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Transit use and physical activity: Findings from the Houston travel-related activity in neighborhoods (TRAIN) study

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ABSTRACT

Transportation-related physical activity can significantly increase daily total physical activity through active transportation or walking/biking to transit stops. The purpose of this study was to assess the relations between transit-use and self-reported and monitor-based physical activity levels in a predominantly minority population from the Houston Travel-Related Activity in Neighborhoods (TRAIN) Study. This was a cross-sectional analysis of 865 adults living in Houston, Texas between 2013 and 2015. The exposure variable was transit-use (non-users, occasional users, and primary users). Self-reported and accelerometer-determined physical activity were the outcomes of interest. Regression models adjusting for age, sex, race/ethnicity, and other covariates of interest were built to test the hypothesis that transit user status was directly associated with 1) minutes of moderate-intensity physical activity and 2) the prevalence of achieving the physical activity guidelines. The majority of participants were female, non-Hispanic black, and almost one-third had a high school education or less. After adjustment, primary transit-use was associated with 134.2 ($p < 0.01$) additional mean minutes per week of self-reported moderate-intensity transportation-related physical activity compared to non-users. Further, primary users had 7.3 (95% CI: 2.6–20.1) times the relative adjusted odds of meeting physical activity recommendations than non-users based on self-reported transportation-related physical activity. There were no statistically significant associations of transit-use with self-reported leisure-time or accelerometer-derived physical activity. Transit-use has the potential for a large public health impact due to its sustainability and scalability. Therefore, encouraging the use of transit as a means to promote physical activity should be examined in future studies.

1. Introduction

Among the four domains of physical activity (Gabriel et al., 2012), the transportation and leisure-time domains offer the greatest opportunity for sustainably increasing total daily physical activity (Reis et al., 2016). In particular, transportation-related physical activity can increase daily activity through physically active travel (walking or biking to/from destinations) and through transit related physical activity (walking or biking to/from mass transit stations/stops).

Previous findings on the relation between transit-use and physical activity should be reviewed based on the instrument used to assess physical activity (self-report or device-based measures), and the study design. In a cross-sectional analysis of a representative sample of US adults, Besser and Dannenberg found that transit users self-reported a median 19-minutes per day of transit-related physical activity (Besser and Dannenberg, 2005). Lachapelle and colleagues further contextualized the transit-use–physical activity relation by demonstrating that public transit users reported engaging in more physically active

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travel than those who use automobiles for transportation and concluded that transit related activity does not displace leisure-time physical activity (Lachapelle et al., 2016; Lachapelle and Noland, 2012). In another cross-sectional study, Lachapelle et al. used accelerometry to find that frequent transit users accumulate an additional 8-minutes of physical activity over non-users (Lachapelle et al., 2011). Using a quasi-experimental design, Miller et al. found that on transit days, transit users accumulate almost 12 more minutes of accelerometer-derived physical activity, than those who do not use transit (transit non-users) (Miller et al., 2015). The body of literature, to this point, indicates that transportation-related physical activity, independent of leisure-time activity, may significantly contribute to weekly physical activity volume that is reflected in guidelines for aerobic activity (Saelens et al., 2014), that is, at least 150 min per week of moderate-intensity aerobic activity or 75 min per week of vigorous-intensity aerobic activity or an equivalent combination of both (United States Department of Health and Human Services, 2008). However, the magnitude of this effect appears to depend upon the physical activity measurement device used and may differ for understudied populations.

The transit-use–physical activity relation is not as well understood among more diverse populations (e.g., older age, race/ethnicity minority, low income groups). This area of inquiry has important public health implications as people of lower socioeconomic status and older populations are at highest risk for many preventable chronic health conditions related to physical inactivity (Smedley et al., 2002). Additionally, transit-use and physical activity has not been fully explored in the context of the transportation and leisure-time domains of physical activity, coupled with device based assessments of total physical activity accumulated throughout the day (Saelens et al., 2014). A combination of self-report and device based assessments is necessary to attribute differences in total physical activity to domain specific estimates of physical activity (Troiano et al., 2012). Device based assessments of physical activity alone are not able to provide any contextual information on the physical activity behavior (the type of physical activity, where it was performed, etc.). Alternatively, self-reports of domain specific physical activity do not provide estimates of total physical activity and often times do not capture physical activity that is less than moderate in intensity.

