Beyond the Quarter Mile: Re-examining Travel Distances by Active Transportation

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Résumé
Le transport actif—en particulier la marche et le vélo—suscite un intérêt grandissant chez les professionnels des milieux de l'urbanisme et du transport, qui y voient une solution aux problèmes environnementaux et à la congestion affligeant plusieurs villes. Cette recherche vise à déterminer la distance que les gens sont prêts à parcourir à pied ou à vélo pour atteindre différents types de destinations à Montréal (Canada) et vise à comprendre de quelle façon ces distances varient selon les secteurs, les buts des déplacements et les caractéristiques socio-économiques des individus. Des données provenant de l'Enquête Origine-Destination (O-D) de 2003 sont utilisées pour calculer la distance réseau parcourue par les piétons et les cyclistes et pour caractériser les déplacements et le niveau socio-économique de chaque individu. Alors que la majorité des travaux sur les distances parcourues en transport actif concerne l'accès à un réseau de transport en commun, cette recherche se penche plutôt sur les déplacements à pied et à vélo pour lesquels le but n'est pas d'effectuer un transfert modal. L'analyse des données de l'Enquête O-D révèle que la distance médiane de marche (650 m) est plus grande que le standard de 400 m généralement utilisé, et qu'une variété de facteurs concernant les personnes et l'environnement bâti ont une influence sur cette distance. Bien qu'il n'y ait pas de standard similaire pour le vélo, l'analyse révèle un parcours médian d'environ 2 kilomètres et une variance importante entre les cas. Ces résultats pourront guider les urbanistes, les designers et les décideurs dans la promotion de la marche et du cyclisme, tout en suggérant des pistes de recherche à venir dans ce domaine.

Mots clés: distance parcourue à vélo, distance de marche, diminution en fonction de la distance

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Abstract
Interest in active transportation—especially walking and cycling—is growing within urban planning and transportation circles as a solution to the environmental and congestion issues plaguing many cities. This paper focuses on how far people are willing to walk or cycle for different trip purposes in Montréal, Canada, and how travel distances vary spatially and by individuals' travel purpose and socio-economic characteristics. The research uses the 2003 Montréal Origin-Destination Survey (O-D Survey) to calculate the network distance traveled by pedestrians and cyclists and to obtain travel and socio-economic characteristics for each individual. Whereas walking distance literature often focuses on distance to transit, this paper examines walking and cycling trips where a second transit mode is not the intended destination. Primarily, the paper reveals that median walking distances recorded in the O-D survey (650 metres) are greater than the commonly-accepted distance or catchment area of 400 metres; various personal built environment factors influence these distances. While no widely-held standard exists for cycling, the analysis reveals a median distance of around two kilometres with a high degree of variation in distances. The findings will guide planners, designers, developers, and policy makers and suggest future research directions within the field.

Key words: cycling distance, walking distance, distance decay

Introduction

As cities face the challenges of traffic congestion and greenhouse gas emissions that have emerged from a half century of auto-oriented planning, cycling and walking are increasingly seen as alternatives that may come to bear a greater proportion of the transport burden. Indeed, the benefits of active transportation are manifold: while potentially reducing traffic congestion, human-powered transportation improves personal health, enhances quality of life, and has been linked to economic vitality in urban settings. Interest in promoting active transportation and better planning for this sustainable transportation mode is a shared preoccupation of urban planners, public health officials, and community activists. The conventional wisdom related to active transportation—which generally refers to walking and cycling—is that trip origins and destinations should be brought closer together, facilitating easier access by these modes. Consequently, for integrated land use and transportation planning as well as promoting active transportation, revealing the distance travelled by pedestrians and cyclists for different purposes has become an important field of research.

A great deal of academic attention has focussed on relationships between urban form and travel behaviour in recent years (Cervero 1994; Greenwald and Boarnet 2007; Handy et al. 2002; Saelens, Sallis, and Frank 2003). This understanding has filtered into practice in many jurisdictions and has become policy in the planning of many transit-oriented developments. This has partly come about due to research from the public health field, which has become increasingly concerned with the health consequences of obesity due to inactivity. Recent studies have shown that increasing walkability is directly associated with reducing the health risks of obesity; notably, in areas where a doubling of walking trips to work occur, rates of obesity decline by almost 10 percent (Smith et al. 2008). Increasingly urban planning and transportation fields have aligned with public health to examine the role that non-motorized transportation can play in improving the health and well-being of urban populations.

