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Environmental Awareness and Inclination towards Walking: A Smartphone Application based study

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Abstract

Walking is considered to be one of the sustainable modes of transportation which reduces traffic demand leading to lower levels of pollution and congestion. It has resulted in improved physical and psychological health of individuals. This study focuses on studying walking behavior of travelers in Bahrain. Walking data was collected through Moves mobile application while a questionnaire survey was conducted to find the characteristics of the participants. Walking distance per day was found to be approximately 400m on average which is insufficient to have any significant impact on health. There was no significant change in walking behavior between day and night timings. Walking behavior was found to be related to familiarity with location, financial status and family structure of the participants. Personal characteristics (age, gender, etc.) and perception of the participant did not have any significant impact on walking behavior. It is recommended to increase awareness related to walking and improve pedestrian facilities in all areas of Bahrain to promote walking.

Keywords: *Walking, Moves smartphone app, Bahrain, travel behavior*

1. Introduction

Changing traveler behavior can be vital in decreasing traffic demand leading to an improved level of service on the highways [1]. Bahrain is a small country, compared to the other gulf countries [2]. Hence, the extension of the road network is not a sustainable approach with limited area. Therefore, strategies should be devised to decrease the number of drivers on roads to maintain the smooth flow. The issue becomes pressing due to the high population growth rate which was calculated last in 2016 and it was equal to 3.8% [3].
The only public transport available in Bahrain are buses and they are not considered as a popular mode of transport. Moreover, trains are considered as future projects and may take time to be done. Cycling is not very popular even though Bahrain is a small country and distances to be travelled are short, but the weather conditions remain hot for most of the day [4]. Moreover, there is a lack of infrastructure for cycling and roads have high speeds which makes it very dangerous for cycling.
Walking is another sustainable mode of transport which reduces the traffic demand and has positive effects on health. Reduction in access to facilities by cars and mixed land use may increase walking trips [5]. Pedestrians tend to choose to walk when the pathways are generous and have better quality even when its time consuming [6]. But the pedestrians are discouraged from walking because of path obstruction and long waiting time at intersections [7]. Walking trips in Bahrain are generally less preferred as the environment is not found appropriate for walking because of the above factors.
This study is designed to fulfill the following objectives; 1) use of a mobile tracking app for monitoring the walking trips; 2) modeling the walking behavior/potential of travelers; 3) finding out correlations between travelers' characteristics, walking behavior and environmental awareness.

2. Literature Review

Pedestrians are among the most vulnerable road users [8]. On the other hand, they are also considered as one active transport modes [9]. Hence, many studies have been carried out to investigate the factors affecting walking trips so that they could be encouraged. Some of those studies are summarized and discussed below.

2.1. Effects of Walking on Health

Walking started to receive attention by sport colleges and disease control centers in 1990s which considered it to be a moderately intense activity. Physicians recommended 3 to 4 miles brisk to avoid chronic diseases and reduce health costs

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[10]. Even a walk of 1 hour per week can greatly reduce chances of cardiovascular diseases. Walking for 2 hours per week reduces the chances for premature death, while increasing the walking period more than that can increase the overall life expectancy [11]. In addition to the physical benefits, walking has also been reported to release stress and improve psychological health even if it is done slowly with slow pace indoors [12].

2.2. Factors Affecting Walking Trips

Studies have shown that length of the trips was the most important factor for the pedestrians, in selection of routes, as compared to congestion, safety or visual attraction [13]. Similar to highway facilities, methods to calculate level of service for pedestrian facilities have also been devised. These methods use physical, locational and user factors for determining level of service for pedestrians [14]. User factors, which are also focused in this study, include pedestrians' perception related to safety and comfort of the facility [15]. Environmental awareness is another important factor which can change the choice of the users to walk more [16].
Among the personal factors, age and gender are the factors related to pedestrian which affect their walking behavior [17]. Family size and structure is also linked to feasibility to walk as it corresponds to the responsibilities on a person affecting his/her decision of mode choice [15]. Access to car/licenses is another important aspect of affecting the choice of walking.

