Case Study on Comparison of Crossing Speed Variation of Pedestrians at Signalized Crosswalks with and without Countdown Displays

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Abstract: Signalized crosswalks are the common pedestrian crossing facilities which are controlled by signal indications. Some signalized crosswalks comprise countdown displays along with the traditional colour displays (i.e. green, red) whereas others only have traditional colour displays. Countdown display is a numerical sequence counting down the time left to cross the road. Crossing behaviour of pedestrians at these two types of crosswalks may be different due to the impact of the countdown displays. The purpose of this study is to compare the crossing behaviour of the pedestrians at signalized crosswalks with and without countdown displays focused onto their average crossing speeds. A crosswalk in a semi-urban city in Sri Lanka was selected as the study site and video surveying was used for data collection. The results showed that the average crossing speeds of the pedestrians at signalized crosswalks with countdown displays are always greater than that of without countdown displays.

Keywords: Crosswalks, Pedestrians, Countdown

1. INTRODUCTION

A crosswalk is a place which is designated for pedestrians to cross a road. Some of these crosswalks are signalized and some are not. Signalized crosswalks are controlled by signal phases. Some signalized crosswalks only possess the colour light displays (i.e., red and green) where the people are allowed to cross the road during the green phase. The people entering the crosswalk have to reach the opposite side before the green phase changes to red phase. There are another types of signalized crosswalks where there are countdown displays showing the number of seconds remaining for the pedestrians to cross the road. In this situation, the pedestrians have the opportunity to adjust their crossing behavior (e.g., speed) based on the amount of remaining time displayed. Basically, what is emphasized here is that the crossing pedestrians have a clear idea when the signal phase changes throughout the crossing procedure. But, the condition on the signalized crosswalks without countdown displays is different. There, the pedestrians have no idea when the signal phase would change. Thus, in

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this research authors studied how these two different conditions affect the pedestrians' crossing behavior at signalized crosswalks.

2. LITERATURE REVIEW

Jayathilake et al (2017) conducted a study on finding the factors affected for start-up times of pedestrians at signalized crosswalks. According to the results, there exists an influence from countdown display of red phase for early start-up pedestrians. However, they have not studied on the total crossing behavior with and without countdown displays in signalized crosswalks. Further, they have not highlighted any red light violation situations from vehicle side. Same authors extended the study to see the influence of gender, age, attar, group crossing, with and without luggages etc. on start-up times.

Ma *et al.* (2015) have carried out an empirical analysis on the effect of countdown signals on pedestrian behaviour. In this study, field observations of critical pedestrian-related parameters at three intersections with countdown signals and two intersections without countdown signals has been collected by video recording for safety and efficiency analyses. According to the results of this research the authors conclude that countdown signals decreases the perception– reaction time and significantly improves crossing speed, especially at the end of clearance time.

Paschalidis *et al.* (2016) suggest that, a high number of pedestrians violate the red light indication and cross the road illegally when there are no countdown displays at signalized crosswalks. They have done a study to investigate the influence of countdown timers on pedestrians' compliance regarding their crossing behaviour at intersections as well as to examine the parameters affecting walking speed adaptation. Two regression models have been developed to examine pedestrians' compliance and the factors that make pedestrians adapt their walking speed as they are crossing the road. The results of this study show that the gender, the age, the perceived comfort and the seconds remaining for the onset of red light are the main parameters that affect compliance. Furthermore, the age, the compliance and the perceived assistance that the countdown timer provides for the walking speed adaptation affect the minimum remaining time before a pedestrian accelerates.

Kim *et al.* (2002) have done a study to evaluate the effects of pedestrian countdown signals in Korea and to compare the numeric and graphic countdown signals. Comparing the two types of countdown signals revealed that the numeric countdown is more desirable than the graphic countdown for pedestrians' compliance with the flashing Walking Person signal.

Lipovac *et al.* (2013) have done an analysis on the behavior of pedestrians at crossings with and without countdown displays. The analysis gave results on the distribution of illegal crossings (at the pedestrian red light) of different categories of pedestrians such as gender and age. Authors conclude that a countdown display significantly reduces the total number of violators, regardless of its location and traffic flow.