Therefore, the purpose of this study is threefold. First, is to evaluate the differences in occasional transit users (occasional users) and primarily transit users (primary users) and transit non-users (non-users) estimates of: a) self-reported transportation-related physical activity, b) self-reported leisure-time physical activity, and c) accelerometer-derived total physical activity. Second, is to estimate the relation between transit-use and physical activity, when accounting for participant characteristics that may be influencing the relations. Third, is to estimate the odds of being sufficiently active (meeting physical activity aerobic guidelines) among occasional users and primary users compared to transit non-users based on domain specific estimates of physical activity and accelerometer-derived total physical activity.

2. Methods

2.1. Study design, setting, and participants

Data for this cross-sectional analysis came from baseline assessments of transit-use and physical activity in the Houston Travel-Related Activity in Neighborhoods (TRAIN) Study. The TRAIN Study is a prospective natural experiment aimed at determining if the extension of a public light rail transit system in Houston, Texas affects both transit-use and physical activity over a five year period (2013–2018). There were 3 new light rail extensions, which added 15 miles of line and 24 stations primarily serving residential and light industrial areas. The new light rail extensions opened in two phases in December 2013 and May 2015. A rolling recruitment and enrollment strategy, involving telephone/email/and targeted community outreach efforts, was employed from November 2013 to October 2015, at which time the desired baseline cohort size was achieved. To be eligible to participate, an individual must have met the following criteria: 1) at least 18 years of age, 2) reside within the defined study buffer area (within 3 mile Euclidean buffer around the new light rail extensions), and 3) not residing with a current TRAIN participant (only one participant per household). A 3-mile buffer, which extends over the existing light rail lines, was chosen to maximize the pool of eligible participants and to provide variability in distances between participants' homes and the light rail lines – the parent study's primary predictor of transit-use. As Durand et al. points out, it is currently not well understood how far individuals are willing to travel, and in particular, walk, to reach public transit (Durand et al., 2016). Therefore, in the interest of capturing a range of probabilities among participants in the parent study, a much larger buffer than the traditional quarter-mile distance, was used. Study materials were offered to participants in English or Spanish, and participants were compensated for their participation. See Durand et al. (2016) for a complete description of the TRAIN Study methodology (Durand et al., 2016).

The analytic sample in the current study included participants that completed a baseline questionnaire (n = 865). At enrollment, all participants were invited to participate in the accelerometer protocol (wear an accelerometer during waking hours for seven consecutive days) in addition to completing the questionnaire. Approximately 77% (688/865) of participants opted-in and were included in the analysis as a sub-sample.

2.2. Data collection

Two data collection instruments were used – a self-administered questionnaire, and a hip-worn tri-axial accelerometer (ActiGraph wGT3X-BT). The questionnaire was sent to/from participants by mail and took approximately 90 min to complete. After returning the questionnaire, the subsample of participants opting to participate in the accelerometer protocol were sent and returned an accelerometer in the mail.

2.3. Variables

The primary independent variable of interest was transit-use. Items pertaining to frequency of transit-use were included in the questionnaire. These were presented as an initial yes/no question: "*Do you ever use Houston's METRO bus and/or light rail systems at all* (*even just occasionally*)?", and a follow-up question conditional on a < *YES* > response, "*Is the METRO your main source of transportation*?" Participants were categorized as transit non-users (do not use transit), occasional transit user (use transit but not as main source of transportation), and primary transit user (use transit as main source of transportation), dependent upon the response[*s*].