2.3. GPS-based Tracking

The accessibility of implicit Global Positioning System (GPS) in cell phone and the improvement of locational administrations in view of the remote systems administration condition, implies that these days field information accumulation is more exact than any time in recent memory, and getting areas from the field is never again basic work [18]. The utilization of GPS hardware for robotized information gathering has lessened the cost of travel time studies fundamentally while expanding the volume of information ready to be gathered[19]. Ritz [20] employed the GPS tracking approach for analyzing travel time and traffic. Pang [21] used GPS and GIS to develop land use – demand pattern models and assessed traffic flows.

2.3. Research Gaps

Review of relevant literature have resulted in the identification of following gaps. Firstly, there seems to be an absence of a study related to walking behavior for Bahrain, or any other Gulf country. The focus of research, for these countries, has mainly been on analyzing traffic data in these countries without discussing alternate modes like walking and cycling. GPS tracking for walking trips monitoring has also not been found. This technique has been applied successfully to give accurate results for car trips while its use for walking trips is not found. Lastly, this would be the first study to combine the traveler perception data with the field measurements to construct models for prediction of daily walking distances. The said models could be helpful for planners and policy makers, from the field of transportation and health sciences, for devising strategies to encourage this sustainable and healthy means of transportation.

3. Methodology

Moves app, which is created and developed by Protogeo, was used in this study to monitor the walking behavior. The open source application provides an effective collection approach. Every twenty-four hours is saved as a separate data file in the records and can be accessed anytime. Moves data is provided in multiple formats including CSV format used in this study.
The first step was to make the people download and use the app and they should use it for 7 days or 5 working days in order to get the data for a complete week. 100 volunteers were approached to use the app which belonged to different geographical locations and socio-economic backgrounds. These volunteers were also asked to fill a questionnaire in order to gather their personal information and perceptions.
App information was used to calculate the following items for each volunteer: number of trips, percentage of walking trips for the whole day, average distance of walking trips per day for whole day, average distance of walking trips per day in day time, average distance of walking trips per day in night time, percentage of walking trips in day time and percentage of walking trips in night time. Day and night times were determined from the sunrise and sunset timings of the days for which the volunteers provided the data.
The questionnaire was divided in to the following sections:

- Section I: Socio- Demographic and personal details.
- Section II: Environmental issues.

3.1. Regression Model

Regression modeling is a form of predictive modeling method which investigates the relationship among a structured and impartial variable/variables. This technique is used for forecasting, time series modeling and finding the causal effect relationship between the variables. It is an important tool for modeling and analysis data. The general form for regression model is shown in equation (1)[22].

$$Y = a + b_1X_1 + b_2X_1 \dots \dots \dots b_nX_n \tag{1}$$

where, Y is the output variable, X are the input variables and a and b are intercept and coefficient, respectively. An input variable will be considered to have a significant effect on the model if its coefficient has a probability or equal or less than 0.05, compared to a t-distribution [23]. Regression model was used in our study to find a relation between the questionnaire and the average walking distance and a relation between the questionnaire and the percentage of walking trips.

3.2. Paired t-Test

The paired t-test compares two averages and tells you if they have a significant difference among them. As the t-value gets larger, it indicates that the groups are different. If the t-value is equal or greater smaller than standard t-value at 95% probability, then the difference is said to be significant and vice versa. t-value can be calculated as per equation (2) [24].

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}} \tag{2}$$

We used the paired t-test to compare the average distance traveled in day time and average distance traveled in night time.

