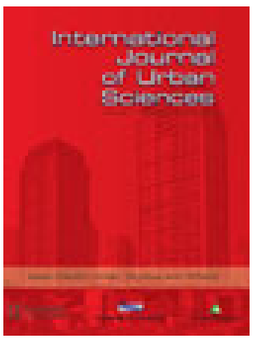

International Journal of Urban Sciences

ISSN: 1226-5934 (Print) 2161-6779 (Online) Journal homepage: https://www.tandfonline.com/loi/rjus20

Measuring walking behaviour in commuting to work: investigating the role of subjective, environmental and socioeconomic factors in a structural model

Yaser Hatamzadeh, Meeghat Habibian & Ali Khodaii

To cite this article: Yaser Hatamzadeh, Meeghat Habibian & Ali Khodaii (2019): Measuring walking behaviour in commuting to work: investigating the role of subjective, environmental and socioeconomic factors in a structural model, International Journal of Urban Sciences, DOI: 10.1080/12265934.2019.1661273

To link to this article: https://doi.org/10.1080/12265934.2019.1661273

Published online: 06 Sep 2019.

INTERNATIONAL JOURNAL OF URBAN SCIENCES
https://doi.org/10.1080/12265934.2019.1661273

Measuring walking behaviour in commuting to work: investigating the role of subjective, environmental and socioeconomic factors in a structural model

Yaser Hatamzadeh, Meeghat Habibian and Ali Khodaii

Department of Civil and Environmental Engineering, Amirkabir University of Technology, Tehran, Iran

ABSTRACT

Most walking-related travel behaviour studies have defined walking behaviour using a single measure of travel and have almost focused on single trips actually taken rather than entire tour. These studies usually neglect the mediating role and the indirect effect of explanatory factors on walking behaviour. This paper tries to understand the walking behaviour in work-tour(s) instead of work trips and presents a definition of walking behaviour using total time of walking and having at least one walking trip in work-tour (s) as two measures of travel simultaneously. Using data collected in the city of Rasht, Iran in 2015 from 432 working commuters, a structural equation model (SEM) was calibrated. Our findings indicate the necessity of addressing subjective factors in walking-related studies in addition to built environment characteristics and the importance of not ignoring the indirect effect of factors which can be quite misleading in interpreting the walking behaviour of commuters.

ARTICLE HISTORY
Received 26 July 2018
Accepted 17 August 2019

KEYWORDS
Transportation; walking behaviour; structural equation modelling; subjective factors; work-tour

1. Introduction

Generally, walking provides exercise and health benefits to individuals and the society. In addition, from the perspective of transportation planning, walking is an affordable mode of transportation, provides access to other motorized modes, and can be used as an independent travel mode in a whole trip, especially in short trips. Therefore, walking in a transportation system is an opportunity for reducing the traffic congestion which could itself reduce emissions and fossil fuel energy consumption. These benefits can especially be gained during trips related to the purposes of work and school which usually constitute the highest share of daily trips in urban areas especially during the peak hours. Because of the many benefits of walking, there has been a substantial recent emphasis on the promotion of walking in daily travel patterns in urban areas around the world. Accordingly, in addition to researchers in public health, walking has received an increasing attention among researchers in the area of transportation planning in recent years. Previous studies have tried to find out association of walking behaviour as a dependent variable with various explanatory factors. The orientation of this study is based on the principles

CONTACT Meeghat Habibian Habibian@aut.ac.ir Department of Civil and Environmental Engineering, Amirkabir University of Technology, Hafez St., Tehran 15875-4413, Iran

of transportation planning. From this point of view, this study concerns four main issues among previous walking related studies, two of which are related to the dependent variable and two others are related to the explanatory variables as follow:

Among the dependent variable, there are two main issues: (1) previous studies have used different travel measures for defining walking behaviour. However, each study has only concentrated on a single measure. In this line, a question is that what measures of travel provide a better definition for walking behaviour? Furthermore, is a measure alone a good indicator for explaining the walking behaviour or multiple measures are needed for a better definition? (2) Almost all previous studies have treated travel as if it was just a trip for a single purpose with a single destination. In other words, almost all concentration of walking related studies has been given to trip-based analysis. The literature review shows that although early travel behaviour analyses in the field of transportation planning were upon trip-based analysis, the tour-based approach has grown during the last few years. It has been found that people decide on their travel modes for the entire tour before leaving home (Frank, Bradley, Kavage, Chapman, & Lawton, 2008) rather than treating travel as if it was just a trip for a single purpose with a single destination. However, this approach has not received enough attention in walking-related studies and researches which consider walking in a tour remains limited. In this line, a question is that to what extent does considering single trips as the basic analysis unit for walking behaviour analysis could be reliable? It seems that in order to provide more reliable analysis on walking behaviour, one should consider walking in the entire tour. In individual-based studies tour-based approach is more accurate to find the actual amount of walking.

On the other hand, there are two arguments regarding the explanatory factors: (1) most of the previous studies have concentrated on built environmental factors and less attention has been given to subjective factors such as individuals' attitudes and beliefs toward walking. However, failure to account for subjective factors may result in the attribution of a disproportionate significance to the physical environment as a predictor of the decisions to use walking (Cao, Mokhtarian, & Handy, 2009). (2) The second point is that most of the walking-related travel behaviour studies have only examined the direct effect of factors on walking trips actually taken without considering the possible mediating influences. However, an important research question related to walking would be that whether there are any structural relationships between factors influencing walking. In other words, one may like to know if any factor could also affect walking behaviour indirectly and through other factors.

Answers to these questions would probably be interesting to transportation planners and policymakers aiming to promote more walking as it helps to adopt more effective strategies. In order to provide a better understanding of walking for transportation, this paper aims to provide a more comprehensive assessment of walking behaviour by (1) using multiple measures of travel simultaneously for defining the walking behaviour, (2) measuring walking behaviour in work-tour(s) rather than a single trip to work, (3) examining the hypothesis that people with positive attitudes towards walking (e.g. people with a professed motivation to engage in exercise or environmentally benign behaviour) demonstrate different walking behaviour, (4) examining relationships in between explanatory factors including individual attitudes, built environmental characteristics and socio-economic characteristics in order to explore any indirect effect on the

walking behaviour; and (5) focusing on the city of Rasht in Iran in order to provide insight in to a case study in a developing country which has not received enough attention in previous studies. According to the Rasht household travel survey in 2007, more than 17.5% of all daily trips made were for the purpose of work (i.e. trips to workplaces) which constitutes the highest share of daily trips (Rasht comprehensive transportation planning study, 2011).