In recent years, the volume and level of detail of active transportation research has increased dramatically. However, few studies have investigated the relationship between walking and cycling distances for a variety of trip purposes. Most walking distance studies have focused on determining an ideal access distance to a particular transit service, such as bus or light rail (Lam, Morrall, and Ho 1995; Neilson and Fowler 1972; Upchurch et al. 2004; Zhao et al. 2003). The acceptable walking distance to transit is often assumed to be 400 metres, despite a relative dearth of recent empirical evidence to support this (Alshalalfah and Shalaby 2007; Iacono, Krizek, and El-Geneidy 2008). Planners often use 400 metres to define service areas around transit stops; however, recent research has shown that commuters will walk farther to reach certain types of transit than the general guidelines used in many North American cities (Alshalalfah and Shalaby 2007; O'Sullivan and Morrall 1996). A dated but particularly relevant study by Seneviratne (1985) considered walking distance to various destinations in Calgary, Canada, with special emphasis on defining "critical" walking distances to LRT and bus stops and other destinations in the Central Business District. Another study explored access/egress distances to transit as a function of total trip length (Krygsman, Dijst, and Arentze 2004). Reviewing the existing literature on walking distances reveals many opportunities for further research, particularly with regards to trips where public transit is not part of the equation.

Within the field of cycling research, a major focus has been on safety issues associated with bicycle commuters (Aultman-Hall and Adams Jr 1998; Epperson 1995; Hunter, Pein, and Stutts 1995; Kim et al. 2007; Doherty, Aultman-Hall, and Swaynos 2000). Some researchers have emphasized travel behaviour of cyclists more generally (Howard and Burns 2001; Shafizadeh and Niemeier 1997; Williams and Larson 1996). Antonakos (1994) indicated that bicycle travel distance has a strong relationship with trip likelihood and frequency. Others examined the effect of dedicated cycling facilities on distance and found that separated bicycle paths may influence significantly longer trips by bicycle (Krizek, El-Geneidy, and Thompson 2007). However, as with walking trips, relatively little research has directly examined travel distance of bicycle trips in the context of various trip purposes, with the notable exception of a study in the Twin Cities region looking at various modes (Iacono, Krizek, and El-Geneidy 2008). The aforementioned study makes use of distance decay functions, which visualize individuals' willingness to travel a certain distance to reach a common destination. Distance decay curves provide a relatively simple way of understanding this subset of travel behaviour, and can be useful when generating gravity-based measures of accessibility at the neighbourhood level (Hansen 1959; Iacono, Krizek, and El-Geneidy 2010).

Researchers, planners and engineers regularly use walking distances derived from the transit literature for multiple destinations (O'Sullivan and Morrall 1996). This paper argues that walking distances for other purposes must be considered independently in order to derive walking distances for different trip purposes. As travel behaviour studies deal with the complex interactions between individuals (or populations) and their environment, a multi-faceted approach to examining trip distances is advocated. For example, the analysis may be viewed from an economic perspective, highlighting both demand and supply factors that influence non-motorized trips. On the demand side, a comparison of the relative attractiveness of certain destinations is highlighted. Conversely, on the supply side, one might consider how walking and cycling distances reported reflect the local availability of particular types of destinations (supermarkets, for example). This paper focuses primarily on exploring the demand side in Montréal. How far are people willing to travel to different destinations by walking and cycling? How do travel distances vary by individuals' travel and socio-economic characteristics? The paper also touches on supply factors by exploring non-motorized trips originating in various geographic areas in the Montréal region.

The next section introduces the data sources and methodology employed in the research. The subsequent section continues with an analysis of travel distance based on different purposes, which is followed by an examination of walking and cycling distances by geographic location and an analysis of travel distance according to socio-economic characteristics of pedestrians and cyclists. The paper concludes by summarizing the findings from the research and identifying policy recommendations.

Data and Research Methodology

The Montréal Metropolitan Region serves as the case study. The Montréal Metropolitan Region comprises an area of 4,259 square km (1,644 square miles) with a population of 3,635,571 (Statistics Canada 2006). The data required came from different secondary sources. The base data source for the analysis comes from the Montréal O-D survey, conducted by the Metropolitan Transportation Agency (AMT) every five years (surveying 5% of the region's population). Respondents to the survey are asked about all travel they made over the course of the previous 24 hours, including short walking trips (Metropolitan Transportation Agency 2003). The O-D survey is conducted between September and December: travel distances were investigated in light of temperature, but no relationship was found. Montréal's 2003 O-D data contains 329,353 observations: the modal share of walking is 9.3 percent and for cycling is 1.0 percent.

