Buletin Teknol. Tanaman, Bil.12 (2015):150-155

Evaluation of pedestrians speed with investigation of un-marked crossing

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Abstract

Pedestrians are one of the most important users of urban intersections and the knowledge of their behavior and use of crosswalks of the urban intersections could help the appropriate design and construction of pedestrian facilities. In order to do this the behavior and crossing speed of 604 pedestrians were collected in Rasht through video recording four intersections. Then the collected information was analyzed by Kolmogorov-Smirnov, Anova and Spearman Correlation tests. The resulted indicated that the pedestrians use the crosswalks in the signalized intersections more than the un-signalized ones and the crosswalk marking is very important in the pedestrians' behavior in using them, so that whatever crosswalks are closer to the intersections, they are used more. Also between the two groups of elder male and female pedestrians, the weight is not a determining factor in the crossing speed of the pedestrians at intersection without the crosswalk marks.

Key words: Pedestrian, Crosswalk, Weight, Age.

Introduction

The crosswalks is one of the most important safety signs that is used for the roads and streets, with different types such as longitudinal markings, traverse markings in order to segregate and identify the vehicles' movement boundaries, control the vehicles movement, transfer the message, as well as guide drivers, and other path users. Also the pedestrian markings specify the shortest path to cross the streets. Among the markings being used in the pathways, the three types of diagonal, ladder and piano markings lead to the highest safety of the pedestrians compared to the other types of markings which is due to their excellent visibility. The studies indicate that the drivers do not slow down when they see th e markings so crossing the crosswalks can have the false feeling of safety for the pedestrians which is associated with risk. On the other hand some pedestrians do not cross the crosswalks for several reasons such as being in a hurry. So the analysis of the pedestrian behavior and speed in marked and unmarked locations is very important (Chen et al, 2010).

Paying attention to the crosswalk and obeying the related rules and recommendations helps to secure the safety and traffic order in the travels. Crosswalk marking is one of the different kinds of road markings that are painted on the certain areas in the intersections and streets for the pedestrians' safe crossing.

In this paper, by analysis of the crossing speed and behavior of 604 pedestrians data in two signalized intersections and two un-signalized intersections in Rasht, analyzes the behavior of the pedestrians who pass the unmarked places despite having access to the marked crosswalks.

Literature Review

Over the past decades, many researchers have studied the speed of pedestrians. Moore (1956) in his article "Psychological Factors of Importance in Traffic Engineering" have recommended that pedestrians' crossing speed while vehicles are approaching to them should be 1.25(m/s) which could vary to 1.22(m/s), as well. Wilson and Grayson (1980) found that average walking speed for men and women are 1.23 and 1.27(m/s) respectively, by examining the relationship between the speed of the pedestrian with respect to age, and sexuality. Griffiths et al. (1984) found that speed of crossing in signalized Intersections for teens, adults and elderly is 1.72, 1.66, and 1.47(m/s) respectively. Tanaboriboon and Guyano (1991) in an article named "Analysis of Pedestrian Movement in Bangkok" found that men and women crossing speed is 1.31 and 1.25(m/s) respectively, by viewing the crossing speed of pedestrians in a signalized Intersection in Bangkok. O'Flaherty (1997) has proposed the speed between 1.2 of 1.25(m/s) for crowded intersections motion of different age groups. In addition, he proposed average speed of 1.6(m/s) for non-crowded areas. Tarawneh (2001), in his article named "Evaluation of Pedestrian Speed in Jordan with Investigation of Some Contributing Factors", checked out the speed of 3500 pedestrians in 27 intersections in a large area in Oman. Based on that he proposed the average speed and 15th percentile pedestrian speed 1.34 and 1.11(m/s) respectively. In this study he also expressed that, age, gender, size of group and street width is greatly effective on pedestrians speed, and male pedestrians move faster than female pedestrians in crossing the street significantly. Gates et al. (2006) have pointed out that average speed of pedestrians who are younger than 65 is faster than pedestrians older than 65 years old for 0.3(m/s) by collecting 1947 pedestrians crossing speed from 11 Intersections in United States and there is no difference between men and women crossing speed. In 2007 in an article named "Research on Pedestrian Behavior and Traffic Characteristics at Un-signalized Midblock Crosswalk: Case Study in Beijing" Shi and his colleague have found that men crossing speed is faster than women crossing speed for 0.1(m/s) by analyzing crossing speed of 1040 pedestrians in crossing un-signalized intersection.