A work-tour is defined in this paper as a complete home-to-home journey where the origin of the first trip is home, the primary destination is workplace and the destination of the last trip is home. It is worth noting that such tour may include one or more non-home stops. No intermediate home stop is present within this tour and whenever the home location is reached, a tour is formed. It is worth noting that the activity (in the case of this study, working in the workplace) for which the trips are made to/from may take a few hours. However, what matter to this research from the point of transportation planning are the trips that are made in the tour and not the type of the activity to be conducted in the tour.

The remaining of this paper starts with a review of the literature on walking behaviour and factors affecting walking. This is followed by a description of the data; and the methodology used in this paper. Model estimation results are then presented. The paper concludes with a summary of the main findings and a discussion of the implications for transportation policy and planning practice.

2. Literature review

Existing studies on walking behaviour (either for transportation or other purposes) have mostly defined walking as walking trips actually taken and have examined the influence of different factors on walking behaviour. We review some of the key issues in this literature.

2.1. Measures for the definition of walking behaviour

Previous studies have used various measures of travel for defining walk behaviour. A group of studies have defined walking behaviour based on frequency. In a study by Lachapelle and Noland, walking behaviour was defined as how frequently an individual walks for different purposes (Lachapelle & Noland, 2012). They used ordered probit models for the analysis. Bhat et al. accounted for the ordinal nature of trip frequency and developed separate trip frequency models for walking for three trip purposes (Bhat, Guo, & Sardes, 2005). Bopp et al. used a dichotomized variable of no walking or walking one or more times per week to better understand the effect of various factors on walking (Bopp, Kaczynski, & Besenyi, 2012).

A walking behaviour measure used in previous studies is walking mode choice. Among these studies, some have modelled simple dichotomous measures of walking or choosing other modes of travel in various trip purposes (Hatamzadeh, Habibian, & Khodaii, 2014; Hatamzadeh, Habibian, & Khodaii, 2017; Manaugh & El-Geneidy, 2011; McMillan, 2007). Some other studies have used more advanced models. For example, Rodriguez and Joonwon considered walking beside other travel modes (bicycle, automobile, carpool, bus, and park-ride) and examined the effect of local physical environment attributes on mode choice using multinomial, nested and HEV choice models (Rodrı´guez and Joo

2004). Kamargianni and Polydoropoulou developed an advanced stated preferences (SP) survey, and calibrated hybrid mode choice model on four alternative modes for the trip to school: car (escorted by parents), bus, bicycle and walk (Kamargianni & Polydoropoulou, 2013).

There are another group of studies in which the relation between walking distance (in some cases, walking time) as a dependent variable and other factors has been addressed. Among these studies, some have captured the mentioned relationship for a variety of trip purposes (Larsen, El-Geneidy, & Yasmin, 2010; Millward, Spinney, & Scott, 2013; Yang & Diez-Roux, 2012) and some others have investigated the potential influences of various factors on public transit walk access distance (Daniels & Mulley, 2013; El-Geneidy, Tétreault, & Sur, 2010; Jiang, Christopher Zegras, & Mehndira, 2012).

Overall, almost all of the mentioned studies have defined walking behaviour using only one of the travel measures mentioned. Moreover, all of them have treated travel as if it was just a trip for a single purpose with a single destination and studies which have investigated walking behaviour in a tour are limited (for example, (Paul, Born, McElduff, Pendyala, & Bhat, 2013; Ye, Pendyala, & Gottardi, 2007)).

2.2. Factors affecting walking behaviour

The influence of different factors on walking behaviour has been studied extensively. The most important factors are reviewed briefly in this section.

Environmental factors are the most widely investigated characteristics for their effect on walking behaviour. Previous studies have incorporated explicit measures of environmental attributes (e.g. (Cervero & Duncan, 2003; Guo, 2009; Humpel, Owen, & Leslie, 2002; Tanishita & van Wee, 2017)), or have developed composite factors for exploring the relation to walking behaviour (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Kuzmyak, Baber, & Savory, 2005; Manaugh & El-Geneidy, 2011). Among environmental factors, land-use and connectivity measures are two main categories which their effect have been studied previously. Among land use characteristics, the most cited factors are the original '3Ds' created by Cervero and Kockelman (Cervero & Kockelman, 1997) namely density, diversity, and design, followed later by destination accessibility and distance to transit (Cervero, Sarmiento, Jacoby, Gomez, & Meiman, 2009).

Following the mentioned studies, some others in recent years have tried to answer the question that how subjective factors such as lifestyle and attitudes, beliefs and personality and individual's perceptions from built environment along with land use attribute could influence travel behaviour (Deutsch, Yoon, & Goulias, 2013; Etminani-Ghasrodashti & Ardeshiri, 2015; Nurul Habib & Zaman, 2012; Ory & Mokhtarian, 2009; Prillwitz & Barr, 2011) and in some cases, their effect has been reported greater than the effect of the built environment (Hurtubia, Atasoy, Glerum, Curchod, & Bierlaire, 2010). However, there are limited studies which have reported the effect of attitudes on walking behaviour (e.g. (Cao, Mokhtarian, & Susan, 2009; Dill, Mohr, & Ma, 2011)). Handy et al. (Handy, Cao, & Mokhtarian, 2006) concluded that the built environment influences walking behaviour after taking neighbourhood preferences and attitudes into account. In a study by Frank et al. both attitudinal predisposition for neighbourhood type and actual characteristics of the built environment in which one lives were found to impact the choice to walk and distances driven (Frank, Saelens, Powell, & Chapman,

2007). Some studies have also paid attention to individuals' perceptions of the environment and their walking or physical activity amount (e.g. (Adams, Bull, & Foster, 2016; Guliani, Mitra, Buliung, Larsen, & Faulkner, 2015; Morckel, 2016)).