The primary dependent variable of interest for self-reported physical activity was total minutes per week of moderate-, and vigorous-intensity physical activity. These estimates were derived from The Self-Administered Modifiable Activity Questionnaire (S-MAQ), which was administered in the questionnaire. The S-MAQ assessed leisure-time and transportation-related (physically active travel and transit related) physical activity over the past seven (7) days. First, participants were asked if "In the past 7-days, did [s/he] do any of the following activities during … leisure-time" and "for transportation". The participant is presented a list of 38 leisure-time physical activities (e.g., bicycling for exercise, walking for exercise, strength or weight training, swimming, etc.), and three activities for transportation (i.e., walking, bicycling, other [e.g., skateboarding]). A "yes" response then directed the participant to enter the "total number of minutes [s/he] did the activity on each day" for the past 7-days. Activities were categorized by intensity level (moderate or vigorous) based on corresponding metabolic equivalent of task (MET) values, where 3–6 METs were moderate-intensity and > 6 METs were vigorous-intensity (Ainsworth et al., 2011). For each intensity category, summary estimates were calculated as the product of the duration and frequency of each activity (in minutes per week), across all activities performed and reported as the total minutes per week of moderate-, and vigorous- intensity physical activity.

The primary dependent variable of interest from the accelerometer-derived estimates was average vector magnitude, an estimate reflecting total ambulatory movement over the observation period. Accelerometer data were sampled at 40-hertz and data were reintegrated and expressed as 60-second epochs prior to further processing. Accelerometer data were screened for periods of wear (i.e., wear-time) using established wear-time algorithms (Choi et al., 2012). Valid wear-time was defined as ≥ 4 of seven days with ≥ 10 h per day. In addition to the triaxial vector magnitude estimate, accelerometer estimates derived using the vertical axis data (counts) were reported to provide more comparability to previous work. Based on accelerometer counts, the time spent in different intensity levels (sedentary, light-intensity, moderate intensity, and vigorous-intensity) were estimated using threshold values proposed by Freedson et al. (Freedson et al., 1998).

Variables entered as potential confounders based on their known associations with transit-use and physical activity (Bopp et al., 2015; Brown et al., 2015; Lachapelle et al., 2016; Lachapelle and Pinto, 2016; Miller et al., 2015) were self-reported in the participant questionnaire. These included age, sex, race/ethnicity (white, Hispanic, black, and other [American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, Asian or East Indian, and other]), body mass index (BMI [weight in kilograms/height in meters^2]), automobile ownership, residence type (single family, multi-family, other), household income ("low income" < 200% of the Federal Poverty Threshold [FPT]; and "not low income", greater than or equal to 200% FPT), educational level (no high school or GED, high school or GED, and some college or more). Using Geospatial Information Systems (GIS), the distance (meters) between a participant's home and the nearest operational transit stop was included as a potential confounder for its associations with transit-use and transportation-related physical activity. Estimates were reported as ordinal variables based on tertiles (10–94 m, 94–314 m, 515 m–5.3 km). In the 3-mile study buffer, there were no "park-and-ride" facilities serving the pre-existing rail lines and none were planned to serve the line extensions, therefore the use of this transit feature was not included as a potential confounder in the analysis.

2.4. Data analysis

Descriptive statistics were conducted on baseline characteristics for all participants and the accelerometer sub-sample. Categorical variables were reported as frequencies with proportions. Bivariable tests for differences were used to assess physical activity levels by transit user status. Tests for normality were conducted on continuous data (physical activity estimates) and revealed that all moderate to vigorous intensity physical activity estimates were non-parametric and positively skewed. Accelerometer-derived light intensity and sedentary time estimates were normally distributed. Hosmer-Lemeshow tests for median differences, chi-square tests for heterogeneity in proportions, and Student's *t*-tests were used to test for differences in mean physical activity levels by transit user status.

Ordinary least squares regression models were used to assess the relation between transit-use and continuous estimates of self-reported minutes per week of moderate-intensity physical activity, and accelerometer determined average vector magnitude, when accounting for potential confounders. Two models, including a minimally adjusted (age only) model, and a fully adjusted model were constructed. Data transformations to account for skewness did not significantly improve model fit, therefore untransformed estimates were modeled to allow ease in interpretation of beta estimates. In each model, outlying physical activity values negatively impacting model fit were recoded to a missing value. No model had > 1% of the physical activity values removed.