3.3. Correlation

Correlation is a method which is used to find how strongly two arrays of variables are related. The result of the correlation technique is based upon the calculation of the correlation coefficient ("r") which has a range of -1 to +1. As "r" gets close to +1 or -1, this shows that there is a strong relationship between two arrays of variables. If "r" is positive, this indicates that both arrays have a direct relationship. If "r" is negative, this indicates that one of the arrays is increasing while the other is decreasing as this is called inverse correlation. If "r" is close to 0, this indicates that there is no correlation or the correlation is a weak correlation. Correlation coefficient can be calculated as shown in equation (3).

$$r = \frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}} \quad (3)$$

The correlation was used to correlate between each question in the questionnaire with the average distance for the whole day

3.4. Questionnaire

The questionnaire focused on specific aims and objectives, including asking and collecting the right type of information and making sure each question is specific, objective and understandable. A questionnaire should assist in accomplishing the research objective. Options such as multiple-choice questions, questions that use a rating or ranking scale and closed-ended questions will produce different types of responses. Multiple-choice questions and questions that use a rating scale are useful for gathering information about preferences, attitudes, opinions and behavior. Closed-ended questions help you gathering fact-based information you can then use to classify people or situations.

4. Analysis

The analysis of data from the questionnaire that the average age of the participants was 26 years which is not too old and not too young and most of them are Bahrainis. Around 52% were female participants and the rest are male. Also, they were asked where each of them lived and how long have they been living there. Efforts were made to include participants from all around the Kingdom of Bahrain which resulted in having respondents from 18 different towns/locations of Bahrain. Regarding how long have then been living there, we got an average of fourteen and a half years which means that they have not moved for a long time and that the results we have got are from a daily routine.

89% of the participants had a driving license and the average time for which they have had the license was approximately 7.5. We also noticed that more than 75% of our participants have three or more cars in the family and only few participants had only one car. 29% of the participants were employed and, 61% were students and the rest were classified under retired or business. 58% were students in university with graduation degree from school, 27% had a bachelor's degree and the rest have master's degree, professional degree, etc. It should be noted at this stage that a major factor for the selection of participants was their willingness to take part in the study. Hence, biasness of certain categories in the data may be due to the fact that participants from those categories were more cooperative to take part in the study.

As stated earlier, walking behavior can also be linked to environmental awareness of the traveler. Hence, questions related to environmental awareness were also made part of the questionnaire in which participants were asked to give their opinion related to environmental problems in the form of ranking. The ranking was from 1 to 5, where 1 means that they strongly disagree with the statement and 5 means that they strongly disagree. The statements given under this section are shown in table 1.

Table 1 also shows the average ranking for each statement given by the participants. It can be seen that the ranking is close to 4 for most of the statements. The highest rankings were given to statements acknowledging the severity of environmental pollution and taking part in this reducing it. Lowest rankings were observed for the statement related to provision of alternate mode facilities in the area and application of restrictions on car use. This could mean that the participants acknowledge the importance of environmental issues and want to take part in it and consider the facilities to be insufficient. It also leads to their perception to rely more on car trips as compared to other modes.

Table 1. Average Ranking for Environmental issues

Factor	Average
Environment Pollution is a problem in your area of residency.	3.667
Environmental pollution may affect your health.	3.989
The environment is deteriorating, it is clearly notable and visible	3.511
Environmental issues need to be considered properly.	3.789
Humans have the right to modify the natural environment to suit their needs.	3.244
Mankind is severely abusing the environment.	3.833
When humans interfere with nature, it often produces disastrous consequences.	3.422
We are approaching the limit of the number of people the earth can support.	3.411
Given the opportunity, you would like to take action toward the environment	3.678
Whether I perform pro-environmentally is entirely up to me.	3.278
Environmental Pollution is a society problem, everyone should have a part.	3.589
It is worthless for the individual consumer to do anything about pollution.	3.100
When I buy products, how my use of them will affect the environment.	3.433
Designing of events for encouraging environmental behavior involves citizens.	3.778
Inclined to behave environmentally when people are engaged in that behavior	3.844
There are opportunities available to change your daily routine	3.611

Public transport in your area is good and you are satisfied with it.	2.822
Bicycle facilities in your area are good and you are satisfied with it.	2.389
Pedestrian facilities in your area are good and you are satisfied with it.	2.778
There should be more restrictions on the use of car in your area	2.722