Nearly all studies conducted in this area have focused on detecting the direct effects between the explanatory variables and the walking behaviour, without considering the possible mediating influences. In one recent exception, applying a full-scale structural equation modelling (SEM), Coogan et al. examined the direct and indirect effects of attitudes/preferences toward a walkable neighbourhood, urban form of the community, urban form of the residence, auto dependency, and satisfaction with the neighbourhood on walking behaviour (Coogan, Adler, & Karash, 2012). There are also some examples which were reliant on 'path diagrams' (e.g. (Bagley & Mokhtarian, 2002; Cao et al., 2007; Guliani et al., 2015)) rather than the full SEM.

Overall, the literature review shows that although walking behaviour has been defined with different travel measures, most of the studies have only used one measure for their analysis. The review also shows that among various explanatory factors, environmental factors are the most widely investigated characteristics and the effects of subjective factors on walking behaviour are limited especially in developing countries. Furthermore, there are insufficient studies that look at the indirect effects of variables and almost all studies have concentrated on the direct effects only. This study addresses gaps in the current literature by examining the direct and indirect effect of various variables including subjective and environmental factors on walking behaviour in work-tour(s) in the city of Rasht, Iran.

3. Data and methodology

This section provides a description of the data collected and the variables examined in the final model. The modelling process using the structural equation modelling (SEM) has also been introduced.

3.1. The survey

This study takes place in the urban areas of Rasht, which is the largest city in north of Iran with a population of more than 550,000 according to the 2006 census. Rasht has experienced a rapid population growth and physical development particularly during 1956 to 2006. Figure 1 show the location of different districts in the city which is related to the development stages of Rasht during the last decades (Master plan of the city of Rasht, 2007). For more information about the spatial structure and street layout of Rasht, see (Hatamzadeh et al., 2014; Hatamzadeh et al., 2017). The rapid growth of Rasht relinquished a balanced urban development and led to the emergence of various urban problems such as heavy traffic jams. While no mass transit system has been provided yet, cars and taxis are the most favourable modes of transportation in daily trips. Furthermore, pedestrians are not given priority and enough attention in urban and transportation planning.

For the purposes of this study, a survey was fielded over respondents who were 18 years of age or older residing and working inside the urban area of Rasht. Respondents were interviewed face-to-face in their workplaces which took about 25 minutes on average. In order to cover various activities related to urban services, the workplaces located in

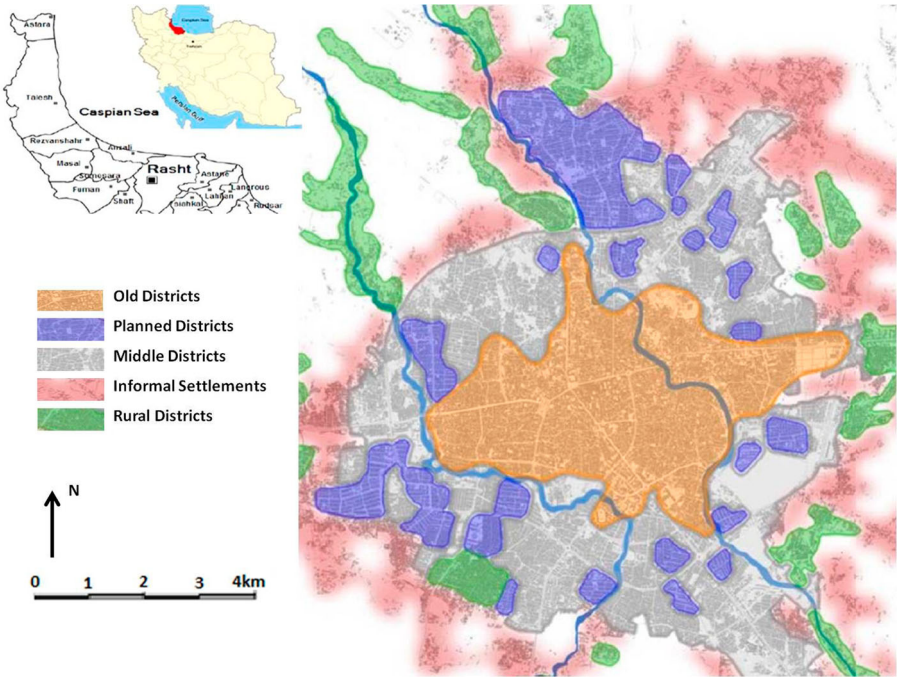

Figure 1. Development stages in the city of Rasht.

the main streets of the city were selected. It is worth noting that according to the master plan of Rasht in 2007, most of the activities related to urban services have been deployed around the main streets of the city. The pattern of deployment of urban and commercial services is linear and is a function of the shape of the roads. The survey was done during a 4-week period in 2015.

All of the respondents were asked to report their trip characteristics such as mode of travel (including every walking done whether as a main mode or as a supplementary mode) and starting and ending time of the trip in their work-tour(s). Table 1 displays summary statistics for the final usable sample size with 432 commuters. Comparing values in Table 1 with the large data collected in the Rasht household travel survey in 2007 (Rasht comprehensive transportation planning study, 2011) confirms that the sample collected is a good representative for the target population as the sample is close to the statistics of the city. The final database for the mentioned study was made up of 5049 households (containing 17706 persons) which were 2.89% of all households residing inside the urban area of Rasht. It is worth noting that in Table 1, household size is reported on all households (i.e. 5049 households) while individual characteristics (i.e. gender and age) are on workers only.

3.2. The analysis

In line with the objectives of this research, a full-scale structural equation model was used for the analysis. In order to be able to analyse the walking behaviour (as the main dependent variable of this study) using multiple travel measures simultaneously, this variable was defined as a latent variable in which various travel measures were used as indicators. The

Table 1. Demographics: gender, marital status, HH size, age, and HH employee (s) ($n = 432$).

		Number	Percent (%)	Percent (%) in 2007
Gender	Male	353	81.71	85.21
	Female	79	18.29	14.79
Marital Status	Single	110	25.46	NA[a]
	Married	322	74.54	NA
Household Size	≤2	52	12.04	17.41
	3	140	32.41	33.14
	4	155	35.88	34.60
	5	71	16.43	11.21
	6	14	3.24	3.64
Age	18–29	115	26.62	20.87
	30–39	159	36.81	32.01
	40–49	106	24.54	34.02
	50–59	44	10.18	10.45
	≥60	8	1.85	2.65
Number of Household Employee (s)	1	147	34.03	NA
	2	215	49.77	NA
	≥3	70	16.20	NA

[a]NA: Not available.