Additionally, multiple logistic regression models were built to test the hypothesis that transit user status has a relation with being sufficiently active. The outcomes of interest were modeled separately and included accumulating at least 150 min of moderate- to vigorous- intensity aerobic physical activity as determined by i) self-reported transportation-related physical activity, ii) leisure-time physical activity, or iii) accelerometry. All data management and statistical analysis were performed using StataSE 14.1 (StataCorp, College Station, TX).

The Houston TRAIN Study protocol and this secondary analysis were reviewed and approved by The University of Texas Health Science Center (UTHealth) at Houston Committee for the Protection of Human Subjects. All participants provided consent to participate.

3. Results

3.1. Participant characteristics

At baseline, there were 865 participants in the full analytic sample and 688 in the accelerometer sub-sample, of those, 562 (81.7%) returned the accelerometer, and of those 365 (64.9%) met the criteria for valid wear-time. Among all participants, 35.6% reported using public transit as their primary means of transportation (primary user), while 15.2% reported not using transit at all, even just occasionally (non-user). Among the accelerometer sub-sample, the distributions of characteristics were similar to the full sample, except for age distributions. See Table 1 for more detail.

Tests for differences in participant characteristics by transit user status in the full and accelerometer sub-sample, revealed there to be significant ($p < 0.05$) differences where the accelerometer group was more likely to be younger, female, black or African American, not automobile owners, living in a single family residence, and living 94.1–314-meters from the nearest transit stop (results not shown).

3.2. Physical activity and transit-use

The median (interquartile range [IQR]) and the mean (± standard deviation [SD]) duration of time spent in minutes per week by intensity category as measured by self-report and accelerometer among transit users and non-users are shown in Table 2.

3.3. Multivariable analysis

The linear relations of transit-use with domain specific continuous estimates of moderate-intensity physical activity are presented in Table 3. Based on the fully adjusted models, primary transit-use was associated with 134.2 ($p < 0.001$) additional mean minutes per week in moderate-intensity self-reported transportation-related physical activity compared with transit non-users. Among the covariates included in the model, owning an automobile was associated with 69.6 ($p = 0.02$) fewer minutes of moderate-intensity transportation-related physical activity compared to those who do not own an automobile.

There were no significant associations between transit-use and self-reported leisure-time physical activity when accounting for other participant characteristics in minimally and fully adjusted models. In the fully adjusted model, having an income level below 200% of FPT was significantly associated with 113.4 ($p = 0.03$) fewer mean minutes per week in moderate-intensity self-reported leisure-time physical activity compared to having an income above 200% of the FPT (data not shown).

Based on accelerometry, older individuals, those living further from a transit stop, and those with higher BMI, were all associated with less activity ($p < 0.05$). The association between age and accelerometer-derived movement was statistically significant in all models

Table 1
Characteristics of study participants at baseline, Houston TRAIN Study, 2013–2015.

Characteristic	All participants (N = 865)	Acc. participants (N = 365)
	n (%)	n (%)
Transit user status[a]		
Non-user	132 (15.2)	59 (16.2)
Occasional user	375 (43.3)	160 (43.8)
Primary user	308 (35.6)	125 (34.3)
Missing	51 (5.9)	21 (5.8)
Age		
18–44 years	271 (31.3)	105 (28.8)
45–64 years	410 (47.3)	200 (54.8)
≥ 65 years	185 (21.4)	60 (16.4)
Sex		
Male	305 (35.2)	131 (35.9)
Female	503 (58.1)	215 (58.9)
Missing	58 (6.7)	19 (5.2)
Race/ethnicity		
White	228 (26.3)	110 (30.1)
Black	327 (37.8)	124 (34.0)
Hispanic or Latino	204 (23.6)	94 (25.8)
Other[b]	49 (5.7)	18 (4.9)
Missing	58 (6.7)	19 (5.2)
Body mass index[c]		
Normal/underweight	230 (29.6)	98 (26.9)
Overweight	255 (29.5)	117 (32.1)
Obese	316 (36.5)	129 (35.3)
Missing	65 (7.5)	21 (5.8)
Education attainment		
< High school/GED	113 (13.1)	36 (9.9)
High school/GED	167 (19.3)	64 (17.5)
> High school/GED	494 (57.0)	233 (63.8)
Missing	92 (10.6)	32 (8.8)
Household income[d]		
Above FPT	647 (74.7)	290 (79.5)
Below FPT	65 (7.5)	25 (6.9)
Missing	154 (17.8)	50 (13.7)
Automobile ownership		
No vehicles	277 (32.0)	109 (29.9)
1 or more vehicles	523 (60.4)	233 (63.8)
Missing	66 (7.6)	23 (6.3)
Type of residence[e]		
Single family	511 (59.0)	212 (58.1)
Multi family	217 (25.1)	97 (26.6)
Other	78 (9.0)	37 (10.1)
Missing	60 (6.9)	19 (5.2)
Meters to transit stop[f]		
10–94 m	287 (33.1)	117 (32.1)
94.1–314 m	287 (33.1)	141 (38.6)
314.1 m–5.3 km	287 (33.1)	103 (28.2)
Missing	4 (0.6)	4 (1.1)

