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The Determinants of Walking Behavior before and during COVID-19 in Middle-East and North Africa: Evidence from Tabriz, Iran

Mohammad Javad Kamelifar [1], Behzad Ranjbarnia [2] and Houshmand Masoumi [3,4,*]

1 Tabriz Metropolis Municipality, Tabriz 5174643119, Iran; m.javad_kamelifar@yahoo.com
2 Department of Geography and Urban Planning, Faculty of Planning and Environmental Sciences, University of Tabriz, Tabriz 5166616471, Iran; b.ranjbarnia@gmail.com
3 Center for Technology and Society, Technische Universität Berlin, Kaiserin-Augusta-Allee 104, 10553 Berlin, Germany
4 Department of Transport and Supply Chain Management, College of Business and Economics, University of Johannesburg, Johannesburg 2006, South Africa
* Correspondence: masoumi@ztg.tu-berlin.de

Abstract: To support the global strategy to raise public health through walking among adults, we added the evidence on predictors of walking behavior in the Middle East and North Africa (MENA) region by emphasizing the mediator—COVID-19. During the COVID-19 outbreak, public restrictions to encompass the spread of the disease have disrupted normal daily lifestyles, including physical activity and sedentary behavior. It was proposed that tremendous changes have occurred on predictors of physical activity in general and walking behavior in particular for three types of walking, including commute, non-commute, and social walking compared to pre-COVID-19 time. This study aimed to identify the determinants of the walking types mentioned above, including subjective and objective variables before COVID-19, and compare them during the COVID-19 period in a sample from Iran, which has not yet been addressed in previous research. Adults (N = 603) finalized an online survey between June 5 and July 15, 2021. This group reported their individual/socioeconomic locations (e.g., home/work) and perception features before and during COVID-19. The paper developed six Binary Logistic (BL) regression models, with two models for each walking type (commute, non-commute, and social walking). For commute trips before COVID-19, the findings showed that factors including BMI, residential duration, p. (perceived) neighborhood type, p. distance to public transport stations and job/university places, p. sidewalks quality, p. facilities attractiveness, p. existence of shortcut routes, commute distance, building density and distance to public transport were correlated with commute walking. At the same time, such associations were not observed for BMI, p. distance to public transport and job/university places, p. facilities attractiveness, building density, and distance to public transport during COVID-19. The variables include age, possession of a driving license, number of family members, p. neighborhood type, p. distance to grocery, restaurant, parking, and mall, p. existence of sidewalks, land-use mix, and distance to public transport indicated correlations with non-commute before COVID-19. However, p. distance to groceries and malls and the p. existence of sidewalks did not correlate with non-commute walking during COVID-19. Ultimately for social walking, age and income variables, and the considerable proportions of subjective variables (e.g., p. distance to services/land-uses, security, etc.), health status and building density were correlated with social walking before COVID-19. Nevertheless, most of the mentioned variables did not explicitly correlate with social walking during COVID-19. As for the implication of our study, apparently, special actions will be needed by urban authorities to encourage adults to enhance their walkability levels by fully considering both objective and subjective indicators and walking types, which will result in healthier lifestyles.

Keywords: transportation planning; urban travel; walking behavior; COVID-19; Middle-East and North Africa

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1. Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has infected millions worldwide [1,2] and impacted many more. Because of its transmission from person to person [3], many developed and developing countries (e.g., USA, England, Turkey, Iran) implemented interventions to induce mobility restrictions and forced their citizens to stay at home (i.e., confinement), to reduce the transmission rate and prevent health services from being overwhelmed, unless shopping for basic necessities, attending to medical issues, engaging in one form of exercise a day (e.g., a run, walk, or cycle), or if employed in an essential job [4]. These facts changed the lifestyle of most people, engaging them in less physical activity and more sedentary behavior than pre-COVID-19 times due to imposed restrictions [5]. For example, according to a report from Google Mobility (2020), as of 23 June, substantial decreases occurred in access to services such as retail and recreation (−48%), supermarket and pharmacy (−10%), public transport (−48%), and workplaces (−51%) during the pandemic in the United Kingdom. Considering that physical inactivity is one of the key risk indicators for chronic illness and all-cause death [6], such limitations on human mobility may have negative health effects in the long run. Consequently, research on the effects of the pandemic on changed patterns of physical activity predictors can be considered a global public health need [7]. Such need is also considered more substantiated in developing countries than developed ones due to insufficient health data and infrastructures.

Accordingly, examining the factors that facilitate walking during quarantine and lockdown periods and comparing it with pre-COVID-19 time may assist in developing strategic initiatives aimed at offsetting negative consequences [8,9]. Based on the literature, various factors influence physical activity, including objective [10,11] and subjective [12,13] measures. The emerging literature in recent years has tried to investigate the relationship between objective or subjective neighborhood characteristics and active transportation behavior [14–18]. These studies support realizing the determinants of walking behavior better and an inclusive analytical framework for walkability research. However, the volume of these studies in scope and geography is rare in developing countries, and more investigations need to be conducted. In addition, employing an integrated approach (using objective, and subjective factors simultaneously) is significantly scarce in previous studies. To the best of our knowledge, no study has yet compared and modeled the determinants of walking behavior before and during the pandemic; there are research gaps in the mentioned areas.

There is a need to grasp better the role of independent variables in shaping various types of walking in different contexts in terms of the mediator, COVID-19 outbreak. This article has taken three modes of walking, including commute, non-commute, and social walking (with a partner/friend), as dependent variables. This approach will help planners and stakeholders have a comprehensive and accurate understanding of the objective and subjective determinants of walking in metropolitan areas of developing countries. Accordingly, the research objectives are to undertake micro-scale studies to: 1—identify the determinants of walking behavior of adults for job-traveling, non-commute, and social walking purposes in the large cities of developing countries; 2—compare the walking behavior determinants for commute, non-commute, and social walking purposes before and during the outbreak of COVID-19.

The rest of the article contains the following units. Section 2 reviews the existing literature on the concept of walking behavior determinants of various types, the impact of the COVID-19 pandemic on walking behavior, and these studies' situation in developing countries. In Section 3, we briefly discuss the employed methods in this paper. Subsequently, in Section 4, we present a summary of results from statistical methods. Section 5 discusses the model similarities and differences of walking behavior determinants before and during the outbreak of COVID-19 and compares the findings with those conducted for developed countries. Ultimately, Section 6 includes the conclusion.