SEM enables using unobserved latent factors that underlie the observed variables as indicators and considers measurement errors for each indicator which was important for this study. These abilities of the SEM are limited in other analytical methods. For example, methods such as the Explanatory Factor Analysis (EFA) derive factor scores and then use those scores as explanatory variables in a model of behaviour which means that we are taking what is really a latent variable (the factor) that is measured (via the score) with error, and treating it as if it were a manifest variable measured without error. In other words, the EFA does not actually consider the error terms for each indicator which leads to an unrealistic estimation of the coefficients relative to the full SEM method. Furthermore, the SEM provides the possibility to estimate the structural relationships between the explanatory factors themselves and the dependent variable, simultaneously (i.e. the direct and indirect effects which were another objective of this study). For a general discussion of the use of SEM in practice, see (Kline, 2005). Using the SEM, it is possible to calculate the total effect of each predicting variable on each endogenous variable including the direct effect and all of the indirect effects (i.e. effects from the predicting variable on other variables that in turn affect the endogenous variable). Equations in structural equation models are estimated by minimizing the difference between the model-implied covariance matrix and the empirically-computed covariance matrix for the data. Latent variables and their related indicators (i.e. observed variables) are introduced in Table 2 and are more discussed in this section.

In this study, walking behaviour as the main dependent variable was defined as the latent variable *walking behaviour*. Three indicators namely walking time, percent of walking time and having at least one walking trip in work-tour(s) were used as candidate measures in the initial model. Time of walking is the total time of walking whether walking as a main mode of transportation or in combination with other modes in work-tour(s). Percent of walking is the ratio of walking time relative to total travel time in work-tour(s).

The survey contained statements about individual's spirits and also his/her attitudes toward walking in work-tour(s). Respondents were asked to state their opinions about

Table 2. Definition of observed variables examined in the modelling process.

Variable Definition	Abbreviation
Ratio of walking time relative to total travel time in work-tour(s)	Walk_Percent
Total time of walking in work-tour(s) (continuous)	Walk_Time
Individual has at least one walking trip in work-tour(s) (yes = 1)	Walk_Freq
Individual and Socioeconomic characteristics	
Individual is aged between 18 to 29 years (yes = 1)	Age18_29
Individual is aged between 30 to 39 years (yes = 1)	Age30_39
Individual is aged between 40 to 49 years (yes = 1)	Age40_49
Individual is aged between 50 to 59 years (yes = 1)	Age50_59
Individual is aged 60 or higher (yes = 1)	Age60up
Gender (Male = 1)	Male
Individual is married (yes = 1)	Married
Individual has been at his/her job for 1 to 5 years (yes = 1)	Occuptime1_5
Individual is obese (i.e. BMI[a] value is greater than or equal to 30) (yes = 1)	Obesity
Household size (continuous)	HSize
Child at elementary stage or younger in household (yes = 1)	Child
There is one (or more) automobile(s) in household (yes = 1)	Veh_CarD
Individual lives in home as owner (i.e. not as tenant or paternal house) (yes = 1)	Rsd_Own
House area (m^2) (1 = less than 70; 2 = 71–90; 3 = 91–110; 4 = 111–150; 5 = more than 150)	Rsd_ArO
Walkability of environment	
Population density in destination zone	Pop_Den
Job-population balance in destination zone	Job_Pop balance
Link density in destination zone	Lnk_Den
Individual spirits (five-point ordinal scale from strongly disagree to strongly agree)	
I am lazy and wake up too late every day	Lazy
Appearance in workplace is important for me	Appearance
I don't like to be seen in street too much	Sense_be_seen
Attitudinal statements (five-point ordinal scale from strongly disagree to strongly agree)	
More walking in work-tour(s) will be good for my health and keeping fitness	Fitness
More walking in work-tour(s) will be a chance to socialize more	Sociability
More walking in work-tour(s) will be effective in increasing vitality and quality of my life	Life_Quality
More walking in work-tour(s) will be useful in having a better environment	Environment
More walking in work-tour(s) will be effective on my performance in workplace	Performance

[a]BMI: The Body Mass Index which was calculated as weight(kg)/height^2(m^2).

each statement on a five-point ordinal scale ranging from 'strongly disagree' to 'strongly agree'. For example, participants were asked to state his/her opinion about the statement 'walking in work-tour(s) will be good for my health' on the mentioned scale. These statements are described in Table 2 and were used as indicators of the two latent variables *Individual Spirits* and *Positive Attitudes*.

In order to examine the effect of environmental factors in the model, several variables were calculated through GIS. Finally, job-population balance[1] and link density[2] for the zone where the workplace was located were selected as the best measures for land used diversity and connectivity (i.e. a proxy for design), respectively. These measures were used as indicators of the latent variable *walkable environment* showing the walkability of the destination zone.

In addition to the mentioned variables, the effects of individual and socioeconomic characteristics were also examined in this study. The effects of individual characteristics were studied separately in the model and not as a latent variable. However, a latent variable *socioeconomic status* was created to capture the effect of wealthier people. Higher car ownership, owing a home, and higher house area were used as indicators for the mentioned latent variable.

As the studied endogenous variables were non-normal, we decided to employ the Browne's Asymptotic Distribution Free (ADF) (Browne, 1984), technique which does

not require multivariate normal data.[3] We carried out the analysis in a two-step approach namely a measurement model and a structural model suggested by Anderson and Gerbing (Anderson & Gerbing, 1988). First, the measurement model was tested through a confirmatory factor analysis (CFA), which showed that how much the observed indicators provided reliable measures of the latent variables. Then, using the identified measurement model, we proceeded to specify the structural model which is presented in the next section. All analyses were performed using AMOS 18.