The data presented cover origin-to-destination trips for pedestrians and cyclists, excluding walking trips to transit and return to home trips. The total number of walking and cycling trips considered are 12,831 and 1,421, respectively. Census boundaries and street networks of the Montréal region are obtained from Desktop Mapping Technologies Inc. The street network is modified to exclude freeways and to include special bicycling and walking paths. Network distance linking every origin to every destination is then calculated using a Geographic Information System by plotting individuals' origins and destinations and calculating distances based on shortest path along the modified street network. This may result in artificially long travel distances in peripheral areas, where low connectivity may prompt travel on non-geo-coded paths. A set of distance decay functions for different purposes (namely work, school, shopping, and leisure) based on the network distances are estimated for walking and cycling trips. Spatial auto-correlation for walking and cycling trips is performed to examine the spatial patterns of clustering of long and short travel distances in different regions of Montréal. Travel and socio-economic characteristics of pedestrians and cyclists obtained from the O-D survey are used in analyzing travel distances according to these attributes, with the results tested for statistical significance using ANOVA and T-tests. The outcome for frequency distributions for both walking and cycling travel distances shows single-sided, long-tailed frequency curves; thus the median distance is considered rather than the mean to examine the relationships between travel distance and individuals' socio-economic characteristics.

Trip Purpose

A more nuanced understanding of trip distances for cyclists and pedestrians emerges when this analysis is placed in the context of trip purpose. Distinguishing between different types of trips provides an understanding of the demand for various types of destinations, and places emphasis on local accessibility to services. A summary of walking and cycling distances based on the purpose of trips is shown in Table 1. Median cycling distance for all purposes (2,242 metres) is approximately three or more times higher than the median walking distance

(653 meters), due to the higher speeds associated with bicycle travel. It is important to note that an individual has a limited amount of time during the day that constraints the amount of time dedicated towards travel (Marchetti 1994). As Marchatti (1994) states, people will travel further distances as speed of travel increases but the amount of time spent travelling will remain relatively constant. This notion is reflected in the higher distances associated with cycling and lower ones associated with walking. Four trip purposes—work, school, shopping, and leisure—are considered to examine the distances travelled by walking and cycling for different proposes. Leisure trips are defined as trips with leisure activities as the destination, rather than leisure as the inherent purpose of the trip.

Table 1. Attributes of walking and cycling for different purposes

	All		**Purpose**							
			Work		**School**		**Shopping**		**Leisure**	
	Walk	**Cycle**	**Walk**	**Cycle**	**Walk**	**Cycle**	**Walk**	**Cycle**	**Walk**	**Cycle**
Mean (m)	813	3,140	993	3,886	757	2,273	754	2,204	860	3,360
Median (m)	653	2,242	801	3,067	636	1,550	581	1,529	683	2,318
85^{th} percentile (m)	1,403	5,517	1,789	6,442	1,243	4,355	1,327	3,926	1,572	6,376
Standard Deviation	604	2,792	718	3,001	526	2,012	605	2,145	642	3,158
Number of cases	12,831	1,421	2,381	620	6,259	369	2,591	205	1,600	227
Percent of total sample (%)	100	100	18.6	43.6	48.4	26.0	20.2	14.4	12.5	16.0

Table 1 shows that median distance to work is highest for both walking and cycling followed by median distances to leisure activities. Of the total walking trips, the percentage of school trips by walking is the highest (48.4%), although the median walking distance is 636 metres, which is lower than all but shopping trips. The highest percentage of cycling trips is 43.6% for work; the median access distance is also high for work trips by cycling (3,067 metres). Overall, the 85^{th} percentile of pedestrian travel is 1,403 metres and the 85^{th} percentile of cyclist travel is 5,517 metres in the Montréal Metropolitan Region. The 85^{th} percentile values can be used in defining catchment areas around existing and new destinations. Catchment areas are generally used in land use and transportation planning to define location issues. They are used to understand existing demand as well as ensuring access to the population by a certain travel mode.

Distance Decay Function

Previous studies have suggested 400 metres as a general guideline for comfortable walking distance for most destinations, yet empirical evidence to support this distance remains scarce. Applying a catchment area around a given land use based on the median or 85th percentile rule assumes that people walking or cycling to these destinations are equally distributed in the area; this assumption is not logically sound. The distribution of demand around land use generally follows a decay curve. The decay curves offers variation for trying to understand the level of demand in a catchment area. Accordingly people choosing to reside near a location value it differently from the ones residing far away. This logic follows gravity theory and has been used in understanding demand for transit (Kimpel, Dueker, and El-Geneidy 2007). A set of distance decay functions for four different purposes are estimated for walking and cycling trips using a negative exponential curve. The statistical summaries including goodness-of-fit statistics (R^2 values) for each distance decay function appear in Table 2. Distance decay curves for work and leisure for both walking and cycling are plotted in Figures 1 and 2, respectively. These figures are useful in understanding the distribution of demand for certain destinations and indicate how close these activities should be located to ensure accessibility by walking or cycling for all the population.