Vujanić *et al*. (2013) proposed a method for assessing pedestrian risk at the signalized pedestrian crossing equipped with countdown displays. They have determined the percentages of males and females at risk while crossing the road at the signalized crosswalk with countdown. The results show that male pedestrians are more often in dangerous situation (20.4%) than female pedestrians (14.4%) while about 3% of all examined pedestrians created conflict situations, more frequently in first 5 seconds and last 5 seconds of red light phase.

Current study tries to compare the crossing behavior of pedestrians with and without countdown signals in a semi-urban setting. For this, same crosswalk with similar conditions are used only make the experiment as with countdown and without countdown. Further, vehicle movement is one direction with four lanes.

3. METHODOLOGY

Initially, it is required to select a suitable site for the experiment. The requirements considered are; being a signalized crosswalk with countdown display, situated in a congested location where a heavy pedestrian_movement can be observed, and availability of a vantage point for capturing an aerial video footage of the pedestrian behavior. Considering all these requirements, the crosswalk in a semi-urban city in Kandy, Sri Lanka was selected as the site. Figure 1 shows the location of the selected study site. This crosswalk comprises countdown displays along with the traditional colour displays (i.e. green, and red). The cycle length of the signal was such that the green phase was 25 seconds while the red phase was of 85 seconds. Furthermore, the composition of the green phase was such that the first 20 seconds were solid green and the last 5 seconds were flashing green. However, there is no “FLASHING DON’T WALK” indication. The selected crosswalk is located in a highly commercial area and in a one way road street with four standard lanes.

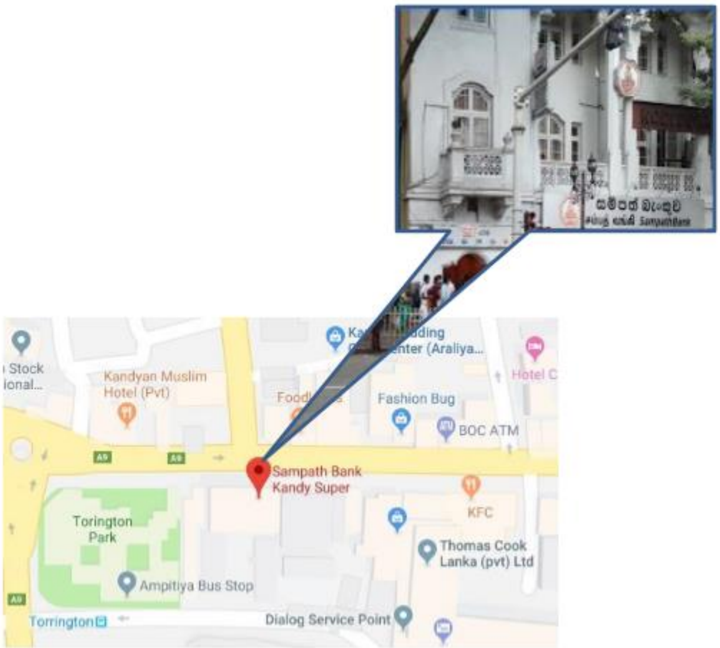

Figure 1: Location of the selected study site

All the data required for both with and without countdown display situations were obtained from the same location. The video data required for without countdown display were obtained by covering the countdown display such that pedestrians couldn’t see it. Covering the countdown display was done after getting special permission from the Kandy police. Figure 2 shows the dimensions of the selected crosswalk.

