walking and using public transit. With the 2 study regions and the neighborhood walkability and income study design, the analysis was not sufficiently powered to assess other neighborhood features such as the occurrence of crime. The public transit literature provides detailed information on the service characteristics associated with transit use,[33] but this information was not available in the current study. Increasing the quality of transit service can increase transit usage.

While active transportation required by transit commuting is likely moderate in intensity, a combined moderate and vigorous outcome measure was also tested. There is at least anecdotal evidence that people often have to rush to transit[34] and the combination of cycling (higher intensity activity) and transit use[35] may potentially be recorded as more vigorous activity. However, there were similar findings regardless of outcome analyzed. Accelerometers cannot separate leisure physical activity from active transportation (the theoretical source of association between MPA and transit use). The relationship between transit use and different domains of physical activity should be considered in more detail in future research.

Conclusion

The current study showed a positive association between the frequency of commuting by transit and physical activity, as measured by MPA, when controlling for sociodemographic characteristics, car availability, and neighborhood income and walkability. The results added to previous studies in 4 ways: 1) by testing if the relationship was similar in high and low walkability neighborhoods, 2) by separating frequent commuters from infrequent ones, 3) by controlling for enjoyment of physical activity and car availability, and 4) by using an objective measure of physical activity and by associating transit commuting with walking to services and destinations near home and near the workplace. Transit commuters not only walked more to transit, they demonstrated a more physically active lifestyle to access utilitarian destinations where they live and work.

Stronger effects of commuting by transit were found when a person lived in a low walkability neighborhood, suggesting they had to walk greater distances to get to transit stops and other destinations.

Infrequent and frequent transit commuters were found to differ in composition, in distribution across built environment and in practice and enjoyment of physical activity. Infrequent transit commuters were more likely

to alternate between transit, cycling, and walking to get to work. Thus, for infrequent commuters, higher MPA was not due solely to transit use but to a variety of active commuting modes (which explained n other analyses the nonsignificance of the coefficient). Self-reported enjoyment of moderate physical activity was positively and significantly associated with walking, but did not confound the relationship between physical activity and commuting by transit.

Significance

Frequently commuting by transit is associated with objectively measured moderate physical activity, especially if transit commuters live in low walkability neighborhoods. Policies known to support public transit use, such as increased availability, frequency or speed of service, could produce physical activity benefits. Public transit investments and zoning policies to provide destinations around homes and worksites may enable an active lifestyle based on transit use. Promoting public transit use is associated with health, social and environmental benefits.

Acknowledgments

We acknowledge the support of the National Institutes of Health grant HL67350, the Social Science Research Council of Canada, the Fond Québécois de recherche sur la société et la culture and the Bombardier Foundation. We also thank our reviewers and guest editor for their thoughtful comments.

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