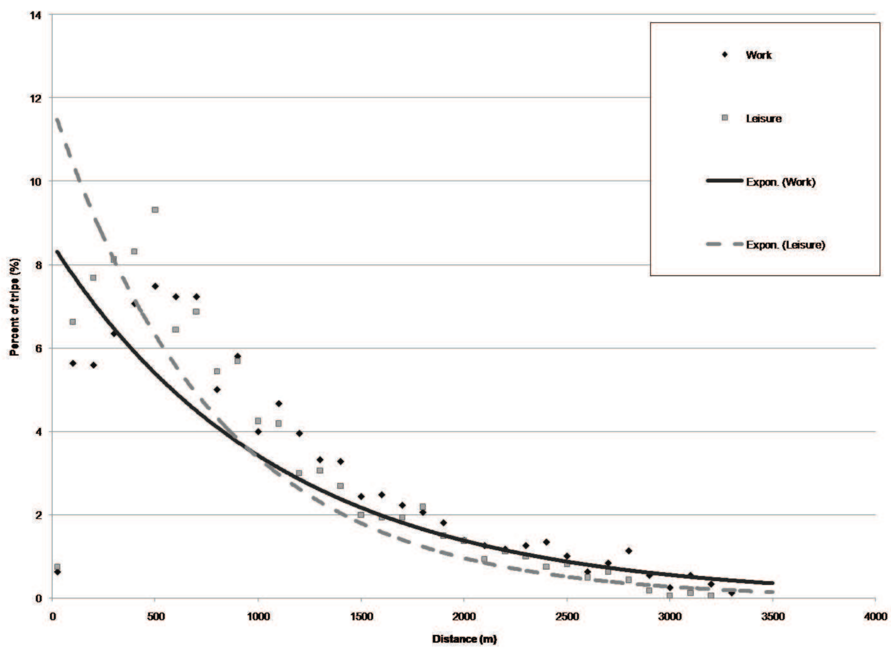
Table 2. Distance decay functions for different purposes for walk and bike trips

Purpose	Walking			Cycling		
	Distance (â)	Constant (á)	Model fit (R^2)	Distance (â)	Constant (á)	Model fit (R^2)
Work	-0.0009	8.4956	0.71	-0.0004	18.641	0.41
School	-0.001	11.392	0.74	-0.001	87.983	0.49
Shopping	-0.001	11.167	0.82	-0.001	184.13	0.50
Leisure	-0.001	11.835	0.76	-0.0006	19.877	0.26

Walking

Table 2 shows that distance decay functions are more similar in case of school, shopping, and leisure trips, while work trips show a more gradually decreasing curve, meaning that more people are willing to walk greater distances to work. Distance decay functions for work and leisure-walking trips are plotted in Figure 1. Figure 1 demonstrates that walking trips extend up to approximately 3.5 kilometres for both work and leisure activities. For short distances, leisure activities comprise a larger share of walking trips; however, for distances greater than 1 kilometre; work trips comprise a greater share. That more people are willing to walk longer distances for work than for leisure activities reveals the more specialized nature of work activities, whereas leisure destinations can be accessed closer to home. This contrasts with past findings from Minnesota, where leisure and entertainment constitute the longest trips (Iacono, Krizek, and El-Geneidy 2008); however, the difference may be due to the definition of leisure in the Montréal O-D survey.

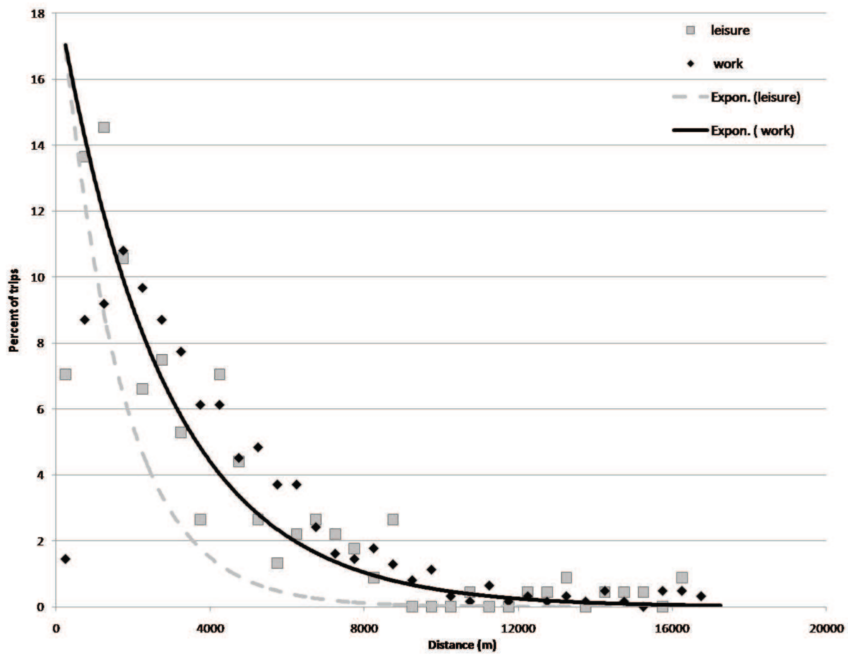
Figure 1. Distance decay curves for walking trips