2. Literature Review

2.1. Objective and Subjective Measures of Walkability

Walkability is the supporting characteristic of complete, sustainable, and healthy cities. Walkable surroundings can encourage physical activity through determined or entertaining walking, subsequently adding social value to the public and acquiring healthy life [19,20]. Accordingly, walking behavior is influenced by ample factors addressing, environmental (objective) and psychological (subjective) contexts. Opportunity is conceptualized as encompassing both the subjective (perceptive wellbeing, security, neighborhood type, etc.) and objective (e.g., environment, distance, variety) contexts that constrain or enable a behavior. Additionally, individual characteristics should not be waived for these analyses.

Some studies have considered relationships between walking and primarily socioeconomic factors, including age, income, gender, education, BMI, work status, marital status, having a dog, having school-aged children, social distancing practices, physical/mental health condition, infection status, and previous activity level [21–26].

Objective indicators of walkability have been predominantly employed in walkability studies more as commute walking determinants. Of importance, certain environment attributes are related to increased walking by community members. Previous studies have incorporated explicit measures of environmental attributes (e.g., [27–29]), or have developed composite factors for exploring the relation to walking behavior [30,31]. Among environmental factors, land-use and connectivity measures are two main categories whose effects have been studied previously [32,33]. These variables calculate the built neighborhood's design, density, and diversity quantitatively [34,35]. The most common indicators in these studies list factors including building and population density [36], land-use mix diversity [11,37,38], land-use mix access [37], street connectivity [30,38], visual dimensions of a place such as lighting [39], etc. These indices have been proven useful in explaining walkability in different metropolitan areas [40,41].

Despite the importance and rich background of objective measures in explaining walkability, others have emphasized the subjective variables in interpreting behavioral consequences of environmental walkability [30]. Yet, a big body of the study has admitted that perceived walkability is equal to the built environment variables [42,43] if not more significant when considering predictors of the walking behavior [44]. The subjective dimension favors individual values and beliefs shaped by social contexts and personal experiences [45], meaning perspectives and experiences of environments are unique between individuals, particularly those living in different spaces. Many studies have demonstrated the merit influence of subjective factors, including safety, neighborhood type, wellbeing, etc., on walking behavior [46–48]. The study results presented by French et al. (2013) indicated that perceived behavioral control was the key determinant of walking, mostly in non-commute walking [49]. Lee (2016) explains that neighborhood perception and safety are important factors determining walkability [50,51]. Factors such as lifestyle and wellbeing, beliefs, and personality could influence travel behavior [52,53]. In some cases such as in non-commute walking, "as mentioned", their effect has been reported greater than the impact of the built environment [54]. However, a review of the effects of workplace relocation on commuting mode change showed that perceptive variables were poor predictors of commuting mode change when relocating workplaces [55].

Apart from debates on both commute and non-commute walking, another type is regarded as social walking or walking with a companion. This type of walking has been investigated very shortly compared to those mentioned. In a universal context, very few studies have investigated the determinants of companion walking. In terms of predictors of walking accompanied by someone, a large body of studies has focused on health status [56,57], socio-economics (e.g., gender, income, age) [58,59], individual perceptions [60,61], and environmental factors (very limited factors including accessibility) [62,63]. The integrated approach is very short and inconsistent, which needs to be more thoroughly investigated.

Overall, the literature review regarding both objective, and subjective measures shows that although walking behavior has been defined with different travel variables, most studies have only used one measure for their analysis and do not follow an integrated approach. The review also shows that environmental factors are the most widely investigated characteristics among various explanatory factors, and the effects of subjective factors on walking behavior are limited.

2.2. Impact of COVID-19 Pandemic on Walking Behavior

Undoubtedly the imposed mobility restrictions that were executed to decrease the spread of the COVID-19 pandemic have affected walking behavior. Still, these variations' extent and spatial-psychological characteristics have not been thoroughly confirmed yet. Much less is known about the differential impacts of COVID-19 response measures on the walking behavior of populations. Although there is an evolving body of literature measuring the possible impact of COVID-19 upon walking and physical activity, Sallis et al., emphasized the requirement for more investigations on this topic [7]. In 2020, researchers from different nations (e.g., Belgium, Canada, Greece, USA, Australia) measured walking behavior changes resulting from their diverse COVID-19 restrictions. Summarizing these research studies, physical activity was lower during COVID-19 restrictions than before restrictions were put in place [64,65]. People's fear of being in public places is also expected to reduce outdoor activity [23,66]. However, other research suggests that the pattern of behavior may be more complex. Cheval et al. (2021) reported a rise of about 10 min in walking and moderate physical activity and an increase of roughly 75 min in sedentary behavior between adults in Switzerland and France. While some activities (e.g., walking for commuting) have been reduced, other activities (e.g., working out indoors) have gone up [67]. However, this assessment similarly endorses the substantial between-individual differences in the impact of the restrictions on physical activity. Research has yet to compare potential changes in physical activity before and during COVID-19 and how walking behavior determinants may have changed.

Changes in social life and the daily routine (i.e., loneliness) and the imposed stress on individuals (insecurity about their health or financial consequences) have also been reported to affect sleep patterns negatively [68,69]. Despite the attempts to indicate the changes and determinants in physical activity [67,70], the evidence is still limited. In addition, very limited studies and comparisons have been accomplished on determinants of walking behavior before and during the lockdown. Further, all previous studies on this topic have used subjective tools; therefore, objective and quantitative ways to monitor population behavior are required to determine the integrated impact of the various objective and subjective indicators on walking behavior to suggest strategies for possible confinements soon. In sum, this integrative approach is particularly relevant in the context of the COVID-19 crisis, which has caused sudden changes in people's work, family, and living environment. This necessitates performing comparative studies to understand changes in determinants of walking behavior.

To investigate the relationships between both environmental (objective), perceptive (subjective) factors as an independent variable, and walking (commute and non-commute walking and having a companion) as a dependent variable before and during the COVID-19, we adopted the same model comparison approach.

2.3. The Condition in Developing Countries

Investigation on walking behavior determinants in a universal context is sparse and inconsistent. Previous studies regarding objective and subjective factors on walking were mainly conducted in developed countries such as the United States [71], Canada [72], the United Kingdom [73], and Australia [74]. Studies examining the perceptions and attitudes that impact walking behavior for neighborhood travel are scarce in developing countries. These nations have different social, historical, cultural, and environmental characteristics relative to developed countries, and thus the psychological factors influencing people's walking behavior in these countries may also differ from those in developed countries [75].

New evidence from developing countries can help us refine our understanding of the attitudinal and perceptual factors that determine people's level of walking.