Abbreviations: Acc: accelerometer; GED: general education diploma; FPT: Federal Poverty Threshold.
Notes
[a] Transit user status is defined as, non-users: those reporting never using the mass transit system; occasional users: those reporting using mass transit but not as their primary means of transportation; primary users: those who use mass transit as their primary means of transportation.
[b] Other are those reporting race/ethnicity as American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, Asian or East Indian.
[c] Body mass index = weight in kilograms/(height in meters)^2. Underweight: < 18.5; Normal: 18.5–24.9; Overweigh: 25–29.9; Obese: ≥ 30.
[d] Household income below FPT is defined as: ≤ 100% FPT to 199% FPT. Above FPT is ≥ 200% FPT.
[e] Single family include: Manufactured/mobile home, townhouse/duplex, single family home. Multi-family include: Dorm room/fraternity/sorority house; apartment complex. Other is a response option provided.
[f] Meters to transit stop is the distance in meters between the participant's home and the nearest mass transit (bus or light rail).

($p < 0.05$), where older age was associated with lower levels of activity (data not shown).

The odds of being sufficiently active by domain of physical activity is presented in Table 4. Considering self-reported transportation-related physical activity, primary users had 7.3 (95% CI: 2.6–20.1) times the relative odds of being sufficiently active than transit non-users, in fully adjusted models. Models adjusted for age only, indicated that primary users had 12.8 (95% CI: 5.4–30.2) times the odds of being sufficiently active based on self-report.

Based on self-reported leisure-time and accelerometer-derived physical activity, occasional users and primary users did not have significantly greater odds of being sufficiently active compared to transit non-users after accounting for other covariates (see Fig. 1).

4. Discussion

This study examined the association between transit-use and physical activity among a community based sample of adults. The unique sociodemographic make-up (majority female and non-white, one-third with high school or less education) provide important insights into the transit-use–physical activity relation in an understudied population. Additionally, few studies have examined the associations between transit-use and transportation-related-, leisure-time-, and device based-physical activity. A combination of physical activity measures allows for contextual information relevant to the relationship to be explored, which is particularly useful for hypothesis generation and health promotion efforts. Overall, results indicate that transit users self-report more physical activity than non-users. Additionally, the majority of this activity appears to be related to transportation specifically, rather than leisure-time physical activity. This higher physical activity makes transit users more likely to meet physical activity guidelines and consequently achieve the healthy benefits associated with an active lifestyle. These results are substantiated by accelerometer estimates of physical activity that indicate transit users record significantly more moderate-intensity physical activity than non-users.