4.1. Walking Trips Analysis

Descriptive statistics related to walking trips is shown in table 2. Each participant was asked to use the app for 7 days to give the data for a typical week. It can be observed that number of walking trips well below the number of motorized trips. People, on average, travel approximately 400m during the day. It would account for approximately 1 hours (or less) of walking during the week which is the minimum limit reported to improve the health conditions [11] (Warburton et al., 2006). Percentage of walking trips and walking distance tend to increase during night times as compared to day times which could be attributed to the hot weather in Bahrain.

Table 2. Walking Trip Statistics

Variable	Average	Minimum	Maximum
Total number of walking trips	4.71	0	20
Total number of motorized trips	31.12	6	76
Percentage of walking trips per day	12.02	0	45.24
Average walking distance per day (Km)	0.43	0	4.02
Average walking distance per day in day time (Km)	0.24	0	1.74
Average walking distance per day in night time (Km)	0.20	0	2.36
Percentage of walking trips per day in day time	8.27	0	38.10
Percentage of walking trips per day in night time	9.11	0	61.19

Paired t-test was also performed to check the significance of the difference between average percentage walking trips and distances during day and night times. The results are shown in table 3. Paired t-tests show that there is no statistically significant difference in walking behavior between day and night times at 5% confidence level.

Table 3. Paried t-test

	Average walking distance in Day time	**Average walking distance in night time**
Mean	0.240	0.20
Variance	0.09	0.13
t Stat	1.04	
P(T<=t)	0.150	
	Percentage walking distance per day in day time	Percentage walking distance per day in night time
Mean	0.08	0.09
Variance	0.01	0.01
t Stat	-0.79	
P(T<=t)	0.217	

4.2. Correlation Analysis

In order to investigate the relationship between the perceptual factors (related to housing location and environmental issues), a correlation analysis was conducted between ranking of factors and walking distance. It can be observed from table 4 that all the rankings have a weak correlation (close to '0') with the walking distance. Hence these factors were not considered for the regression models presented in the proceeding sub-section.

Table 4. Correlation of perceptual factors with average walking distance per day

Factor	Correlation
Environment Pollution is a problem in your area of residency.	-0.075
Environmental pollution may affect your health.	-0.141
The environment is deteriorating, it is clearly notable and visible	-0.079
Environmental issues need to be considered properly.	-0.210
Humans have the right to modify the natural environment to suit their needs.	-0.025
Mankind is severely abusing the environment.	-0.168
When humans interfere with nature, it often produces disastrous consequences.	-0.037
We are approaching the limit of the number of people the earth can support.	-0.034
Given the opportunity, you would like to take action toward the environment.	0.223
Whether I perform pro-environmentally is entirely up to me.	0.003
Environmental Pollution is a society problem, everyone should have a part.	-0.169
It is worthless for the individual consumer to do anything about pollution.	0.013
When I buy products, how my use of them will affect the environment.	-0.091
Designing of events for encouraging environmental behavior involves citizens.	0.127
Inclined to behave environmentally when people are engaged in that behavior	-0.049
There are opportunities available to change your daily routine	0.083
Public transport in your area is good and you are satisfied with it.	-0.100
Bicycle facilities in your area are good and you are satisfied with it.	-0.071
Pedestrian facilities in your area are good and you are satisfied with it.	-0.020
There should be more restrictions on the use of car in your area	0.021

4.3. Regression Model

One of the methods used to relate between the questionnaire data and the applications data was by regression models. It should be noted that all the tips were observed during last week of January during which the weather conditions were almost the same. Bahrain is a small country hence weather conditions remain the same throughout the country at a particular time of the year. Due to these reasons, temperature was not considered for regression as it was approximately the same for all respondents throughout the study period. The following regression models were developed in this study:

- Model to predict % walking trips per day
- Model to predict % walking trips per day during day time
- Model to predict % walking trips per during night time
- Model to predict average walking distance per day
- Model to predict average walking distance per day during day time
- Model to predict average walking distance per day during night time

The models are shown in tables 5-10. R-square was observed to be very low for all the models which requires further investigation in the future through the inclusion of additional variables. However, these models can still be used to understand the relationships between the variables collected in this study and walking behavior.