The previous works in developing countries are even more dramatically scarce. For example, most of these studies have been conducted in Turkey [76], Brazil [77], and Iran [78,79]. For example, some studies in Iran have been conducted on children/adolescents' walking behavior, particularly in some cities, including Tehran, Yazd, Rasht, and Kerman [80,81] with no consideration for the integrated approach. These studies analyzed a wide range of policy-sensitive variables. They found that walking time to school, car ownership, and safety concerns negatively impacted active traveling to school. In the area of adults/seniors, these studies are even rare. In a more recent study by Hatamzadeh and Hosseinzadeh (2020), they concluded that the top priority policy that may lead to a higher probability of choosing walking as a mode of transportation among adults is to plan for higher mixed-use developments that could afford more accessibility and make the neighborhood more stimulating for the adults which could itself raise the inclination to walk and as a result increase the various group's engagement [82].

From what was mentioned in the literature review, these gaps can be identified:

Apart from existing contextual gaps in developing countries (North Africa and Middle-East in particular) regarding walking behavior determinants, the lack of employing the integrated approach (using both objective and subjective determinants of walking behavior simultaneously) in most universal studies is observed. Further, to the best of our knowledge, the impact of the COVID-19 pandemic as a mediator on walking behavior, along with comparing it with the before-COVID-19 period, has not yet been addressed in both developed and developing countries. Ultimately, taking into consideration the different modes of walking (commute, non-commute walking, and social walking) as dependent variables is innovative in these countries, which is what this research aims to address.

This paper aims to answer the following questions to identify both subjective and objective determinants of walking behavior in the understudied context of MENA:

(1) What factors determine the walking behavior of adults for the commute, non-commute, and social walking purposes during COVID-19 in the large cities of the MENA region?
(2) Have the determinants of walking behavior for commute, non-commute, and social purposes changed after the outbreak of COVID-19 in the MENA region?

We hypothesize the existence of a huge difference between walking behavior determinants before and during the COVID-19 pandemic. In addition, we hypothesize that subjective factors have the most significant impact on changing the walking behavior after the outbreak of COVID-19 in the large cities of the MENA region. Social walking is affected by the pandemic more than other types of non-commute and commute trips. This paper assumes that both subjective and objective determinants of walking behavior for commute, non-commute, and social purposes have different patterns before and during the outbreak of COVID-19 in the MENA region. The effects of subjective measures on walking behavior have changed more radically after the pandemic compared to objective factors. The subjective factors including perceived accessibility to neighborhood facilities, subjective walkability, perceived attractiveness of facilities, perceived security, and subjective wellbeing have had stronger significant differences between pre-COVID-19 times and after the pandemic. The objective measures that have had significant differences before and after the pandemic include accessibility to public transport stations and construction density.

3. Materials and Methods

3.1. Case Study

Tabriz is the fourth largest city of Iran and one of its metropolitan towns with approximately 1.6 million citizens (2021). It is located in the northwest of Iran and is the most populous and largest city. This city is regarded as one of the top industrialized cities within the country of Iran with a high rate of pollution as a result of cars and factories emissions. This city is regarded as one of the top industrialized cities within Iran, with a high rate of pollution due to cars and factories emissions. Like any other big town in Iran, this city has witnessed rapid transformation during the last 25 years. The city was selected as the first healthy city of Iran in 2020 [83]. The geographical characteristics of Tabriz are listed in Table 1.

Table 1. Geographical Characteristics of Tabriz.

Key Features	Tabriz
City (km^2)	325 km^2 (125 sq. mi)
Urban Area (km^2)	512 km^2 (198 sq. mi)
Divisions	10 Districts
Urban Planning Governance	Tabriz Municipality
Urban Transportation System Governance	Organization of transportation and Traffic
Availability of city-wide Urban Development Plan	Yes (2013)
Availability of city-wide Strategic Transportation Master Plan	Yes (2019)

Changes in urbanization after the emergence of modernism in urban planning have destroyed the traditional elements and structures of the city. Moreover, functional zoning has replaced the organic system and functional diversity of city and urban neighborhoods. Consequently, walk-friendly neighborhoods altered, and the overall walkability of the city has decreased dramatically. It is to say that the establishment of the BRT system started about 15 years ago to lessen the heavy traffic of its main street, and recently one of the metro lines has started serving people. However, this city suffers from a lack of sufficient and high-qualified public transportation systems moving many citizens to use private cars in their commutes.

3.2. Data and Variables

This study is based on data collected from an online questionnaire survey conducted between 5 June to mid-July 2021 and secondary data using a 1.2000 GIS map (objective). Respondents provided detailed information about their individual characteristics, perceptions of their neighborhood, mode choice for commute, non-commute, social trips, and health status. Of the 1090 people who started the survey, only 668 respondents completed enough questions to be used in these analyses. Some were removed during the modeling procedure due to item non-response (603 remained). The total sample size was 603 and is representative of Tabriz city, according to Cochran (1963). This paper comprises exploratory research aimed to identify walking behavior determinants and provide insights into their variation before and during the outbreak of COVID-19 in large Iranian cities, and as an example, for large MENA cities.

Socioeconomic characteristics, mode choice, participants' perception, health status, and built environment (objective) variables are presented in Table 2. The variables are classified into binary, continuous, and categorical variables. Continuous variables are age, monthly income, BMI (body mass index), residential duration, number of family members, commute distance, land-use mix, distance to public transport, and building density. Categorical variables include neighborhood type, access to different services, neighborhood environment, facilities attractiveness, walkable places, security, wellbeing, and health status.

Table 2. Socioeconomic, subjective, and objective variables.

Variables	Description and Coding
Age	Continuous
Gender	Female = 1, Male = 0
Education	Diploma and Undergraduate = 1, Bachelor = 2, Master = 3, PhD and higher = 4
Income	Continuous
Possession of Driving License	Yes = 1, No = 0
BMI	Continuous
Number of family members	Continuous
Residential Duration	Continuous
Neighborhood Type	Less than 2 floors = 1, 2 to 6 floors = 2, 6 to 10 floors = 3, 10 to 20 floors = 4, more than 20 floors = 5
Cul-de-sac	From 1 = very little to 5 = very much
Distance to Different Services	Less than 5 min = 1, 5 to 10 min = 2, 10 to 20 min =3, 20 to 30 min = 4, More than 30 min = 5
Perceptive Neighborhood Environment (1. Existence of trees across the street, 2. Existence of architecturally attractive buildings and houses, 3. Existence of attractive scenery for walking, 4. Suitable slope of streets for walking, 5. Existence of Suitable urban furniture and benches at short distances)	From 1 = very little to 5 = very much
Perceptive Walkable Places (1. Existence of sidewalks, 2. Separation of street from sidewalk by green spaces, 3. Existence of shortcut routs)	From very little = 1 to very much = 5
Overall Quality of Sidewalks (Width, attractiveness, quality of materials and ups and downs)	From very bad = 1 to very good = 5
Facilities Attractiveness	No existence = 1, Not attractive at all = 2, Not very attractive = 3, Medium = 4, Acceptable Attractiveness = 5, Very attractive = 6
Perceptive Security (1. The streets of the neighborhood are not well lit at night, 2. Due to the crime rate, our neighborhood is not secure enough, 3. There is a lot of traffic on the streets around our neighborhood making walking difficult and unpleasant, 4. There are no pedestrian crossing signs on the busy streets of our neighborhood, 5. The streets do not have speed bumps)	From Strongly disagree = 1 to Strongly agree = 4
Wellbeing and Health Status (1. Feeling of Depression, 2. Feeling of Anxiety, 3. Feeling of Being Energetic, 4. Feeling cheerful and cool, 5. Emotionally stable and confident, 6. Overall Health status)	From Very Low = 1 to Very High = 10
Objective Built Environment (Commute distance- Distance to public transport- Street length, Land use mix, Number of Intersections, Building & Population density)	Continuous
Travel Mode Choice	Walking = 1, Other modes (e.g., Private car, Public transport, Metro and . . .) = 0