4. The walking behaviour model

Figure 2 shows the final walking behaviour model with 44 parameters and a degree of freedom 127. Each latent variable is measured with several observed indicator variables which were introduced in the previous section. For identifiability purpose (Kennedy, 1998), one of the indicators is fixed with an unstandardized coefficient of 1.0. A measurement error term is also considered for each of the indicators. Table 3 shows the unstandardized values for the direct effects and presents the statistical significance of such effects. All of the relationships were significant at 10 percent level (*p-value* < *0.1*). The right-hand

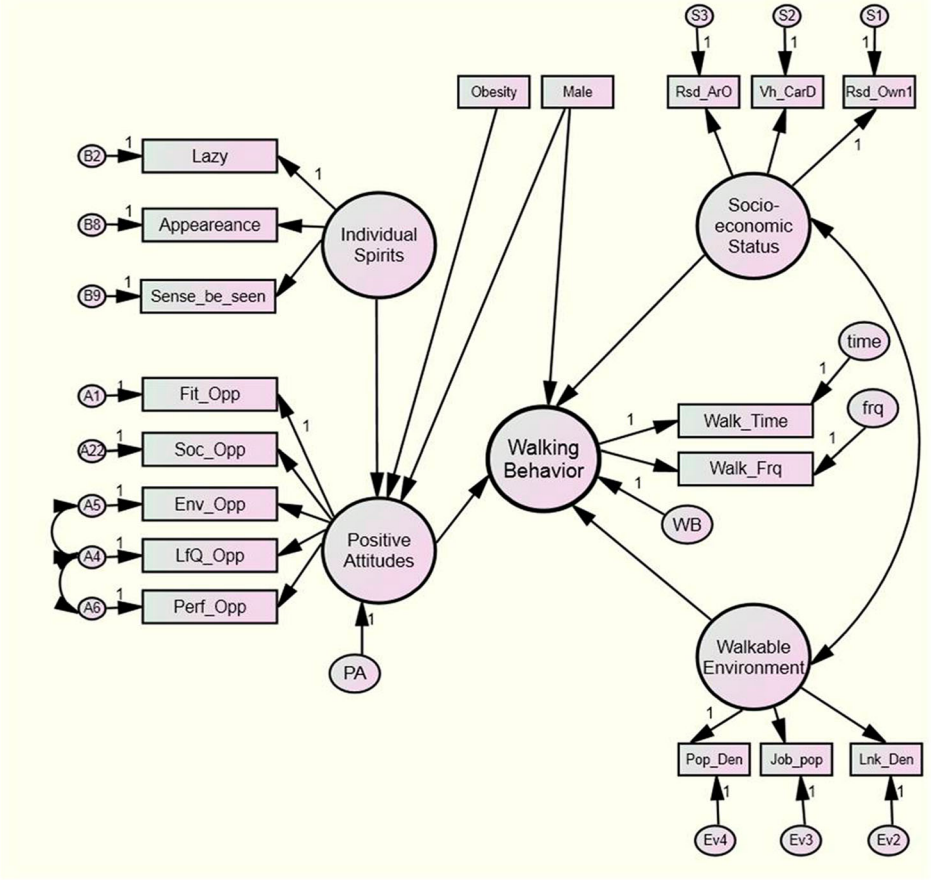

Figure 2. Final walking behaviour model.

Table 3. Parameter estimates for the final Walking behaviour model (regression weights).

			Un-standardized beta	S.E.	*P*	Standardized beta
Walk_Time	<—	Walking_Behaviour	1.000	–	–	.896
Walk_Frq	<—	Walking_Behaviour	.004	.002	***	.354
Walking_Behaviour	<—	Socio_economic_Status	−32.824	6.781	***	−.333
Walking_Behaviour	<—	Walkable_Environment	.047	.024	.045	.077
Walking_Behaviour	<—	Positive_Attitudes	9.438	2.413	***	.157
Walking_Behaviour	<—	Male	−8.668	2.414	***	−.151
Fit_Opp	<—	Positive_Attitudes	1.000	–	–	.449
LfQ_Opp	<—	Positive_Attitudes	1.689	.152	***	.563
Perf_Opp	<—	Positive_Attitudes	1.141	.137	***	.366
Env_Opp	<—	Positive_Attitudes	1.810	.198	***	.578
Soc_Opp	<—	Positive_Attitudes	3.007	.273	***	.832
Positive_Attitudes	<—	Obesity	.233	.058	***	.204
Positive_Attitudes	<—	Male	.088	.048	.067	.093
Positive_Attitudes	<—	Individual_Spirits	−.046	.028	.098	−.090
Lazy	<—	Individual_Spirits	1.000	–	–	.484
Appeareance	<—	Individual_Spirits	1.659	.163	***	.780
Sense_be_seen	<—	Individual_Spirits	1.496	.159	***	.774
Rsd_ArO	<—	Socio_economic_Status	1.933	.304	***	.425
Vh_CarD	<—	Socio_economic_Status	1.478	.236	***	.751
Rsd_Own1	<—	Socio_economic_Status	1.000	–	–	.385
Pop_Den	<—	Walkable_Environment	1.000	–	–	.794
Lnk_Den	<—	Walkable_Environment	.567	.044	***	.377
Job_pop balance	<—	Walkable_Environment	.005	.000	***	.983

***The regression weight is significantly different from zero at the 0.001 level (two-tailed).

column of Table 3 shows the standardized coefficients for all the parameters. The total effect of each predicting variable on each endogenous factor is also shown in Table 4.

In terms of assessing the model fit, numerous goodness-of-fit measures were looked out. According to the results found, root mean square error of approximation (RMSEA) for the final model was 0.066 which is under the acceptable value of 0.08. Other measures such as Goodness-of-fit index (GFI), Adjusted goodness-of-fit index (AGFI), Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) were all found acceptable as they are higher than the value of 0.9 (GFI = 0.98, AGFI = 0.973, CFI = .927, TLI = .912) (Byrne, 2001).

5. Discussion

The final model was achieved after controlling for all possible relationships between various variables. Relationships which were not significant at 10% level were excluded

Table 4. Standardized total effects on endogenous variables.

	Exogenous variables					
Endogenous variables	Male	Obesity	Walkable environment	Socio-economic status	Individual spirits	Positive attitudes
Walking_Behaviour	−.137	.032	.077	−.333	−.014	.157
Walk_Time	−.123	.029	.069	−.299	−.013	.141
Walk_Frq	−.048	.011	.027	−.118	−.005	.056
Positive_Attitudes	.093	.204	.000	.000	−.090	.000
Fit_Opp	.042	.091	.000	.000	−.040	.449
Soc_Opp	.077	.169	.000	.000	−.075	.832
Env_Opp	.054	.118	.000	.000	−.052	.578
LfQ_Opp	.052	.115	.000	.000	−.051	.563
Perf_Opp	.034	.075	.000	.000	−.033	.366

from the final model. The final model also represents the best goodness of fit relative to various models developed. The model indicates that adding indirect effects gives a better model than accounting for direct effect of variables alone.