Transportation Engineering Institute of America (1999) has proposed a moving speed between 1.1 of 1.2(m/s) to pedestrians for crossing the street. The Manual on Uniform Traffic Control Devices in both version (2003 and 2009) have proposed moving speed of 1.21(m/s) for pedestrians to cross Intersections. Due to the book of highway capacity manual (HCM 2000, HCM 2010), Pedestrians crossing speed is based on the proportion of elderly pedestrians in all users. This book in both version 2000 and 2010, for ratio of less than 20 percent of elderly pedestrians have proposed the speed of 1.2 and 1.34(m/s) respectively And for higher proportion both versions have proposed the speed of 1(m/s).

Methodology

Data Collection

Pedestrian behavior data were collected at 2 signalized and 2 un-signalized intersections in the city of Rasht that were in north of Iran. Surveys were conducted at the morning and evening peak periods 7:00 to 9:00 and 17:00 to 18:00 at weekdays by video cameras. Then the statistics making and data collection were performed by filming each intersection in which 604 totals of pedestrians was evaluated. Using a stopwatch on the recorded videos for crossing time and speed of each pedestrian according to sex, age, weight, and group movements from signalized and un-signalized were calculated.

Data Analysis

After collecting 604 pedestrians data have been analyzed and measured by statistical tests. Statistical test which have been used here includes: Kolmogorov-Smirnov, Anova, Gabriel and Spearman Correlation tests that have been introduced, following.

The results of pedestrian crossing at unmarked crosswalk

In this study, the pedestrians crossing in the signalized and un-signalized intersections at the peak hours based on sex, marked and un-marked crosswalks and the single and group movements were inventory. Then the behavior of the pedestrians in choosing the marked and un-marked crosswalks based on each intersection is according to the Figures 1 to 4.