3.3. Analysis Methods

We developed six binary logistic (BL) regression models using travel mode choices (walking and other types of trips) as the dependent variables to determine the influencing factors. Three BL regression models were generated for commute, non-commute, and social walking before COVID-19; we then repeated this process for the mentioned walking types during the outbreak of COVID-19. The Six BL models for walking behavior determinants showed how different they were before and during the pandemic. Through the six models, the determinants of walking behavior were established based on the perceptions of residents (subjective), and the built environment (objective). The first round of BL models used 42 variables as independent variables. Variables were then eliminated from the BL models based on the highest *p*-value. This process was repeated until a suitable model was achieved based on significant variables and a higher value of Nagelkerke's R^2. An Omnibus test reveals the validity of the BL models with significant variables (*p*-values of less than 0.05) and higher Nagelkerke's R^2 values.

4. Results

4.1. Descriptive Statistics

The survey respondents were 603 residents of Tabriz city. In connection with gender, 59.2% of respondents were women, while 40.8% were men. Although they came from diverse age groups, the least represented group was the 18s, and the majority of respondents were aged between 28 and 40 at the time of the survey. The detailed statistics regarding gender and age can be found in Figure 1.

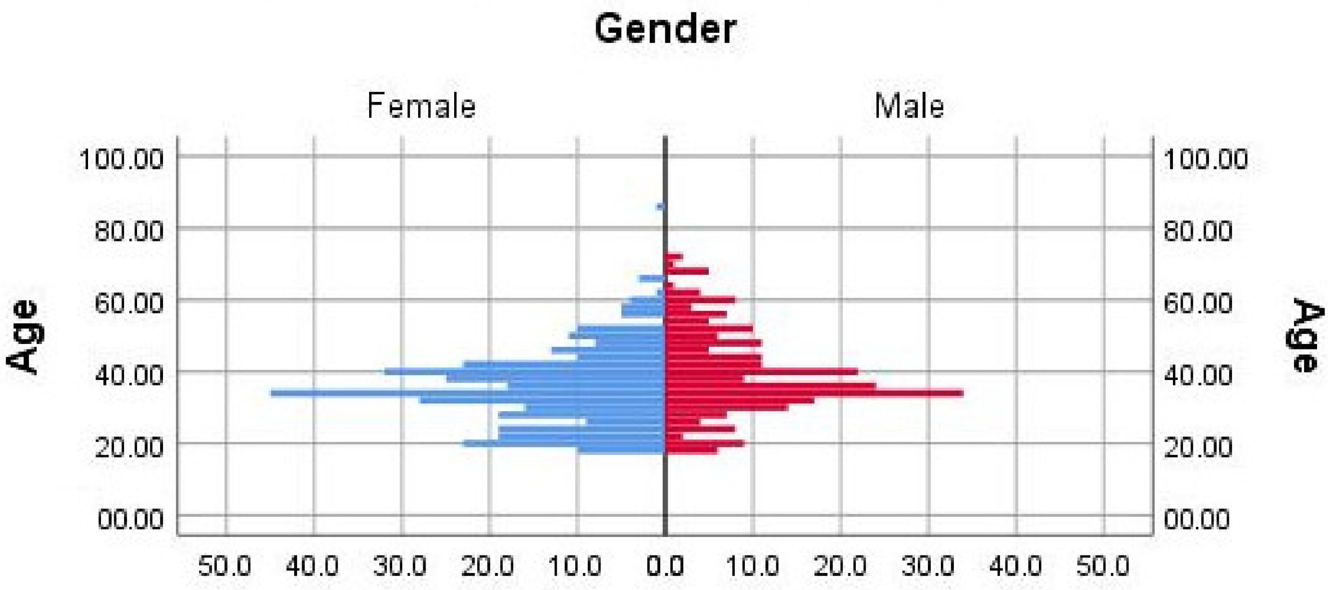

Figure 1. Frequency of Age and Gender in the sample.

Regarding the quality of sidewalks, about 18% of respondents considered the quality to be higher than moderate. Moreover, only 6.3% of participants found the quality of facilities in their neighborhoods very attractive, while 21.8% supposed that the facilities in their neighborhoods were not absorbing at all. In terms of mode choices for commute and non-commute trips, it should be noted that around 13.5% and 22.5% of contributors choose walking as their modes of transport, respectively. Table 3 shows the frequency of different mode choices for commute and non-commute trips before and after the COVID-19 outbreak.

Table 3. Commute and non-commute trips.

	Commute Trips				Non-Commute Trips			
	Before COVID-19 Pandemic		During COVID-19 Pandemic		Before COVID-19 Pandemic		During COVID-19 Pandemic	
Category	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Walking	81	13.4%	108	17.9%	134	22.2%	135	22.4%
Private Car	248	41.1%	280	46.6%	299	49.6%	348	57.7
Bus	85	14.1%	35	5.8%	60	10%	23	3.8%
Taxi	68	11.3%	81	13.4%	53	8.8%	38	6.3%
Taxi Apps	36	6%	38	6.3%	28	4.6%	35	5.8%
Metro	11	1.8%	7	1.2%	9	1.5%	5	0.8%
Organizational Service	42	7%	42	7%	5	0.8%	8	1.3%
Bicycle	13	2.2%	12	2%	13	2.2%	11	1.8%
Motorbike	1	0.2%	0	0	0	0	0	0
Missing Data	18	3%	0	0	2	0.3%	0	0
Total	603	100%	603	100%	603	100%	603	100%

4.2. Model Fit

We generated six BL models for this research. Here, we present the final models after the elimination of insignificant variables. The implications for further research are then discussed subsequently.