The final model shows that only two indicators namely walking time and having at least one walking trip in work-tour(s) provided reliable measures of the latent variable *walking behaviour*. Percent of walking time in work-tour(s), as the third indicator was excluded through a confirmatory factor analysis (CFA). According to the final model, some variables affect *walking behaviour* with a direct effect only, some with an indirect effect only and some others with direct and indirect effect simultaneously. These relationships are more discussed in this section.

Our findings reveal that having positive attitudes toward walking, directly leads to a higher amount of walking in work-tour(s) (Beta = 0.157). Among various opinions measuring the positive attitudes, the opinion 'more walking in work-tour(s) will be a chance to socialize more' was found with the highest weight confirming the idea that walking to/from work could be a mean for more socializing. Therefore, commuters with such needs have a higher positive attitude toward walking and thereby walk more in their work-tour(s). The next opinion comes is that 'more walking in work-tour(s) will be useful in having a better environment'. This finding confirms the hypothesis rose in the introduction that people with more environmental concerns, have a more positive view on walking in work tour(s) and, therefore, have more walking.

Positive attitude itself is affected directly by the variable *individual spirits*. The negative effect of *individual spirits* on *positive attitudes* (Beta = −0.090) seems logical as this latent factor estimates with a positive coefficient on the following three survey statements: 'I am lazy and wake up too late every day' (*lazy* in Figure 2; fixed coefficient of 1.0), 'Appearance in workplace is important for me' (*Appearance*), and 'I don't like to be seen in street too much' (*Sense_be-seen*). The negative effect of *individual spirits* on *positive attitudes* leads to an indirect negative effect on walking behaviour of commuters in work-tour(s). This means that a commuter with the mentioned characteristics as his/her individual spirit is less likely to walk in his/her work-tour(s). The highest loading among indicators of the latent variable *individual spirits* was about the importance of appearance in workplace which could be related to sweating due to walking which could itself be related to the high humidity in Rasht.

Results also show that environmental characteristics of the workplace do help to explain *walking behaviour* directly. The latent variable *walkable environment* estimates with a positive coefficient on population density, job-population balance, and link density. This means that individuals working in places with higher walkability, are more likely to walk in their daily work-tour(s).

According to the results found, the latent factor *socioeconomic status* serves to negatively explain *walking behaviour* (Beta = −0.333). The latent variable *socioeconomic status* is somehow representing wealthier people as it estimates with a positive coefficient on variables such as higher car ownership, owing a home (i.e. not as tenant or paternal house), and higher house area. This means that wealthier people are less likely to walk more in their work tour(s) relative to others.

Among individual characteristics, gender was found as a significant variable in the final model. Being male affects walking amount with a direct effect and also a positive indirect

effect through *positive attitudes*. This leads to a negative total effect of the variable on *walking behaviour* (Beta = −0.137). These findings mean that the walking amount of females was significantly higher than males despite the fact that male have more positive attitudes toward walking. A reason behind this finding may be that females view working trips as an opportunity to socialize as mentioned in previous studies (e.g. (*6*)). Another reason may be due to car accessibility which is probably limited for females in family. According to the results found, being obese was a significant predictor in the model. This variable affects walking behaviour indirectly only. Individuals who were obese had higher positive attitudes toward walking which could be due to benefits of walking such as health and quality of life. These commuters did more walking in their work-tour(s).

6. Conclusions

This article intended to contribute to the literature by (1) using various measures of travel for defining the walking behaviour rather than a single measure only; (2) considering tours as the basic analysis unit rather than single trips; (3) examining the effect of individual subjective factors (here we only accounted for *positive attitudes* and *individual spirits*) as well as built environment characteristics and controlling for the effect of socio-economic characteristics; (4) investigating the role of indirect effects on walking behaviour rather than direct effects only; and (5) providing an insight into the case of walking in Iran as a developing country which has not been well addressed in previous research.

Using structural equation modelling (SEM) a walking behaviour model was presented utilizing unobserved latent factors that underlie the observed variables. From the final model we concluded that time of walking in work-tour(s) (i.e. total time of walking whether walking as a main mode of transportation or in combination with other modes) and having at least one walking trip in work-tour(s) results in better goodness of fit of walking behaviour. However, time of walking was found with a higher weight (i.e. load factor); which means that total time of walking in work tour(s) seems to be more contributed to interpreting the walking behaviour. These finding show that in addition to short trips as potential for walking, promoting walking in combination with other modes (such as public transit which has some walking at the beginning and the end of a trip) could also be a target for the policy makers who are aiming to increase the amount of walking in daily travel.

The final structural model developed shows that some variables affect walking behaviour through a direct effect only, some with an indirect effect only and some others with direct and indirect effect simultaneously. As the final model was achieved after controlling for all possible relationships between variables, a general finding of this study was that adding indirect effects gives a better model (in terms of goodness of fit measures, level of significance, and interpretability of variables) than accounting for direct effect of variables alone. In other words, the final model shows structural relationships among key factors in the explanation of walking behaviour (i.e. how walking behaviour is shaped) and therefore, provides a better interpretation of walking behaviour of commuters. In fact, using a mediating factor helps to explain the effects of a third variable (mediator) mediating the relationship between the independent and dependent variables.

Interestingly, it was found that having positive attitudes plays the most important mediating role in the structural relationships among various variables. Furthermore, the total

effect of having positive attitudes was even higher than the environmental characteristics of the destination zone (i.e. the walkability of the zone where the workplace is located). This finding suggests that in order to promote walking in commuting between home and work, applying physical policies alone (such as improving the infrastructure) cannot be sufficient and policies concerning commuter's attitudes should also be considered in transportation planning. Policies aiming to change individuals' attitudes towards walking could bring about behavioural change by informing commuters about the consequences of their transport choices, and potentially persuading them to change their behaviour. According to the results found, individual spirits such as concerns about appearance in the workplace negatively affects an individual's attitudes towards walking and as a result, has a negative indirect effect on the amount of walking. As discussed before, a reason behind this finding could be related to the sweating which is very much related to the high humidity of the city. Therefore, measures such as providing opportunities such as possibility to take a shower at work might be useful.