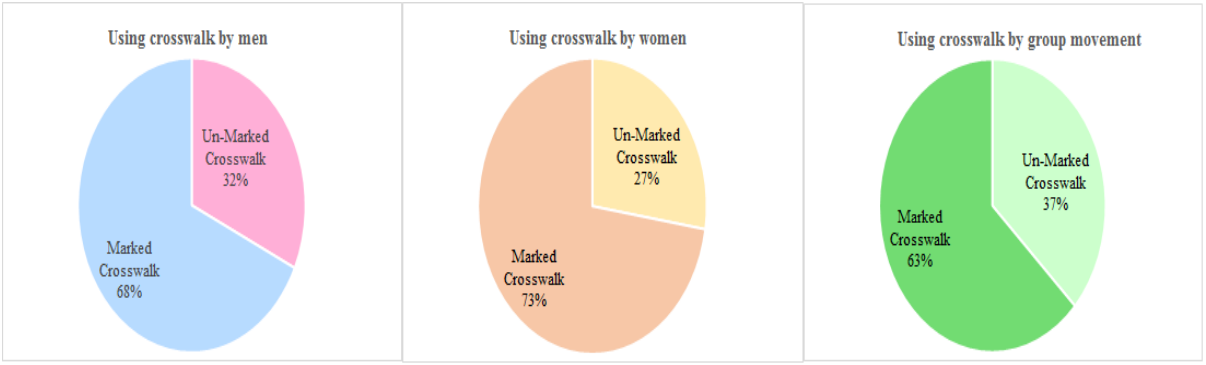

Figure 1. Using crosswalks at signalized intersections No.1

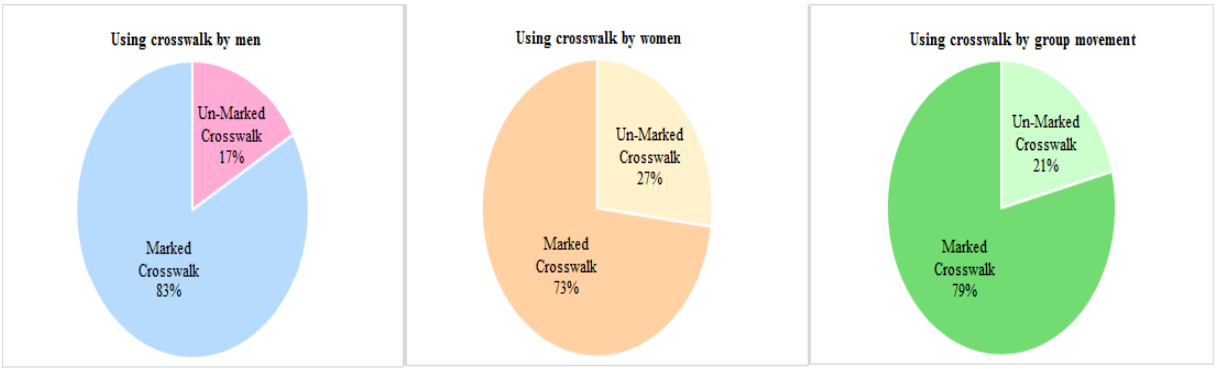

Figure 2. Using crosswalks at signalized intersections No.2

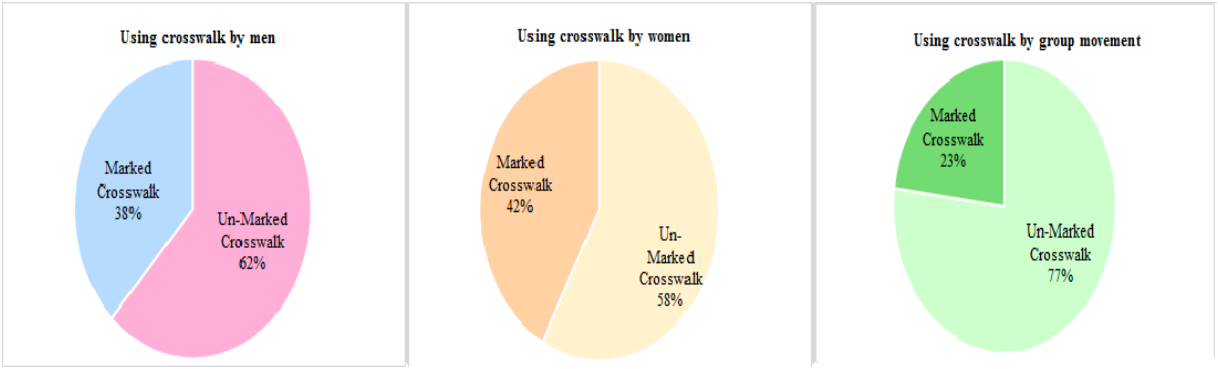

Figure 3. Using crosswalks at un-signalized intersections No.3

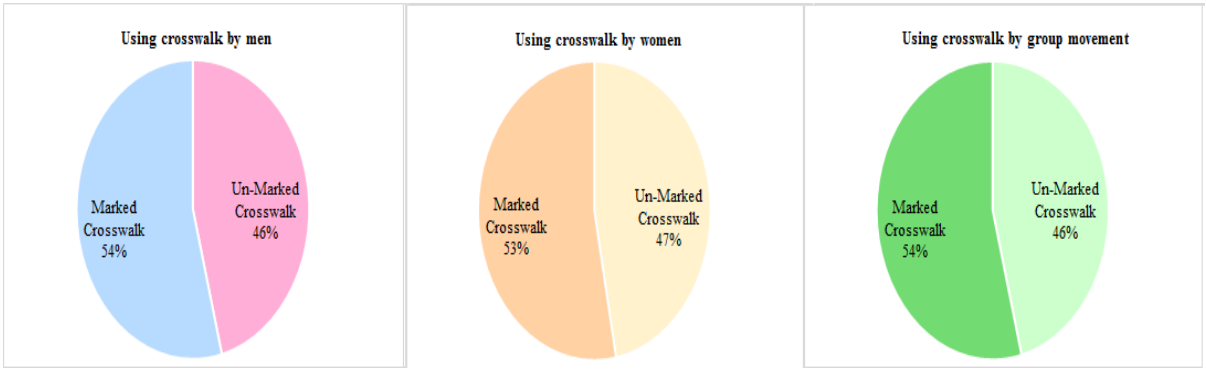

Figure 4. Using crosswalks at un-signalized intersections No.4

According to figures 1 to 4 between male and female pedestrians, the female pedestrians have used the crosswalks more. Also in the signalized intersections more people used the crosswalks than the un- signalized intersections. Perhaps the reason is that in the signalized intersections people use the crosswalks due to higher control in separate crossing of the cars and the pedestrians and the pedestrians felt completely safe when the light is green and they use the crosswalk. However in the un-signalized intersections, since no specific time id allocated to the pedestrians, they cross the street where it is closer to their destination in which the marking is effective in the rate of crossing the crosswalks. The location of pedestrian markings is significantly effective in the use of the pedestrians. By considering the diagrams in figures 1 to 4, the percentage of people who used the crosswalk in the intersection 2 is higher than the percentage of people who used the crosswalk in the intersection 1. However, these intersections are similar in terms of control. The width of the line is the same, but the location of the markings and the access of the two sides of the streets are different (Intersection 1 is a square but the intersection 2 is a cross road). What distinguishes the crosswalks is that in the Intersection 1, the crosswalk markings link at the four sides of the intersection and the pedestrians accumulate at the beginning of each crosswalk but in the intersection 2, it is impossible to link the crosswalks because of the existence of the square and the long distance. Therefore since the pedestrians select the direct and short paths they cross with a low distance from the crosswalks.