4.2.1. The Impact of the Built Environment and Individual Perception on Commute Walking Behavior before and during COVID-19

The best model for walking behavior determinants for commute trips before COVID-19 was generated with 11 significant variables after running 22 models. Subsequently, these variables were employed similarly for commute trips during COVID-19 to be comparable. The first model's dependent variable is the dummy variable of pre-COVID-19 travel mode choices. We divided the respondent's answers into two categories of walking and other modes of travel. Having the highest p-value, the following variables were each omitted from the model: age, gender, income, education, job, possessing of a driver's license, number of family members, disability status, distance to different services (e.g., distance to parks, malls, bank, etc.), perceptive neighborhood environment (1. the existence of trees across the street, 2. the existence of architecturally attractive buildings and houses, 3. the existence of attractive scenery for walking, 4. suitable slope of streets for walking, 5. the existence of Suitable urban furniture and benches at short distances), perceptive walkable places (1. the existence of sidewalks, 2. separation of the street from the sidewalk by green spaces), perceptive security (1. the streets of the neighborhood are not well lit at night, 2. due to the crime rate, our neighborhood is not secure enough, 3. there is a lot of traffic on the streets around our neighborhood, making walking difficult and unpleasant, 4. There are no pedestrian crossing signs on the busy streets of our neighborhood, 5. The streets do not have speed bumps), Perceptive Wellbeing and Health Status (1. feeling of depression, 2. feeling of anxiety, 3. feeling of being energetic, 4. feeling cheerful and cool, 5. emotionally stable and confident, 6. overall health status) and objective built environment (1. street length, 2. population density, 3. distance to public transport, 4. land use mix, 5. Intersection). The perceived distance to one's job/university has a significant negative correlation with walking behavior, while the real distance (commute distance) has less significance. It is the same for the perceived distance to public transport stations and real distance to public transport. The probable explanation for this is that perceptions are more influential in commute and long-distance walking than objective factors. There is a positive and highly significant correlation between shortcut routes and walking for commute due to time travel reduction, which is an effective factor for commute trips.

Furthermore, perceived neighborhood type is highly significant in the model due to its substantial role in walking behavior across the entire population. As can be understood from Table 3, residents with higher rates of BMI tend to choose walking as their mode of transport for commuting, probably due to its impact on losing weight and staying fit. Furthermore, facility attractiveness and overall quality of sidewalks positively correlate with walking for commute trips. Besides this, despite insignificancy, residential duration and building density were kept in the model to improve the results. Nagelkerke's R^2 is 0.28, correctly covering 90.7% of the variables.

As mentioned, we generated our first model to recognize walking behavior predictors for commute trips before the outbreak of COVID-19. Subsequently, we developed our second model to compare the determinants of walking behavior before and during the COVID-19 spread. With the aim of comparison, the independent variables are exactly the identified variables in the first model, while the dependent variable is the dummy variable of during-COVID19 travel mode choices. As Table 4 indicates, most variables lose their significance after the pandemic, which can be interpreted to mean that residents are more likely to choose other modes of transport during COVID-19 or prefer not to commute due to remote working. Among the variables, perceptive distance to job/university, commute distance, neighborhood types, and shortcut routes are still significant. This likely happens due to their crucial impact on utilitarian walking.

Table 4. Binary logistic models for commute walking behavior pre and after COVID-19.

	Pre-COVID-19				During COVID-19			
Variable/Measure	**Wald**	**B**	**Beta**	***p***	**Wald**	**B**	**Beta**	***p***
BMI Before/During COVID-19	5.390	0.132	1.141	0.020	0.995	0.042	1.043	0.319
Residential Duration	2.654	−0.026	0.974	0.103	2.977	−0.024	0.976	0.084
P. (perceived) Neighborhood Type	7.845	−0.385	0.680	0.005	5.476	−0.262	0.770	0.019
P. Distance to Public Transportation Stations	5.062	−0.366	0.694	0.024	1.991	−0.194	0.824	0.158
Distance to Job/University	9.493	−0.548	0.330	<0.001	10.311	−0.495	0.641	<0.001
Sidewalks overall quality	3.601	0.371	1.449	0.058	0.690	0.139	1.149	0.406
Facilities Attractiveness	5.294	0.403	1.496	0.021	0.045	−0.029	0.971	0.832
Walkable Places 3 (existence of shortcut routs)	9.341	0.529	1.697	0.002	11.664	0.516	1.675	0.001
Commute Distance	5.253	−0.493	0.611	0.022	4.034	−0.363	0.696	0.045
Building Density	0.874	0.158	1.171	0.350	0.935	0.138	1.148	0.333
Distance to P. Transport	3.729	2.092	8.098	0.053	1.066	0.771	2.162	0.302
Constant	2.930	−3.716	0.024	0.087	0.090	−0.510	0.600	0.764
Omnibus Test of Model Coefficients	Chi-Square 55.352		*p* <0.0001		Chi-Square 41.677		*p* 0.000	
Hosmer and Lemeshow Test	Chi-Square 3.703		*p* 0.883		Chi-Square 10.922		*p* 0.206	
Model Summary	−2 Log likelihood		Nagelkerke R^2	Percentage correct	−2 Log likelihood		Nagelkerke R^2	Percentage correct
	195.642		0.281	90.7	258.288		0.190	87.9

4.2.2. The Impact of Built Environment and Individual Perception on Non-Commute Walking Behavior before and during COVID-19

In this step, after running 25 models, the greatest model for pre-COVID-19 walking behavior determinants for non-commute trips was developed using the following highly significant (p-value of less than 0.05) and marginally significant ($0.05 < p$-value < 0.1) variables: age, possession of a driving license, number of family members, neighborhood type, distance to grocery, distance to restaurant, distance to parking, distance to mall, the existence of sidewalks, land-use mix, and distance to public transport. Age and possession of a driving license had a negative and highly significant correlation with pre-COVID-19 walking behavior. The same results are seen for the distance to mall, distance to restaurant, and distance to public transport (objective) variables, which means that before the pandemic, with the increasing perceived distance to malls/restaurants and increasing objective distance to public transport, the rate of walking is reduced dramatically among the residents. On the other hand, some factors, including the number of family members, neighborhood type, distance to parking, and land-use mix variables, had a highly positive association with pre-COVID-19 walking behavior. The highly positive association between land use mix and walking behavior can be interpreted to mean that as land use mix increases, the likelihood that a resident chooses to walk for non-commute trips also rises. In this regard, sidewalks and distance to grocery variables are marginally significant and positively connected to pre-COVID-19 walking behavior. Then, non-commute walking behavior determinants were compared before COVID-19 and during COVID-19 pandemic periods based on the previous step procedure. As Table 5 indicates, except for three variables, namely the existence of sidewalks, grocery distance, and restaurant distance, other variables are still significant. The distance to restaurants variable loses its significance probably due to lockdown regulations during the pandemic in which authorities enforced restaurant closure. In addition, no determination rate was observed for distance to grocery stores during COVID-19, which can probably be interpreted that residents could not commute for daily shopping. The Omnibus and Hosmer–Lemeshow tests prove that the model is significant; Nagelkerke's R^2 and the correct percentage of variables in the model point out that the model is an acceptably good fit (Table 4).