Saelens et al. found that transit-use, specifically, is responsible for differences in transit-users and non-users overall physical activity. The authors noted there were no differences in leisure-time activity by transit user status, indicating any observed differences in total activity can be attributed to transit-use. In the current study, post hoc pairwise differences tests (data not shown) of unadjusted estimates of total physical activity (via accelerometry) indicate that occasional users and primary users are more physically active (moderate intensity) than non-users. Using the domain specific (self-reports) estimates of physical activity to parse out what domain of activity is accounting for the observed differences in total physical activity, one may hypothesize that transit users' physical activity does not differ significantly from non-users in moderate-intensity leisure-time activity, but rather in transportation-related moderate-intensity activity. It should be noted the other domains of physical activity (i.e., occupational and household), were not measured with the questionnaire and could be accounting for the observed differences in total physical activity. Yet, previous research has shown significant declines in occupational and household related physical activities among American adults in the latter half of the 20th century (Brownson et al., 2005; Church et al., 2011). Future studies should explore this hypothesis further with temporally matched self-reported and accelerometer-determined physical activity.

Although the current study did not temporally match the self-reported activity with accelerometry, combining these physical activity assessment tools enabled the analysis of domain specific changes in activity. This is an important strength of the current study. In addition to a robust physical activity assessment, the inclusion of a racially and ethnically diverse sample that represents a greater percentage of non-white adults in Houston, Texas is an additional strength (University of Texas School of Public Health Institute for Health Policy, 2011). These demographic factors are important, particularly in Houston, where non-white individuals have disparate self-ratings of health, insurance coverages, health screenings, and children's health indicators (e.g., obesity proportions, insurance coverages, etc.) than their white counterparts

Table 2
Accelerometer determined and domain-specific self-reported physical activity by transit user status at baseline, Houston TRAIN Study, 2013–2015.

	Transit user status			P
	Non-users median (IQR)	Occasional users median (IQR)	Primary users median (IQR)	
Transportation-related physical activity				
Moderate-intensity, m wk^{-1}	0.0 (0.0–0.0)	0.0 (0.0–60.0)	107.5 (3.0–280.0)	< 0.01
Sufficiently active[a], n (%)	7 (5.3)	39 (10.4)	121 (39.3)	< 0.01
Leisure-time physical activity				
Moderate-intensity, m wk^{-1}	120.0 (0.0–260.0)	121.0 (0.0–310.0)	120.0 (0.0–280.0)	0.20
Vigorous-intensity, m wk^{-1}	0.0 (0.0–35.0)	0.0 (0.0–90.0)	0.0 (0.0–20.5)	< 0.01
MVPA, m wk^{-1}	130.0 (0.0–330.0)	180.0 (52.5–390.0)	134.0 (0.0–377.5)	0.01
Sufficiently active[a], n (%)	72 (54.6)	243 (64.8)	162 (52.6)	< 0.01
Acc. determined physical activity				
Wear-time, minutes	826.8 (769.0–905.1)	830.6 (777.1–902.9)	815.3 (746.3–869.9)	0.18
Mean counts, TOC/d	164.2 (119.6–221.2)	172.5 (121.8–246.4)	186.5 (141.3–248.3)	0.09
Mean vector magnitude[b], m d^{-1}	425.7 (339.3–540.3)	422.3 (313.9–565.8)	478.2 (359.2–606.5)	0.14
Sed.[c], m d^{-1}, mean (SD)	579.0 (94.3)	594.0- (117.8)	567.1 (143.4)	0.98
Lt. int.[d], m d^{-1}, mean (SD)	249.0 (69.7)	242.3 (82.1)	235.5 (79.0)	0.54
Mod. int[e], m d^{-1}	10.7 (3.3–18.2)	12.1 (6.7–22.5)	19.4 (10.4–29.0)	< 0.01
Vig. int.[f], m d^{-1}	0.0 (0.0–0.3)	0.0 (0.0–0.0)	0.0 (0.0–0.1)	0.92
Accumulated MVPA[g], m d^{-1}	10.7 (3.3–20.3)	12.6 (6.7–23.9)	19.4 (10.4–29.0)	< 0.01
Bouted MVPA[h], m d^{-1}	0.0 (0.0–6.7)	1.5 (0.0–9.2)	4.3 (0.0–14.6)	< 0.01
Sufficiently active[a], n (%)	17 (12.9)	50 (13.3)	51 (16.6)	0.24

