The Effect of Distance Intervals on Walking Likelihood

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Increasing private car ownership and car dependency has led to a low share of walking as an active mode as well as congestion, air pollution, and health problems in developing countries. There is a higher likelihood of walking on mandatory trips at almost all distances than the discretionary ones. Furthermore, investigating individual heterogeneity in different trip distances reveals that people aged less than 14 are more likely to choose walking on mandatory trips longer than 2400 m. Besides, those aged 25–44 years old or above 65 have less tendency to choose walking on mandatory trips with distances of 2000–2400 m and 800–1200 m, respectively. These findings are almost different on discretionary trips; compared to other age groups, people aged 15–24 years are less likely to choose walking on discretionary trips with a distance of 800–1200 m. Moreover, in trip distances of 1200–1600 m, the elderlies have a greater tendency to choose walking compared to other age groups.

transportation | walking distance | mandatory trips | discretionary trips

1. Introduction

The increasing urban sprawl, car ownership, dependency, and the mechanization of urban life have affected people's tendency to walk [1][2][3][4]. Low non-motorized share has resulted in various problems, including congestion, longer travel time, air, and noise pollution, overweight due to diminished physical activity, and staggering economic costs [5][6]. According to the most recent data from the World Health Organization, about 4.2 million people died because of air pollution and the resulting disease. Moreover, more than 1.9 billion adults, 18 years and older, were overweight which over 650 million were obese in the world. Based on this report, 25.8% of people are obese, and 27,000 people died because of air pollution in Iran [7][8]. This has gradually highlighted the necessity of encouraging people to choose active travel modes, such as cycling and walking. There are many reasons for preferring walking among people due to travel-related factors as well as mental, social and environmental health. Walking has many advantages over other transportation modes such as independence from motorized traffic congestion, lack of need for parking, lack of air and noise pollution, low/no monetary cost and improvement in mood and relieving stress [9]. In this regard, local authorities also attempt to increase the share of active travel modes to favor physical activity, improve air quality, reduce the accident rate, lift spirit and mood, and lower inevitable fatalities [9][10].

Identifying factors affecting sustainable transportation modes is essential to increase walking and thus benefit from its potential advantages. This would lead to proper planning and policymaking to achieve the goals and perspectives in encouraging people towards walking [11][12]. Among the critical factors in walking likelihood, most studies have acknowledged distance as a key element. Still, contradictory findings have been seen for different trip purposes, age groups, and environmental contexts [13][14][15]. For example, Larrañaga et al. [16] found that with an increase in trip distance, the probability of choosing walking in work, educational, and recreational trips reduced in Brazil. Hatamzadeh et al. [13] investigated walking likelihood across genders in school trips to study the effect of different distance intervals (increasing by 0.25 miles) on walking likelihood in Rasht, Iran. They found that with an increase in trip distance, the probability of choosing walking reduced, and boys are more sensitive to walking distance than girls. In terms of first/last mile of trips, Paydar et al. concluded that the average preferred walking distance between origin and metro stations is 336 m in Shiraz, Iran [17]. Tsunoda et al. [18] explored the accepted walking and cycling thresholds of Japanese elderlies and found 1 and 2 km as the acceptable distance for walking and cycling, respectively. Besides, Piccioni et al. [19] identified a range of 500 m (0.31 miles) as an acceptable walking distance in an urban environment, intended as the maximum average distance people are willing to travel to reach their destination for both mandatory and discretionary trips. Agrawal and Schimek [20] investigated the effect of socio-economic characteristics and BE variables on the duration and length of walking trips in the USA. They found that the average distance of recreational walking trips is twice as large as that for work trips (1 mile vs. 0.5 miles).

Further, the lowest and highest recreational walking distance belonged to children and adults (30–64 years, 1.25 miles). Hatamzadeh et al. [21] explored the probability of choosing walking for working and shopping trips across genders in Rasht, Iran. They found that, on working trips, the effect of trip distance on the walking likelihood of women was more than men, while on shopping trips, the relationship was vice versa. In addition to the trip distance, many contradictory findings have been reported in the literature about the impact of travelers' age on walking distance and likelihood. For example, Pucher and Dijkstra [22] found that as people get older, the number of walking trips would reduce in the Netherlands and Germany. Moreover, elderlies (aged above 65 years old) walk 25% less than the average number of mandatory walking trips while they walk 39% more than this amount for recreational and exercise trips. Meanwhile, Teshome [23] reported a direct relationship between the probability of walking and age in work trips in Ethiopia, while Rodriguez and Joo [24] reported an inverse relationship in the USA. Larrañaga et al. [16] found that as an individual gets older, the probability of choosing walking decreases on work, educational, and recreational trips in Porto Alegre, Brazil.