Table 5. Binary logistic models for non-commute walking behavior pre and after COVID-19.

	Pre-COVID-19				**During COVID-19**			
Variable/Measure	**Wald**	**B**	**Beta**	***p***	**Wald**	**B**	**Beta**	***p***
Age	4.578	−0.022	0.979	0.032	5.715	−0.024	0.976	0.017
Possession of Driving License	12.161	−0.941	0.390	<0.001	12.512	−0.943	0.389	<0.001
Number of family members	5.581	0.204	1.226	0.018	5.320	0.199	1.220	0.021
Neighborhood Type	4.805	0.337	1.401	0.028	7.681	0.432	1.540	0.006
Distance to Grocery	3.073	−0.289	0.736	0.080	1.839	−0.220	0.746	0.175
Distance to Restaurant	4.095	−0.281	0.755	0.043	1.872	−0.187	0.829	0.171
Distance to Parking	6.931	0.245	1.277	0.008	3.309	0.168	1.182	0.069
Distance to Mall	9.863	−0.893	0.409	0.002	8.994	−0.845	0.430	0.003
Walkable Places 1 (Existence of sidewalks)	2.741	0.165	1.180	0.098	0.483	0.068	1.071	0.487
Land-use mix	9.368	0.128	1.137	0.002	2.958	0.070	1.073	0.085
Distance to Public Transport	6.779	−0.994	0.432	0.009	5.595	−0.984	0.398	0.018
Constant	4.585	1.931	6.894	0.032	7.054	2.381	10.817	0.008
Omnibus Test of Model Coefficients	Chi-Square 50.845		*p* <0.0001		Chi-Square 40.705		*p* <0.0001	
Hosmer and Lemeshow Test	Chi-Square 8.615		*p* 0.376		Chi-Square 8.324		*p* 0.402	
Model Summary	−2 Log likelihood		Nagelkerke R^2	Percentage correct	−2 Log likelihood		Nagelkerke R^2	Percentage correct
	536.293		0.134	78.9	546.432		0.108	78.4

4.2.3. The Impact of Built Environment and Individual Perception on Companionship in Walking before and during COVID-19

The binary logistic model for companionship in walking pre-COVID-19 was generated after removing the insignificant variables with higher p-values. The data in Table 5 show that perceived distance to grocery stores, restaurants, parks, and malls, along with facilities attractiveness and overall health status, have a positive and highly significant association with companionship in walking. On the other hand, although there are significant associations between sidewalks, shortcut routes, security 1, security 2, a feeling of anxiety, depression, and building density with social walking, these correlations are negative. The negative association between security 1,2 (streets are not well lit at night, the neighborhood is not secure), the existence of sidewalks variables and companionship in walking can probably be due to the security matters, which means having a companion in walking can give a sense of security and confidence to pedestrians. There are four marginally significant variables: income, cul-de-sac, distance to job/university, the existence of shortcut routes, and being energetic, meaning they have a slight impact on companionship in walking.

Compared to companionship in walking before the pandemic, the companionship after the pandemic has decreased dramatically, probably due to the infectious nature of COVID-19 and the resulting outcomes. The dominance of subjective variables in this type of walking is promising compared to the two other walking modes. Table 6 represents the details of our model in terms of social walking.

Table 6. Binary logistic models for Companionship in walking pre and after COVID-19.

	Pre-COVID-19				**During COVID-19**			
Variable/Measure	**Wald**	**B**	**Beta**	***p***	**Wald**	**B**	**Beta**	***p***
Income	3.057	−0.145	0.865	0.08	2.886	−0.129	0.879	0.089
Cul-de-sac	3.032	0.278	1.321	0.082	0.557	−0.106	0.899	0.455
Distance to Grocery	5.336	0.493	1.611	0.021	3.812	−0.368	0.692	0.051
Distance to Restaurant	6.180	0.313	1.368	0.013	3.297	0.204	1.227	0.069
Distance to Park	4.799	0.329	1.72	0.028	3.563	−0.249	0.78	0.059
Distance to Mall	10.894	1.351	3.86	0.001	7.056	0.978	2.658	0.008
Distance to Job/Uni	3.407	0.197	1.821	0.065	2.641	−0.163	0.85	0.104
Sidewalks overall quality	4.920	0.254	0.776	0.027	0.096	−0.032	0.968	0.756
Facilities Attractiveness	9.355	0.388	1.475	0.002	4.441	0.239	1.27	0.035
Walkable Places 1 Existence of sidewalks	4.790	−0.247	0.781	0.029	1.309	−0.123	0.885	0.253
Walkable Places 3 (existence of shortcut routs)	3.569	−0.381	0.683	0.059	0.846	−0.167	0.846	0.358
Security 1 (streets are not well lit at night)	7.234	−0.406	0.667	0.007	1.899	−0.18	0.835	0.168
Security 2 (neighborhood is not secure)	5.608	−0.404	0.667	0.018	0.038	−0.028	0.972	0.846
Feeling of Depression	10.020	−0.16	0.852	0.002	0.061	−0.011	0.989	0.804
Being energetic	3.219	0.116	1.123	0.073	2.644	0.112	1.118	0.104
Feeling of Anxiety	10.888	−0.200	0.819	0.001	1.281	−0.07	0.933	0.258
Overall Health Status	5.128	0.307	1.359	0.024	8.094	0.396	1.486	0.004
Building Density	4.881	−0.267	0.765	0.027	0.975	−0.096	0.908	0.323
Constant	2.012	1.818	6.161	0.156	0.001	0.034	1.034	0.978
Omnibus Test of Model Coefficients	Chi-Square 82.973		*p* <0.0001		Chi-Square 36.056		*p* 0.007	
Hosmer and Lemeshow Test	Chi-Square 4.576		*p* 0.802		Chi-Square 8.453		*p* 0.391	
Model Summary	−2 Log likelihood		Nagelkerke R^2	Percentage correct	−2 Log likelihood		Nagelkerke R^2	Percentage correct
	354.670		0.304	71.8	400.541		0.143	66.3

5. Discussion

This research examines and compares the correlations between objective neighborhood variables, perceived built environment, and walking of three different types, commute, non-commute, and social walking before and during the COVID-19 pandemic in Tabriz. We found that most respondents had reduced their levels of overall walking during the lockdown resulting from fear of infection and disease anxiety. A large body of literature mostly emphasizes non-commute walking. There is less evidence of investigation on the correlation of various indicators with commute and social walking. To the best of our knowledge, this is the first analysis to investigate the changes in adults' walking behavior before and during the COVID-19 pandemic considering the differences in various types of walking. Our findings driven from binary logistic regression demonstrate the important variances in the impact of different variables on the modes of walking behavior according to the perceived built environment and physical neighborhood factors, which are in line with some pre-conducted studies [84,85].