One of the policies that can be suggested based on the results found is to plan for higher mixed-use developments. Among the built environment variables examined, the variable with the highest weight was related to the job-population balance index which implies that a more balance between employment opportunities and population in the destination zone could provide more accessibility for workers which could itself increase the propensity to walk. Moreover, according to our findings, the latent variable representing wealthier people serves to negatively explain the walking behaviour. The mentioned latent variable has the highest weight on the variable showing higher car ownership. This finding supports previous studies that in order to attract drivers out of their car, improving walking infrastructure should be enhanced by transportation demand management push policies (i.e. policies discourage car usage).

Some limitations are also important to point out. The sample examined in this study was limited to workplaces located in the main streets of the city. According to the master plan of the city of Rasht, it was assumed that the main streets of the city cover various activities related to urban services. However, in order to cover more job activities, one should also consider workplaces located in minor streets. The data used in this study was based on a self-reported interview among workers and, therefore, one of the limitations of this study was the probability of forgetting trip information by the respondents which could affect the exact duration of walking in a work-tour. Finally, while some environmental variables were controlled in this study, they are limited. A limitation was the lack of information about the actual travel distance as the home addresses of the respondents was not registered in the data collection stage and, therefore, travel time between home and workplace was used instead. Furthermore, this study was limited in examining the effect of various other environmental factors such as attributes of the path or the social environment of the origin or destination places that could affect the walking behaviour.

Altogether, despite the model presented, this subject is still interesting and open for future studies. Suggestions for future research include a number of segmentations of the sample. For example, it would be of interest to explore how these relationships may differ by number of work-tours or type of commute mode. Future studies could also examine the influence of various mobility constraints such as having a busy day (i.e. too much planning), or small children. Comparing results in this study for other travel purposes (such as shopping which is not as mandatory as a work trip) could also be interesting.

Notes

1. Job-population balance was suggested by Ewing et al. $\left(1-\left|\frac{\text{Job}-0.2\times\text{Pop}}{\text{Job}+0.2\times\text{Pop}}\right|\right)$ as an index that evaluates the balance between jobs and inhabitant population of an area (Ewing et al. 2014). According to Ewing et al. zones with just one type of land use (residential or nonresidential) has no attraction for pedestrians to make walking trips.
2. Higher link density (i.e. more links in an area) could provide better network for pedestrians and tend to increase walking mode choice
3. By far, maximum likelihood estimation (MLE) technique is suggested for endogenous variables which are distributed multivariate normal (see, e.g. (Kennedy, 1998, Bentler & Dudgeon, 1996)).

Acknowledgements

The authors would like to acknowledge the students who cooperated in the survey stage. Also, special thanks to Sara Mahmoodi for her very useful helps in all stage of the research.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Yaser Hatamzadeh http://orcid.org/0000-0001-6187-6522
Meeghat Habibian http://orcid.org/0000-0002-4130-9042
Ali Khodaii http://orcid.org/0000-0002-6646-1817

References

Adams, E. J., Bull, F. C., & Foster, C. E. (2016). Are perceptions of the environment in the workplace 'neighbourhood' associated with commuter walking? *Journal of Transport & Health*, *3*(4), 479–484.
Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modelling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*, 411–423.
Bagley, M. N., & Mokhtarian, P. L. (2002). The impact of residential neighbourhood type on travel behaviour: A structural equations modelling approach. *The Annals of Regional Science*, *36*(2), 279–297.
Bentler, P. M., & Dudgeon, P. (1996). Covariance structure analysis: Statistical practice, theory, and directions. *Annual Review of Psychology*, *47*, 563–592.
Bhat, C. R., Guo, J. Y., & Sardes, R. (2005). *Non-motorized travel in the San Francisco Bay area*. Austin: Department of Civil Engineering, The University of Texas.
Bopp, M., Kaczynski, A. T., & Besenyi, G. (2012). Active commuting influences among adults. *Preventive Medicine*, *54*, 237–241.
Browne, M. W. (1984). Asymptotically distribution-free methods for the analysis of covariance structures. *British Journal of Mathematical and Statistical Psychology*, *37*, 62–83.
Byrne, B. M. (2001). *Structural equation modelling with AMOS: Basic concepts, applications*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.
Cao, X., Mokhtarian, P. L., & Handy, S. L. (2007). *Do changes in neighbourhood characteristics lead to changes in travel behavior? A structural equations modelling approach*. 86th annual meeting of transportation research board, Washington, DC.
Cao, X., Mokhtarian, P. L., & Handy, S. L. (2009). Examining the impacts of residential self-selection on travel behaviour: A focus on empirical findings. *Transport Reviews*, *29*(3), 359–395.

Cao, X., Mokhtarian, P. L., & Susan, L. (2009, June). The relationship between the built environment and nonwork travel: A case study of Northern California. *Transportation Research Part A: Policy and Practice*, *43*(5), 548–555.

Cervero, R., & Duncan, M. (2003). Walking, bicycling, and urban landscapes: Evidence from the San Francisco Bay area. *American Journal of Public Health*, *93*(9), 1478–1483.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D*, *2*(3), 199–219.

Cervero, R., Sarmiento, O., Jacoby, E., Gomez, L., & Meiman, A. (2009). Influences of built environments on walking and cycling: Lessons from Bogota. *International Journal of Sustainable Transportation*, *3*, 203–226.

Coogan, M. A., Adler, T., & Karash, K. (2012). The paths from walk preference to walk behaviour: Applying latent factors in structural equation modelling. *Journal of Transport and Land Use*, *5*(3), 68–82.

Daniels, R., & Mulley, C. (2013). Explaining walking distance to public transport: The dominance of public transport supply. *Transport and Land Use*, *6*(2), 5–10.

Deutsch, K., Yoon, S. Y., & Goulias, K. (2013). Modelling travel behaviour and sense of place using a structural equation model. *Journal of Transport Geography*, *28*, 155–163.

Dill, J., Mohr, C., & Ma, L. (2011). *The role of the built environment and psychology on bicycling and walking behaviour: What matters? What comes first?!* Poster session. Presented at the active living research annual conference, San Diego, CA.

El-Geneidy, A. M., Tétreault, P. R., & Sur, J. (2010). *Pedestrian access to transit: Identifying redundancies and gaps using a variable service area analysis*. 89th transportation research board annual meeting, Washington, DC.

Etminani-Ghasrodashti, R., & Ardeshiri, M. (2015). Modelling travel behaviour by the structural relationships between lifestyle, built environment and non-working trips. *Transportation Research Part A*, *78*, 506–518.