According to the above-mentioned research, it can be found that most studies used distance as a continuous variable and did not categorize it into smaller intervals for a more accurate analysis. In addition, the effect of trip distance on walking likelihood in different trip purposes has been studied only for specific groups such as men and women, elderlies or students, limiting the applicability of the proposed model. Further, there are also quite contradictory results regarding travelers' age. Given the different nature of such kinds of trips, in terms of spatial and temporal characteristics, walking behaviors and thus model specifications seem likely to be completely different. Mandatory trips (i.e., work and educational activities) occur at specific places and times.

In contrast, discretionary trips (i.e., shopping and leisure activities) are more flexible and could be even avoided or shifted to off-peak hours in the neighborhood of travelers' residing location by implementing appropriate policies.

2. Individual/Household Characteristics

Individual and household characteristics have frequently been examined in different studies, though inconsistent walking results were reported. Concerning gender, Agrawal and Schimek [20] found that men were 13% less likely to choose walking for recreational, exercise, and access to transit trips than women in the USA. However, there is no significant difference in tendency to walk for work trips and average trip distance across genders. Furthermore, they found that when the income exceeded $30 per day, the extent of walking diminished by 40% for mandatory trips. On the other hand, when the income is higher than $30, the extent of walking for recreational and sports trips grew continuously. In contrast, Larrañaga et al. [16] and Zavareh et al. [25] found that with an increase in income, the likelihood of walking reduced in trips with work, educational, and recreational purposes, while Ton et al. [26] report a negative relationship for high-income households in the Netherlands. In the case of household car ownership, it was found that the number of walking trips for households without a private car was 3.5 times higher than those with at least one [27]. Besides, they found a significant positive relationship between the level of education and the number of discretionary and mandatory walking trips in Portland. In a further study, Khan et al. [28] concluded that as the household size increased, the probability of walking trips increased in Seattle, while Ton et al. [26] reported a negative relationship in the Netherlands. Sehatzadeh et al. [29] found that car ownership is lower in regions with greater walking potentials in New Jersey. They concluded that households were less likely to choose walking with an increase in the number of vehicles. Kaplan et al. [30] concluded that with an increase in household car ownership, the probability of choosing walking reduced. On the other hand, some other studies observed that the number of vehicles per person with a driving license in the household had no significant impacts on choosing walking for students' educational trips in Austin, Texas [31]. Further, higher car ownership had a negative impact on choosing walking for work and shopping trips [32].

3. Trip Characteristics and Built Environment (BE) Variables

The trip-related factors such as trip distance, trip starting and ending time, cost, and trip purpose are other influential factors affecting walking likelihood.

The impacts of distance on walking likelihood were thoroughly discussed in the introduction section [33]. Concerning the departure time of walking trips, Hatamzadeh et al. [13] found that the time of day had a different impact on walking likelihood in educational trips across genders in Rasht, Iran; they concluded that this variable had no significant impacts on girls, while it had a significant positive impact on boys (in the afternoon). Hatamzadeh et al. [21] observed that women were more likely to choose walking in the morning for their working trips than men. Further, on shopping trips, men and women had a greater tendency to walk at 7–8 a.m. or 5–7 p.m. in Rasht, Iran. In another study, Kaplan et al. [30] concluded that walking likelihood is greater at the weekends in Germany.

Many studies have examined the effect of BE variables on walking behavior. To this end, Reid and Cervero [34] proposed the BE variables affecting walking as the following six *Ds* variables: density, diversity, design, distance to transit, destination accessibility, and demand management. According to the studies, people living in high-density urban regions walk more from/to public transportation stations [35]. Furthermore, better network connectivity is associated with an increased number of walking trips [29]. Concerning design variables, T-shaped or three-leg intersections result in poor network connectivity and are considered a barrier to walking.

On the other hand, other junctions (e.g., four-leg intersections) increase network connectivity, thereby providing a greater variety of potential paths for people [29]. Mixed land-use and network connectivity improve accessibility in neighborhoods [36]. Moreover, mixed land use (entropy) is one of the most influential and important variables affecting walking trip behavior [21][37].

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