In our first and second model (commute determinants before and during COVID-19), socioeconomic factors indicated the least correlation when predicting walking before and during the pandemic, which contradicts some previous studies [86,87]. The role of these factors is promising. The variable BMI showed positive correlations with commute before COVID-19, which is consistent with some previous findings [85,88–90]. Those with higher BMI were likely inclined to walk to reach their jobs for health reasons. However, that significance was not observed during COVID-19. It is probable that COVID-19 anxiety and infection fear prevented them from walking. Regarding subjective variables, significant negative correlations were seen between perceived neighborhood type and distance to different services/land uses (e.g., Public Transport and Job/University) with commute walking before COVID-19. It means that by increasing the perceived compactness of the neighborhood as a result of perceived high building density and enhancing distance to job places, the tendency for commute declined before COVID-19, which confirms that residents did prefer to commute using other transport modes, mostly private cars in perceived dense and distanced areas. This would be consistent with some conducted studies [91–93]. Nevertheless, such a correlation did not exist during COVID-19 for the factor of "distance to public transport". This is probably because, during COVID-19, individuals did not select public transport as their commute mode choice. Further, remote work can be regarded as another reason. Other subjective factors such as sidewalks' overall quality, facilities attractiveness, and shortcut routes, indicated positive correlations with commute before COVID-19. While, except for the variable of "the existence of shortcuts", the other two variables were not significant determinants during COVID-19.

Our third and fourth models for non-commute walking determinants before and during COVID-19 included more socioeconomic determinant variables signifying the importance of individual characteristics' role in determining the use of non-commute walking rather than commute. The age variable showed no considerable difference compared to the pre-COVID-19 period. The significance is even higher during COVID-19. Young adults are likely more motivated to do neighborhood walking during COVID-19, which is in line with previous studies [21,94] in China and Jordan. In terms of having a driving license, despite enhancing private car usage in COVID-19 times, no considerable difference has taken place after the COVID-19 outbreak meaning those who possess a driving license have a lesser tendency to engage in non-commute walking. Accordingly, some studies have drawn similar results in the USA, Jamaica, etc. [95]. Similarly, the same positive correlations were obtained for some family members. Similar to our first model for commute walking, the variable of neighborhood type (perceived compact area) showed a correlation with non-commute walking. However, this correlation is negative, which probably indicates that perceived compact areas have high attractiveness for non-commute walking, enabling residents to meet their daily needs before and during COVID-19. In this regard, there are some consistent investigations [10,11,37,38]. Apart from it, negative associations were observed between perceived distance to non-commute targets (e.g., Grocery, Restaurant, and mall) with walking before COVID-19. In contrast, no associations existed between perceived distance to groceries and restaurants during COVID-19. People have probably been using other modes rather than walking to provide their needs from grocery shops. In the case of restaurants, due to the pandemic restrictions, most of them had no inner service. Perceived distance to parking showed a positive correlation with walking in both pre and post-COVID-19, meaning that individuals prefer walking mode rather than driving in cases they have no closer access to the parking. Believing in the existence of sidewalks, preferably well-designed ones, is regarded as an important determinant in non-commute walking based on the findings of this study before COVID-19. At the same time, such correlation was not found during COVID-19, which indicates the impact of the pandemic in pushing people toward a sedentary lifestyle. Ultimately, two objective factors including land use mix (in line with studies of Christian et al., 2011; Boakye-Dankwa et al., 2019) [40,96] and distance to public transport (in line with investigations of Newmann and Kenworthy, 1989; Holden and Norland, 2005) [97,98] explain non-commute walking with similar results before and during COVID-19 periods. Sufficient diversity of land uses probably increases the chance of non-commute walking. Higher distance to public transport acts as a barrier against walking on both periods. The obtained results demonstrate the consistency of our study's objective and subjective measures regarding non-commute walking.

Our fifth and sixth models (social walking determinants before and during COVID-19) explain the predictors of walking with a companion. Here, the income is negatively associated with walking, which means most higher-income groups do not tend to walk with a partner; that is likely these groups prefer to use private cars once they have a partner due to their dominance in Iranian cities. This output is consistent with the study in [57]. It showed that individuals from sparsely-populated regions and lower-income categories were over-represented in larger walking groups. However, the outcomes of the majority of studies conducted in westernized countries contrast our results [59,99]. Apart from this, perceived Cul-de-sac and distance to various services/land uses (distance to Grocery, Restaurant, Park, Mall, Job/Uni) positively correlate with social walking. This can be interpreted as indicating that the perceived security matters or lack of street lighting in the neighborhoods create a sense of anxiety, making a partner/friend accompany the individuals before COVID-19. However, during COVID-19, such associations were not seen in two factors of Cul-de-sac and distance to Job/Uni. It is likely that by decreasing various types of walking during COVID-19, choosing other modes of transport has increased. Perceived quality of sidewalks and some other factors including facilities attractiveness, being energetic, and overall health status were positively associated with walking accompanied by a partner before COVID-19, while during COVID-19, some of these factors such as sidewalk quality and being energetic did not show any correlations with social walking. The interpretation is that the overall walking in each type has decreased during the pandemic.

On the other hand, sidewalk and shortcut routes, lack of street lighting, neighborhood security, and feeling of depression and anxiety indicated negative correlations with companionship walking before COVID-19. Although, none of the mentioned variables showed any correlations during COVID-19. Lastly, the only significant objective determinant was building density before COVID-19, which turned out to be uncorrelated during COVID-19. Therefore, in these models, people's perceptions are vital in predicting social walking before COVID-19.