Ewing, R., Tian, G., Goates, J. P., Zhang, M., Greenwald, M. J., Joyce, A., … Greene, W. (2014). Varying influences of the built environment on household travel in 15 diverse regions of the United States. *Urban Studies*, 2330–2348.

Frank, L., Bradley, M., Kavage, S., Chapman, J., & Lawton, K. (2008). Urban form, travel time, and cost relationships with tour complexity and mode choice. *Transportation*, *35*(1), 37–54.

Frank, L. D., Saelens, B. E., Powell, K. E., & Chapman, A. E. (2007). Stepping towards causation: Do built environments or neighbourhood and travel preferences explain physical activity, driving, and obesity? *Social Science & Medicine*, *65*, 1898–1914.

Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J., & Saelens, B. E. (2005). Linking objectively measured physical activity with objectively measured urban form – findings from Smartraq. *American Journal of Preventive Medicine*, *28*(2), 117–125.

Guliani, A., Mitra, R., Buliung, R. N., Larsen, K., & Faulkner, G. E. J. (2015). Gender-based differences in school travel mode choice behaviour: Examining the relationship between the neighbourhood environment and perceived traffic safety. *Journal of Transport & Health*, doi:10.1016/j.jth.2015

Guo, Z. (2009). Does the pedestrian environment affect the utility of walking? A case of path choice in downtown Boston. *Transportation Research Part D*, *14*, 343–352.

Handy, S., Cao, X., & Mokhtarian, P. L. (2006). Does self selection explain the relationship between built environment and walking behaviour? Empirical evidence from Northern California. *Journal of the American Planning Association*, *72*(1), 55–74.

Hatamzadeh, Y., Habibian, M., & Khodaii, A. (2014). Walking behaviours by trip purposes. *Transportation Research Record: Journal of the Transportation Research Board*, *2464*, 118–125.

Hatamzadeh, Y., Habibian, M., & Khodaii, A. (2017). Walking and jobs: A comparative analysis to explore factors influencing flexible and fixed schedule workers, a case study of Rasht, Iran. *Sustainable Cities and Society*, *31*, 74–82.

Humpel, N., Owen, N., & Leslie, K. (2002). Environmental factors associated with adults' participation in physical activity: A review. *American Journal of Preventive Medicine*, *22*, 188–199.

Hurtubia, R., Atasoy, B., Glerum, A., Curchod, A., & Bierlaire, M. (2010). *Considering latent attitudes in mode choice: The case of Switzerland*. Proceedings. Presented at the the world conference on transport research.

Jiang, Y., Christopher Zegras, P., & Mehndira, S. (January 2012). Walk the line: Station context, corridor type and bus rapid transit walk access in Jinan, China,. *Journal of Transport Geography*, *20*(1), 1–14.

Kamargianni, M., & Polydoropoulou, A. (2013). *Development of a hybrid choice model to investigate the effects of teenagers' attitudes towards walking and cycling on mode choice behaviour*. Annual meeting of the transportation research board, Washington, DC.

Kennedy, P. (1998). *A guide to econometrics* (4th ed.). Cambridge, MA: MIT Press.

Kline, R. (2005). *Principles and practice of structural equation modelling* (2nd ed.). New York, NY: The Guilford Press.

Kuzmyak, J. R., Baber, C., & Savory, D. (2005). Use of walk opportunities index to quantify local accessibility. *Transportation Research Record: Journal of the Transportation Research Board*, *1977*, 145–153.

Lachapelle, U., & Noland, R. B. (May 2012). Does the commute mode affect the frequency of walking behaviour? The public transit link. *Transport Policy*, *21*, 26–36.

Larsen, J., El-Geneidy, A., & Yasmin, F. (2010). Beyond the quarter mile: Re-examining travel distances by active transportation. *Canadian Journal of Urban Research: Canadian Planning and Policy (Supplement)*, *19*(1), 70–88.

Manaugh, K., & El-Geneidy, A. (2011). Validating walkability indices: How do different households respond to the walkability of their neighbourhood? *Transportation Research Part D*, *16*(4), 309–315.

Master plan of the city of Rasht. (2007). Final edition, department of housing and urban development (Guilan), Rasht.

McMillan, T. (2007). The relative influence of urban form on a child's travel mode to school. *Transportation Research Part A — Policy and Practice*, *41*, 69–79.

Millward, H., Spinney, J., & Scott, D. (April 2013). Active-transport walking behaviour: Destinations, durations, distances. *Journal of Transport Geography*, *28*, 101–110.

Morckel, V. C. (2016). Examining the relationships between perceived neighbourhood mobility characteristics, perceived incivilities, travel attitudes, and physical activity amongst university faculty and staff. *Journal of Transport & Health*, *3*(1), 86–95.

Nurul Habib, K. M., & Zaman, M. H. (2012). Effects of incorporating latent and attitudinal information in mode choice models. *Transportation Planning and Technology*, *35*(5), 561–576.

Ory, D., & Mokhtarian, P. (2009). Modelling the structural relationships among short-distance travel amounts, perceptions, affections, and desires. *Transportation Reseach Part A*, *43*, 26–43.

Paul, S., Born, K., McElduff, K., Pendyala, R. M., & Bhat, C. R. (2013). *Exploring the characteristics of short trips: Implications for walk mode choice*. Annual meeting of the transportation research board, Washington, DC.

Prillwitz, J., & Barr, S. (2011). Moving towards sustainability? Mobility styles, attitudes and individual travel behaviour. *Journal of Transport Geography*, *19*, 1590–1600.

Rasht comprehensive transportation planning study. (2011). Final report (final edition), Municipality of Rasht (Andishkar consulting engineers), Rasht, 399.

Rodrı´guez, D. A., & Joo, J. (2004, March). The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D*, *9*(2), 151–173.

Tanishita, M., & van Wee, B. (2017). Impact of regional population density on walking behaviour. *Transportation Planning and Technology*, *40*(6), 661–678.

Yang, Y., & Diez-Roux, A. V. (2012). Walking distance by trip purpose and population subgroups. *American Journal of Preventive Medicine*, *43*(1), 11–19.

Ye, X., Pendyala, R. M., & Gottardi, G. (2007). An Exploration of the relationship between mode choice and complexity of trip chaining patterns. *Transportation Research Part B*, *41*(1), 96–113.