Cycling

Distance decay curves for bicycle trips including work and leisure trips are presented in Figure 2. There is a greater variation in the distribution of distances among cyclists than among pedestrians. Median cycling distances are nearly four times greater than walking trips. This supports Marchetti's (1994) constant travel time theory mentioned earlier. The fitted curve indicates that the vast majority of bicycle trips for work purposes are less than 5 kilometres, while most leisure trips recorded are less than 3.5 kilometres. Notably, the curve for work trip distances decreases much more gradually than that for leisure trips, indicating that like pedestrians, cyclists are generally willing to travel greater distances for work than other purposes. This, too, contrasts with the Twin Cities study (Iacono, Krizek, and El-Geneidy 2008) which may be explained by the inclusion of cycling trips for fitness purposes (which tend to be longer than bicycle trips to leisure destinations) in the Twin Cities region. Unfortunately, with the data available it is not possible to compare the questions asked in the two surveys.

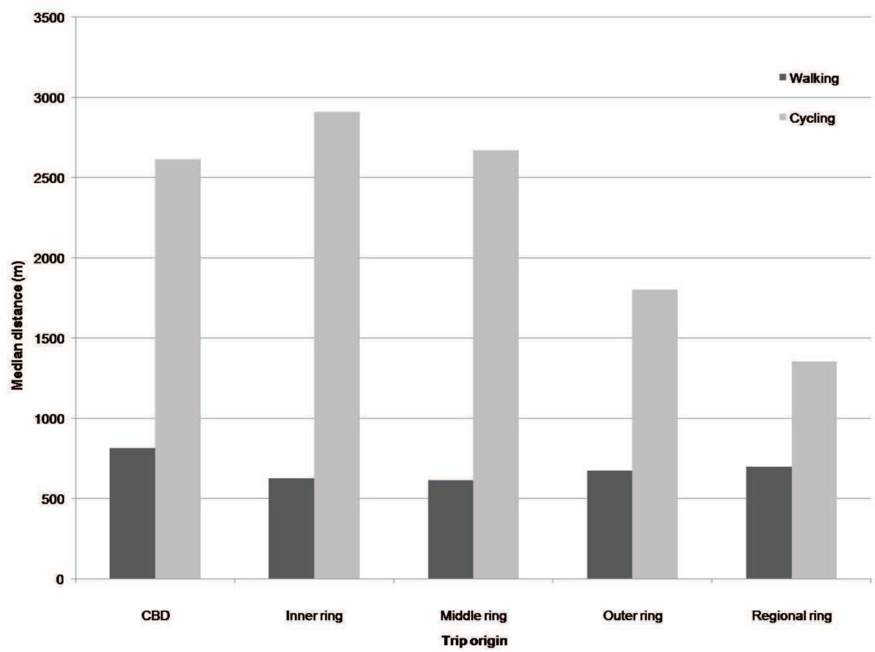
Figure 2. Distance decay curves for bicycle trips



Trip Origin

For purposes of this research, the Montréal Metropolitan Region is divided into five areas using the city's borough and neighbouring municipality boundaries as shown in Figure 3 and 4. Beginning in the city core, the regions are: 1) Central business district (CBD); 2) Inner ring; 3) Middle ring; 4) Outer ring and 5) the Regional ring. Among five regions, the CBD has the highest median walking distance (813 metres). The percentage of walking trips originating in this region is the lowest (6.6 percent), likely due to its relatively small area and population. The analysis shows that with increasing distance from the CBD, the median walking distance decreases up to the middle rings and then increases in the outer and regional rings. The scenario is different in case of cycling trips; the highest median distance of 2,910 metres is found in the inner ring. Trips originating in the inner ring involve greater distances by cycling than trips from other regions, though median cycling distances within the middle ring and CBD are near to those observed in the inner ring. Although the median walking distances of the outer ring and regional ring are marginally higher than those in the middle ring, median cycling distances in the outer and regional ring are much lower than those in the other three regions.