The results of this study are based on six binary logistic models; they indicate that the different characteristics in both periods before and during COVID-19 affect various types of walking. In other words, huge differences were observed in determinants of walking behavior in periods before and during COVID-19. Among the different types of walking, social walking was massively affected by the COVID-19. The role of subjective variables is vital in this type of walking. However, the significance of the correlated subjective variables was lost during the pandemic. Therefore, the COVID-19 pandemic is regarded as a strong mediator in predicting walking behavior. The differences between the distribution of both subjective and objective determinants of walking behavior were also proven. In other words, the model of each type of walking was made by bringing together the particular factors that created different patterns. Such diversity of walking behavior determinants needs the attention of urban authorities. In our study, the obtained results showed consistency and inconsistency of objective and subjective variables for different types of walking. In this regard, Gebel et al. (2009) and Gebel et al. (2011) state that the perceived neighborhood walkability is not essentially the same as objective neighborhood walkability, which is consistent with some outputs of this study in non-commute walking [100,101]. It seems that some individuals are likely to misperceive their environment as having low or high walkability. The fact that perceived behavioral control was pointed out as the strongest predictor of walking corroborates previous research findings [102,103]. Despite the importance of objective variables, especially in non-commute walking, subjective data should complement one another to produce a more holistic understanding of walkability and walking behavior. In our study, the effects of subjective factors including "perceived accessibility to neighborhood facilities, subjective walkability, perceived attractiveness of facilities, perceived security, and subjective wellbeing" have radically changed compared to the objective variables' impact after the COVID-19 outbreak. Accompanied by subjective variables, the two objective factors of "accessibility to public transport stations and building density" have had significant differences. These differences are due to the establishment of new metro stations, as well as urban regeneration and expansion schemes. Lastly, including socioeconomic circumstances and health status or motivation into understandings of walkability investigations are vital for interpreting the interplay between individuals and their environment [104]. The benefit of integrating various data, "which is regarded as the strength of this research", is that they may guide more cost-effective interventions. For example, rather than encouraging the restructuring of neighborhood networks, inhabitants may request for strategic organizing of cross-walks or the introduction of paved walking trails.

We found that those who care more about their health and gas emissions from cars are more likely to walk for a commute. Seemingly these groups are more aware of the health benefits of walking and reducing car usage. Increased awareness and knowledge regarding active transportation's environmental and health benefits may be important in promoting active transportation. Besides that, rationally distanced establishment of public transport stations is considered another strategy for those whose workplaces are rather far away. For non-commute walking, one important policy implication of this study concerns improving neighborhood design, especially to encourage including more services and land uses that support the strategy of land-use mix. Incorporating elements such as green space, shade, benches, and recreational facilities could enhance all ages groups' comfort and aesthetic experience. Finally, the important intervention for social walking could be the same with non-commute walking and creating open spaces for more social interactions that directly impact the negative feelings of individuals and make it desirable to walk with a partner in the neighborhood. These implications emphasize before COVID-19, as this phenomenon will disappear due to human knowledge.

The strengths of this study, apart from using different types of determinants including both objective and subjective factors, included the timeliness of the survey during the COVID-19 period, the collection of retrospective data to capture the period before the pandemic, and the use of standardized self-report walking measures. However, there were some limitations. The data were collected during the pandemic, which forced us to do online sampling with 603 participants. A larger sample size could run an additional reliable set of data for modeling various types of walking. Further, the sample mostly contained younger adults from middle-income households.

6. Conclusions

This paper aimed to identify walking behavior determinants in walking of three types, Commute, Non-commute, and Social walking, and compare them for two different periods, before and during the outbreak of the COVID-19 pandemic. It was conducted among adults in one large Iranian city (Tabriz) as an example of a developing country context. In conclusion, numerous lessons are apparent from this study.

First, the volume of walking has increased in both types of commute and non-commute trips during COVID-19 compared to before COVID-19 (due to the decrease in the use of public transport), which contradicts with some of the studies carried out in developed and developing countries [94,105], for example, US and China. Similarly, in Mena countries (Egypt, Jordan, United Arab Emirates, Kuwait, Bahrain, Saudi Arabia, Oman, Qatar, Yemen, Syria, Palestine, Algeria, Morocco, Libya, Tunisia, Iraq, and Sudan), a study conducted by Abouzid et al. (2021) confirmed that walking levels in these countries have declined (before 29.2%; during 20.3%) [106]. However, in line with the findings of this study, there are some examples in both developed and developing nations that indicate an increase in walking levels [107,108], for example, Bangladesh and Canada. Commute trips in Iran showed a 4.5% increase while the proportion of non-commute trips remained constant before and during the COVID-19 pandemic (before: 22.2%; During: 22.4%). In other words, the results are highly localized in both developing and developed countries.

Second, the determinant factors of walking behavior during COVID-19 in Tabriz included:

- Commute walking: perceived neighborhood type, perceived distance to job/university, perceived sidewalks overall quality, perceived existence of shortcuts and commute distance.
- Non-commute walking: perceived neighborhood type, perceived distance to parking, perceived distance to mall, distance to public transport.
- Social walking: perceived distance to grocery, perceived distance to restaurant, perceived distance to park, perceived distance to mall, perceived attractiveness of facilities, and perceived overall health status. The details can be found in Tables 4–6.

Third, although generally, we found that some objective and subjective indicators appear to be significant determinants of the walking behavior before COVID-19, the majority of these determinants have lost their significance due to the emergence of COVID-19. Thus, as a strong mediator, the COVID-19 plays a fundamental role in walking habits. Accordingly, it was proven that there are huge differences between walking behavior determinants before and during COVID-19.

Fourth, although both objective and subjective variables appear to have merit influence on walking behavior either in commute or non-commute trips, the social walking determinants clearly indicate the dominance of subjective variables rather than objective measures. Therefore, it was proven that subjective variables have the most significant impact on the walking behavior of adults in large cities of the MENA region.

Fifth, despite the fact that various types of walking have been largely affected by the COVID-19 pandemic, this impact on social walking was even more compared to commute and non-commute walking. Accordingly, 10 out of 16 factors lost their significance after the pandemic. Hence, it was proved that social walking has been affected more during COVID-19.

Sixth, the effects of subjective factors including "perceived accessibility to facilities, subjective walkability, perceived attractiveness of facilities, perceived security, and subjective wellbeing" on various types of walking have dramatically changed after the emergence of the COVID-19 pandemic. Such alterations have also been considered in objective measures including accessibility to public transport and building density.

Overall, the results obtained from this study comprehensively add new evidence to the existing literature, showing that influential variables act remarkably differently before and during the COVID-19 outbreak. In other words, the mediator, COVID-19, highlights important differences related to the determinants of walking behavior. In addition, the findings provide an opportunity to offer some policies and design implications to similar cities in Mena or other developing regions to encourage adults toward active living. Thus, there is a substantial need for more integrated and holistic research in developing and developed countries that enables academicians to compare and help stakeholders and policymakers accurately plan to enhance walkable communities.

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