In the un-signalized intersections, the use of crosswalk affects the use of the pedestrians. As seen in the results at the intersection 3, due to the long distance the pedestrians crossed the streets from the un-marked areas; however, at the intersection 4 the percentage of people crossing the crosswalk was higher, although the intersection is un-signalized. The crosswalk at the intersection 4 is near the square.

The results analysis of the weight effect on the pedestrians crossing speed

Table 1 shows the effect of weight on the pedestrians crossing speed in the un-marked areas within all intersections and in order to remove the effects of age, the speed of pedestrian whom have same age compared with each other. For this study, using the Kolmogorov – Smirnov for the normality of the data was examined. After determining that the speed data is normally distributed, using the analysis of variance (ANOVA) and Spearman correlation for correlation coefficient was observed. In order to determine difference factors, the Gabriel's post hoc test was used shown in Tables 2 and 3.

Table 1.The analysis between speed and weight of the Pedestrian with the same age at unmarked crosswalk at all intersections

Gender	Age Group	Weight group	Number of pedestrians	Average Speed (m/s)	Standard Deviation (m/s)	ANOVA Evaluation Results upper 95% Certainty	Cohesion Test Result and Spearman Cohesion
Male	Teen	Thin Normal Fat	2 19 1	1.43 1.30 1.33	0.137 0.163 N/A	P-Value =0.546 F=0.625 **The difference was not significant**	P-Value =0.416 R= -0.183 **No significant relationship**
	Young	Thin Normal Fat	11 140 17	1.43 1.30 1.18	0.059 0.151 0.176	P-Value <0.0001 F= 9.875 **major difference**	P-Value <0.0001 R=-0.321 **correlation is significant**
	Middle-aged	Thin Normal Fat	17 80 10	1.38 1.29 1.15	0.171 0.177 0.180	P-Value =0.023 F=3.949 **major difference**	P-Value =0.005 R=-0.280 **correlation is significant**
	Elderly	Thin Normal Fat	15 30 17	1.21 1.20 1.04	0.199 0.204 0.126	P-Value =0.143 F=2.042 **The difference was not significant**	P-Value =0.107 R= -0.252 **No significant relationship**
Female	Teen	Thin Normal Fat	1 1 N/A	1.15 1.15 N/A	- - -	**The number of observations is not enough**	**The number of observations is not enough**
	Young	Thin Normal Fat	7 104 20	1.29 1.26 1.08	0.159 0.180 0.241	P-Value =0.002 F=5.654 **major difference**	P-Value =0.008 R=-0.237 **correlation is significant**
	Middle-aged	Thin Normal Fat	10 37 18	1.18 1.15 1.00	0.117 0.158 0.142	P-Value =0.004 F=6.234 **major difference**	P-Value =0.001 R=-0.416 **correlation is significant**
	Elderly	Thin Normal Fat	13 19 15	1.03 0.98 0.96	0.162 0.138 0.140	P-Value =0.751 F=0.292 **The difference was not significant**	P-Value =0. 555 R= -0.154 **No significant relationship**

Table 2.The evaluation result for all group correlation analysis (male)

Gender	Age Group Comparison			P-Value	Cohesion Test Result and Spearman Cohesion
	Age* Group				
Male	Young	Thin	Normal	<0.0001	Major difference with all group (Games-Howell)
			Fat	<0.0001	
		Normal	Thin	<0.0001	Major difference with all group (Games-Howell)
			Fat	0.033	
		Fat	Thin	<0.0001	Major difference with all group (Games-Howell)
			Normal	0.033	
	Middle-aged	Thin	Normal	0.325	Major difference with fat group (Gabriel)
			Fat	0.026	
		Normal	Thin	0.325	Major difference with fat group (Gabriel)
			Fat	0.035	
		Fat	Thin	0.026	Major difference with all Groups (Gabriel)
			Normal	0.035	
	Elderly	Thin	Normal	1.00	No Major difference with all Groups (Gabriel)
			Fat	0.367	
		Normal	Thin	1.00	No Major difference with all Groups (Gabriel)
			Fat	0.121	
		Fat	Thin	0.367	No Major difference with all Groups (Gabriel)
			Normal	0.121	

Table 3.The evaluation result for all group correlation analysis (female)