Figure 3. Median walking and cycling distances in regions from the city centre

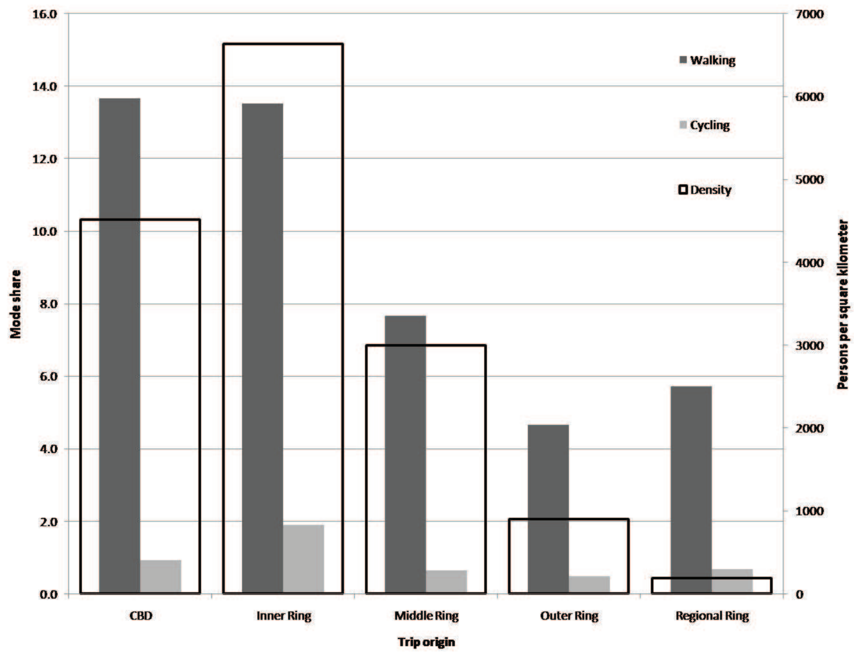


Spatial auto-correlation for walking and cycling trips is performed to examine the spatial patterns of clustering of long and short distances originating in different regions. The results for walking trips shown in Figure 4 reveal a clear pattern between clusters of long and short distance trips within the regions. Trips originating in the CBD and inner ring have longer walking distances than those from other areas, whereas an especially dense cluster of low distance walking trips is observed in the middle ring. Interestingly, this clustering of short distance walking trips occurs immediately adjacent to a cluster of long distance walking trips in the inner ring. Spatial auto-correlation was also performed for cycling trips to understand the spatial pattern within different regions: the results did not reveal any general clustering patterns, possibly due to the small sample size for cycling trips.

Figure 4. Long and short walking distances originating in different parts of the Montréal Region

In order to better understand the travel distances observed in the various geographic sub-regions, an examination of the built environment in these areas is performed. Figure 5 compares the share of walking and cycling trips in each region to the residential density (persons per square kilometre). This finding is consistent with other studies which have found close links between active modes of transportation and the built environment (Handy et al. 2002; Saelens, Sallis, and Frank 2003). In this case a simple density approach helps provide generalizations for future studies. A close relationship obtains between the density of inhabitants and walking and cycling, with a few notable exceptions. There is as great a share of walking trips originating in the CBD as in the inner ring, yet a lower residential density than the inner ring; this is likely due to the density of destinations, which contribute to a high walk share. As observed from Figure 3 the CBD and the inner ring had the highest distances traveled by walking and cycling in term of median distances. Likewise, at the periphery, while residential density decreases between outer ring suburbs and the regional ring, walking and cycling rates increase. The study does not explain whether this is due to aesthetic considerations, route conditions or a combination of aspatial factors beyond the scope of the research. However, this finding lends weight to research that suggests that other factors such as land use mix, urban form, and residential self-selection may partly explain walking and cycling patterns (Forsyth et al. 2007).

Figure 5. Population density and percentages of walking and cycling trips originating in different parts of the Montréal Region