Abbreviations: IQR: interquartile range; m wk^{-1}: minutes per week; sed: sedentary; lt int: light intensity; mod int: moderate-intensity; vig int: vigorous intensity; MVPA: moderate- to vigorous-intensity physical activity; TOC/d, total counts per day; m wk^{-1}: minutes per week; m d^{-1}: minutes per day.
Notes
[a] Sufficiently active indicates accumulating at least 150 min of moderate- to vigorous- aerobic physical activity per week.
[b] Mean value of the square root of the total sum of squares from each of the three axes over detected wear periods.
[c] Sedentary intensity defined as 0–99 counts.
[d] Mean daily light intensity defined as 100–1951 counts.
[e] Total number of minutes over all days with valid wear data spent in moderate-intensity defined as 1952–5724 counts.
[f] Total number of minutes over all days with valid wear data spent in vigorous intensity defined as ≥ 5724 counts.
[g] Total number of minutes over all days with valid wear data spent in moderate- to vigorous-intensity defined as ≥ 1952 counts.
[h] Mean daily moderate- to vigorous-intensity bout duration defined as 8 of 10 min ≥ 1952 counts.

Table 3
Estimates of the relation between transit use and continuous estimates of physical activity at baseline by self-reported physical activity domain and accelerometry in multivariable analysis, Houston TRAIN Study, 2013–2015.

Transit user status	Continuous estimates of physical activity[a] by domain and measurement device b (SE)		
	Self-reported transportation activity[a]	Self-reported leisure activity[a]	Accelerometer derived activity[b]
Age adjusted			
Non-user		Ref.	
Occasional user	44.2 (22.1)*	60.5 (34.6)	1.2 (34.3)
Primary user	176.1 (22.7)**	65.5 (35.6)	57.2 (35.4)
Fully adjusted[c]			
Non-user		Ref.	
Occasional user	41.4 (24.2)	76.4 (40.1)	− 10.1 (34.5)
Primary user	134.2 (34.0)**	91.0 (56.9)	8.7 (47.0)

Abbreviations: OR: odds ratio; CI: confidence interval.
Notes
* Indicates significance at 0.05 level.
** Indicates significance at 0.001 level.
[a] Beta coefficients for self-reported physical activity represent unstandardized minutes per week of moderate-intensity physical activity.
[b] Beta coefficients for accelerometer derived physical activity represent unstandardized average vector magnitude, or the mean value of the square root of the total sum of squares from each of the three axes over detected wear periods.
[c] Covariates included in the fully adjusted model are as follows: age, sex, race, education, federal poverty level status, body mass index, automobile ownership, type of residence, and distance between home and nearest transit stop.

Table 4
Relative odds of sufficient physical activity at baseline by self-reported physical activity domain and accelerometer in multivariable analysis, Houston TRAIN Study, 2013–2015.

Transit user status	Achieving physical activity guidelines[a] by physic activity domain and measurement device OR (95% CI)		
	Self-reported transportation activity	Self-reported leisure activity	Accelerometer derived activity
Age adjusted			
Non-user		Ref.	
Occasional user	2.3 (1.0–5.7)	1.4 (0.9–2.2)	1.0 (0.5–1.9)*
Primary user	12.8 (5.4–30.2)*	0.9 (0.6–1.3)	1.5 (0.8–3.0)
Fully adjusted[b]			
Non-user		Ref.	
Occasional user	1.8 (0.7–4.6)	1.4 (0.9–2.3)	0.9 (0.4–1.8)
Primary user	7.3 (2.6–20.0)*	1.3 (0.6–2.5)	0.9 (0.3–2.6)

Abbreviations: OR: odds ratio; CI: confidence interval.
Notes
* Indicates significance at 0.01 level.
[a] Categorized as achieving the minimum volume of physical activity if accumulating at least 150 weekly minutes of moderate- to vigorous- intensity physical activity.
[b] Covariates included in the fully adjusted model are as follows: age, sex, race, education, federal poverty level status, body mass index, automobile ownership, type of residence, and distance between home and nearest transit stop.