Table 5. Model to predict % walking trips per day

	Coefficients	Std. Error	t Stat	P-value
Intercept	4.80	1.46	3.29	0.001
Duration of stay at the current address	-0.39	0.07	-5.96	0.000
Adults (above 18 years) living with you	1.40	0.26	5.38	0.000
R-square		0.11		

The number of adults in the family seems to have a positive impact on the proportion and distance of walking trips in almost all the models. Hence, families with higher adult proportion would be more inclined towards walking which could be due to higher awareness towards health and maturity which may lead to encouraging each other towards walking. Effects of walking groups have also been found effective in another recent study as well [25].

Duration of stay at the current location seems to have a negative impact on the % of trips, especially during the day time (See table 6 and 7). It could mean that travelers make most of the routine (work, education, etc.) trips by their cars when they are more familiar with the location.

Students seem to walk more than other categories of travelers in this study. This is shown by the positive coefficient of this variable in models of overall and day time walking distance per day (see table 8). Possible reason for this trend could be the involvement of students (young population) in more activities than others. Interestingly, number of cars in the household also seems to have a positive impact on the model for walking distance during day time. It could be explained if the number of cars is taken as an indication of financial status of the family. In that case, families with high financial status, leading to better housing locations, may prefer to walk more due to better environment.

Table 6. Model to predict % walking trips per day during day time

	Coefficients	Standard Error	t Stat	P-value
Intercept	13.29	3.82	3.48	0.000
Nationality	-12.20	3.49	-3.49	0.000
Duration of stay at the current address	-0.32	0.07	-4.36	0.000
Adults (above 18 years) living with you	1.29	0.28	4.57	0.000
Driving License	2.86	1.59	1.79	0.073
R-square		0.11		

Table 7. Model to predict % walking trips per day during night time

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.00	0.89	-1.12	0.261
Adults (above 18 years) living with you	0.97	0.24	4.02	0.000
R-square				0.02

Table 8. Model to predict average walking distance per day

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.10	0.10	1.03	0.300
Student	0.26	0.09	2.98	0.003
Adults (above 18 years) living with you	0.05	0.02	2.07	0.039
R-square				0.020

Table 9. Model to predict average walking distance per day during day time

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.10	0.11	-0.88	0.380
Student	0.13	0.06	2.18	0.030
Number of cars in the house	0.08	0.03	2.22	0.030
R-square				0.020

Table 10. Model to predict average walking distance per day during night time

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.06	0.07	0.83	0.400
Adults (above 18 years) living with you	0.04	0.02	2.39	0.017
R-square				0.020

5. Conclusion

This study was aimed at monitoring and analyzing the walking behavior of people in Bahrain. Moves mobile application was used for monitoring the data while questionnaire survey was used to collect data related to travelers and their perceptions.
It was found that most of the trips were taken by cars and walking trips were in small proportion for all participants of the study. There was no significance difference found between walking distance travelled during day and night times in the study period. Walking distance was not found to be correlated with the perception of the participants related to environmental awareness or pedestrian facilities. Average walking distance recorded for the participants was less than the recommended values to have any significant health effects.
Walking behavior was found to be inversely related to familiarity with the residential location and positively correlated with the number of adults in the family. From the regression models developed in this study, it could be observed that walking is related to the financial and socio-economic condition of the participant instead of their personal characteristics (such as gender, nationality, etc.).
Based upon the observations of this study, it is recommended to increase awareness among the population of Bahrain related to importance and effects of walking. It is further recommended to improve the pedestrian facilities in all areas of Bahrain to encourage walking.

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