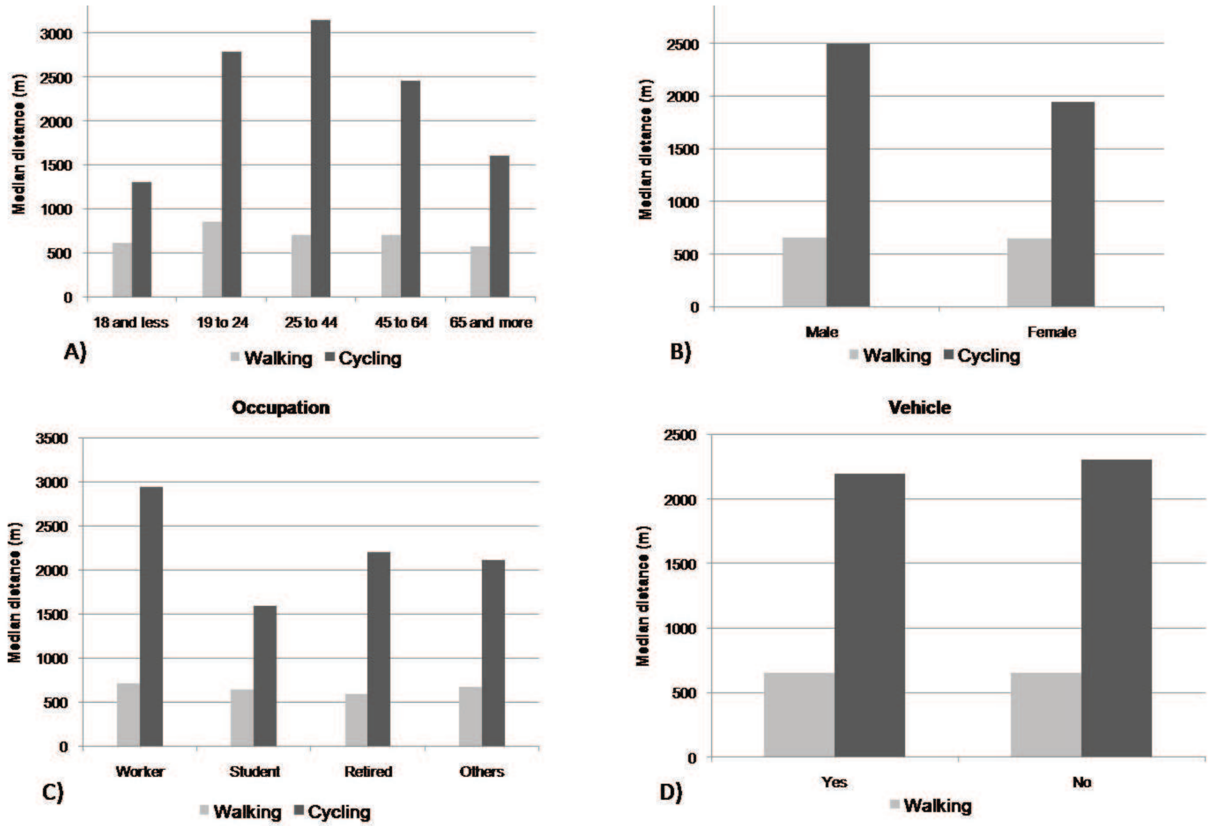
Socio-economic Characteristics

This part of the analysis focuses on how travel distances vary with the individuals' socio-economic characteristics. It includes four demographic and socio-economic attributes (age, gender, occupation, and motorized vehicle availability) in order to understand any relationships with median distance travelled.

Age Groups

Figure 6(a) shows the relationship of age to walking and cycling distance. For the median walking and cycling distances, the observations are different with a statistical significance at the 99 percent confidence level. The age groups showing the greatest number of walking trips are below 18 and over 65 years of age; they represent 54.7 percent of the total walking trips, likely due to lower rates of car ownership in these age

Figure 6 Median distance based on socio-economic characteristics: (a) age groups; (b) gender; (c) occupational status; and (d) availability of motorized vehicle



groups. Figure 6(a) indicates that median walking distances for children and seniors are slightly shorter than other age groups. Not surprisingly, walking trips comprise a greater proportion of all trips by seniors (8.1 percent) than cycling trips within the same population (2.1 percent).

Trip distances travelled by children (1,300 metres) and seniors (1,604 metres) are shorter than the distances travelled by cyclists observed within the age group of 18 to 65 years old. The highest median distance (3,142 metres) travelled by the cyclists is observed in the age group of 25 to 44 years. However, in terms of walking distances observed, there is a far lower level of variability. In general, an especially strong relationship exists between the age of the individuals and the distance they are likely to bicycle. This finding points to the need for measures to improve the sense of security for vulnerable users of the road.

Gender

Figure 6(b) shows the relationship between median travel distance and gender of survey respondents, which is significant at the 95 percent confidence level. Previous studies indicated that men represent a larger percentage than women of all cycling trips (Cynecki, Perry, and Frangos 1993; Moritz 1998; Williams and Larson 1996). This analysis finds a similar result where 67 percent cyclists are male and 33 percent are female. The relationship is not present for walking trips. Although the difference in median walking distance between men (657 metres) and women (648 metres) is low, it is significant at the 95 percent confidence level. The analysis shows a clear and strong difference of median cycling distances based on gender; male cyclists are willing to travel greater distances (2,493 metres) than the female cyclists (1,942 metres), an observation that supports previous findings (Howard and Burns 2001) and is significant at the 99 percent confidence level. The differences observed in cycling rates and distances between women and men suggest that specific strategies targeting women may have beneficial results.