(University of Texas School of Public Health Institute for Health Policy, 2011). The current study finds that black individuals had higher levels of moderate-intensity transportation-related activity, while Hispanics had lower levels of transportation-related activity. Alternatively, the associations were reversed when considering leisure-time activity. Although this finding was not statistically significant, future work should focus on these groups to understand the mechanisms that are

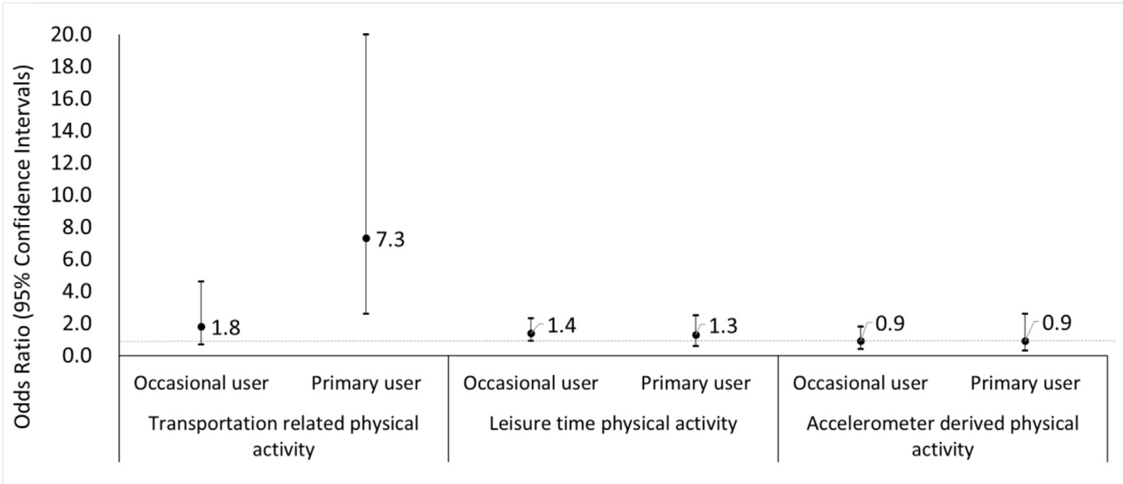

Fig. 1. Relative adjusted odds of mass transit users accumulating at least 150 min per week of moderate-intensity aerobic physical activity by domain specific and accelerometer derived physical activity, Houston TRAIN Study, 2013–2015.

underlying these associations.

This study has limitations that should be noted. First, the cross-sectional study design precluded any claims of temporality or causality between transit-use and physical activity. A longitudinal design, coupled with more robust measures to estimate transit-use, would overcome this limitation while helping to elicit a dose-response relationship. Second, the Houston TRAIN Study sample included participants that reside within a 3-mile Euclidean buffer of the light rail system. Therefore, these participants are likely not representative of other City of Houston residents in terms of their transit-use and possibly their physical activity, so there can be no claims of generalizability to greater Houston and other populations. Future work should aim to study transit-use across multiple cities to obtain a more representative sample and thereby derive external study validity. Finally, the nature of the Houston TRAIN Study's data collection protocols required the accelerometer assessment to occur after the survey assessment, precluding a temporal match between the measures. Additionally, self-reports of transit-use and physical activity are subject to recall and social desirability biases, and accelerometry may be prone to participant reactivity (Strath et al., 2013). The data illustrate the possibility of over-reporting in self-reports of physical activity, and therefore the results should be interpreted cautiously.

5. Conclusion

These results suggest using transit as one's primary source of transportation has the potential to significantly contribute to the total volume of physical activity needed to realize health benefits, including decreased risk of premature death, cardiovascular disease, diabetes, obesity, and some cancers. Transit-use has the potential for a large public health impact due to its sustainability and scalability, with benefits that extend beyond physical activity including reductions air pollution and traffic accidents, and improved social interaction (Kamruzzaman et al., 2014). Therefore, encouraging the use of transit as a means to promote physical activity should be examined in future studies.

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Conflicts of interest

The authors declare there is no conflict of interest.

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