Gender	Age* Group	Age Group Comparison		P-Value	Cohesion Test Result and Spearman Cohesion
Female	Young	Thin	Normal	0.976	Major difference with fat group (Gabriel)
			Fat	0.042	
		Normal	Thin	0.976	Major difference with fat group (Gabriel)
			Fat	<0.0001	
		Fat	Thin	0.042	Major difference with all Groups (Gabriel)
			Normal	<0.0001	
	Middle-aged	Thin	Normal	0.924	Major difference with fat group (Gabriel)
			Fat	0.047	
		Normal	Thin	0.924	Major difference with fat group (Gabriel)
			Fat	0.004	
		Fat	Thin	0.047	Major difference with all Groups (Gabriel)
			Normal	0.004	
	Elderly	Thin	Normal	0.885	No Major difference with all Groups (Gabriel)
			Fat	0.834	
		Normal	Thin	0.885	No Major difference with all Groups (Gabriel)
			Fat	0.994	
		Fat	Thin	0.834	No Major difference with all Groups (Gabriel)
			Normal	0.994	

As shown in Tables 1 to 3 the speed rate of the pedestrians crossing all the intersections were compared with statistical tests. About the effect of weight on the speed of pedestrians it was observed that the average speed of both male and female pedestrians was significant at 95% confidence only among the young and the middle-aged pedestrians. However in young and the middle-aged pedestrians in both sexes the speed difference of the weight groups was not statistically significant. To determine the difference factors Gabriel hoc test was used. As the results of this test are shown in Table 2 they have significant differences among the three weight groups for young male age groups. In the middle-aged male groups the factor causing the difference are the overweighed group that are significantly different from the thin (P=0.026) and normal (P=0.035). However in the elder group the difference between the weight groups is not statistically different. According to Gabriel hoc test findings in Table 3, the crossing factor difference among the female at young and middle-aged age groups is the overweighed group. In other words, in both young and middle-aged groups the thin and normal groups cross the crosswalks with closely related speeds. Old women ANOVA indicated that non of the weight groups have significant statistical with each other (P=0.751), the Correlation coefficient test rejected the significant association between the groups (P=0.555). This indicates that in the older age group (60 years and above) weight is not a determining factor.

Unmarked and marked crossing speed comparison

As shown in figure 5, the highest 15th percentile speed in both marked crosswalks and unmarked crosswalks is related to the male pedestrians; while the group of pedestrians had a lower crossing speed in both cases in the intersections and had the minimum average speed and 15th percentile speed. Additionally, crossing speed in marked crosswalks is higher than the crossing speed in unmarked crosswalks in both signalized intersections and un-signed intersections.

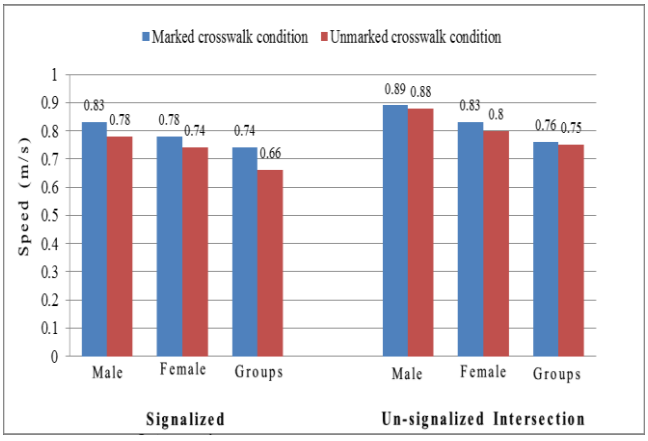

Figure 5. Compare the 15th percentile crossing speed of pedestrians taken in marked crosswalks condition and unmarked crosswalks condition

By comparing crossing speed result of present study with other studies which have been presented in the literature review are observed that the pedestrians average speed in un-marked and marked crossing condition is much lower than the speeds reported by other researchers.

Conclusion

In this study, we investigate the crossing speed of pedestrians at signalized and un- signalized intersections in marked and un-marked crosswalks found that:

- Pedestrians at signalized intersections use crosswalks more than the un-signalized intersections.
- The location of the crosswalk is very effective so that as the distance with the intersection becomes lower it is used more frequent.
- In the young and middle-aged male group, the difference in crossing speed at un-marked crosswalks is significant at 95% level in all weight groups. However in the teenage and old age groups, the difference of the weight groups was not statistically significant.
- In the young and middle-aged female group, the difference in crossing speed at un-marked crosswalks is significant at 95% level in all weight groups. However in the old age group, the difference of the weight groups was not statistically significant.
- In both male and female older age groups (60 years and above), weight is not a determining factor in crossing the non-marked areas.

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