Occupation

Figure 6(c) shows the relationship between the occupation of pedestrians and cyclists and median travel distance by walking and cycling. The median walking and cycling distances for people of different occupational status are significant at the 99 percent confidence level. Workers have the highest median walking distances, with students, retired persons and others all slightly lower. This may be due the specialized nature of work locations, requiring workers to travel greater distances. In terms of the overall proportion of walking trips, students make more trips (54.9 percent) than other occupations, such as workers (28.6 percent) and retired persons (11.2 percent). This is likely due the lower rates of vehicle ownership among students and minors. On the other hand, workers make more cycling trips (53.1 percent) than other groups such as students (37.9 percent) and retired persons (4.5 percent) and travel greater distances both for walking and cycling trips than other groups. Only 2.1 percent of cycling trips are made by seniors. The unexpected result is that retired persons travel greater distances than students; however, the percentage of retired persons is very low.

Availability of Motorized Vehicle

In Figure 6(d), the availability of a motorized vehicle in the household is examined for its influence on median walking and cycling distances. In Montréal, those who reported walking and cycling trips in the O-D survey had similar rates of motorized vehicle ownership in their households. About 70.5 percent of pedestrians and 68.3 percent of cyclists have at least one motorized vehicle in their household. In the case of walking trips, the difference between these two modes in terms of median distances is negligible. Cyclists travel greater distances to reach different destinations when the household does not possess any motorized vehicle (significance level 90 percent). The result may indicate that motorized vehicle availability has an influence on median travel distance, though less so in the case of walking.

Conclusions

With a view to promoting sustainable modes of transport, this paper focused on how far people are willing to travel for different purposes and destinations by walking and cycling in the Montréal Metropolitan Region. The research examined how travel distances vary by geographic location and individuals' travel and socio-economic characteristics with an aim to filling some of the gaps in active transportation and travel behaviour research. Primarily, the study revealed that median walking distances recorded in the Montréal Origin-Destination survey are greater than the commonly-accepted distance of 400 metres used as a planning guideline. The results suggest that people in Montreal typically walk longer than 400 metres: factors such as geographic location (origin) and trip purpose influence trip distance. Land use and transportation planners and engineers can use such information to determine catchment areas and understand the level of access to services through walking and cycling in Montréal. In the Montréal region, the median walking distance is approximately 650 metres and is higher (800 metres) for work purposes.

Rather than suggesting a new standard for walking distances, the research points to the application of the distance decay function as a tool for accurately predicting walking distances. While no widely-held standard exists for cycling, the analysis reveals a median distance of around two kilometres with a high degree of variation in travel distance, particular by age, gender, and geographic area. The findings point to the need to target specific populations and areas to increase both rates of cycling and distances cycled.

Distance decay functions for both walking and cycling reveals that work trips have the most gradually declining curve, meaning that people will cycle and walk farther for work than they will for other purposes in Montréal. This finding is coherent with the specialized nature of work, requiring individuals to travel greater distances to access particular locations; however, the findings contrast with past research (Iacono, Krizek, and El-Geneidy 2008) which found walking and bicycle trips longest for leisure and recreation purposes.[1] School trips and trips for children are relatively short distances yet comprise the largest percentage of walking trips. Seniors as a group represent the second highest proportion of walking trips. Gender analysis of travel distance reveals that the median cycling distances are higher in case of men than for women, although walking distance appears not to be affected by gender. Planners need to give greater attention to understanding these groups' needs in terms of walkable and cyclable communities.

The findings here apply only to the Montréal Metropolitan Region; caution should be made in making generalizations. Since the goal was to understand how far people are willing to walk or cycle to certain destinations, the analysis focussed on generalized trip purposes. More detailed analysis to explain some of the findings would need to incorporate the effects of built environment, social attitudes, residential self-selection, the timing of the trip, or the availability and condition of walking and cycling facilities. Better information about precise routes would improve the analysis, since pedestrians and cyclists generally use short cuts which could not be modeled on the existing road network. Future research should aim towards this higher level of detail.

Drawing on the findings of detailed case studies of particular urban practices and experiences will allow planners, designers, developers, and policy makers to create appropriate pedestrian and cycling facilities and urban environments that will help people reach their varying destinations by active modes of transport.

Note

[1] If comparative analyses are to be performed between regions, variation between travel surveys will have to be addressed to deal with differences in concepts such as "leisure travel."

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