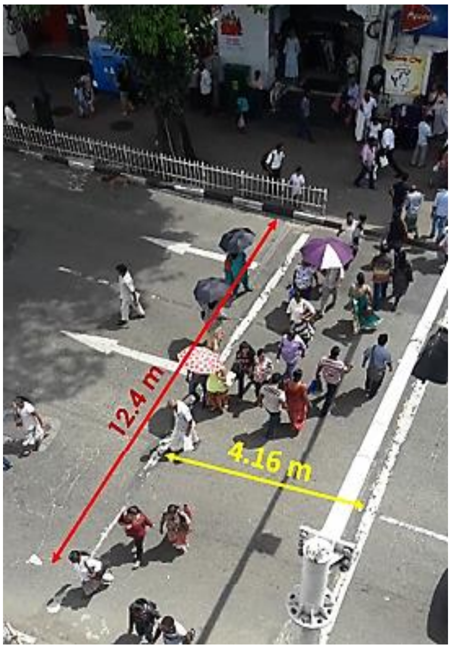

Figure 2: Dimensions of the selected crosswalk

Video surveillance technique was adopted as the data collection method. The camera was placed such that the pedestrians as well as the signal indications were clearly visible. Data used for this study was captured on a Wednesday, from 11.00 am to 12.00 noon. Data sample consists of 500 randomly selected pedestrians, where half of the sample selected with countdown and remaining without countdown. Thus, two data samples are exclusively independent.

Travel length and travel time were extracted through a tracking software "TRACKER-4.11.0". This software includes both manual and auto tracking options. Considering easiness and accuracy, auto tracking option was used. Thirty minute video recordings were divided into small (4-5 min) video clips and imported to the software. After importing the video, X and Y coordinate axes were defined along the length and the width of the crosswalk as shown in Figure 3. The known length of the crosswalk was used as the calibration stick length to calibrate the video. The head of the pedestrian was selected as the point mass. Then, the pedestrians crossing paths were autotracked as shown in Figure 4. The software gave X and Y coordinates of the pedestrian at each frame. The frame rate was 30 frames per second. Finally, the travel length was calculated using these X and Y coordinates. When calculating the travel length, corrections were applied for the errors occurred due to the camera angle as well as the varied heights of pedestrians. Based on the extracted travel length and time data, the average crossing speeds were found categorizing the pedestrians based on their entering time on to the crosswalk.

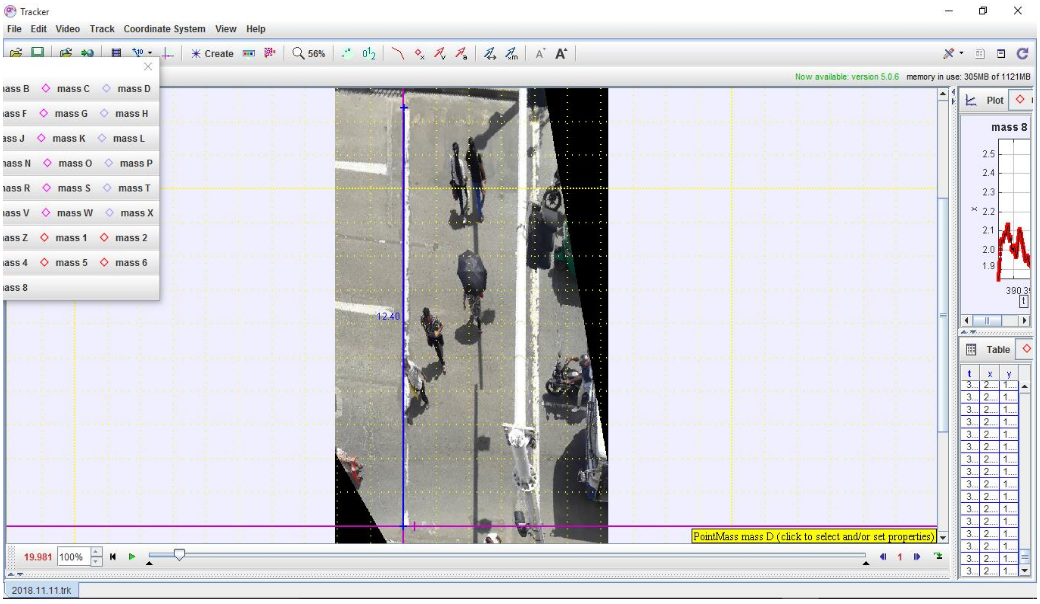

Figure 3: Defining X and Y coordinate axes and calibration stick

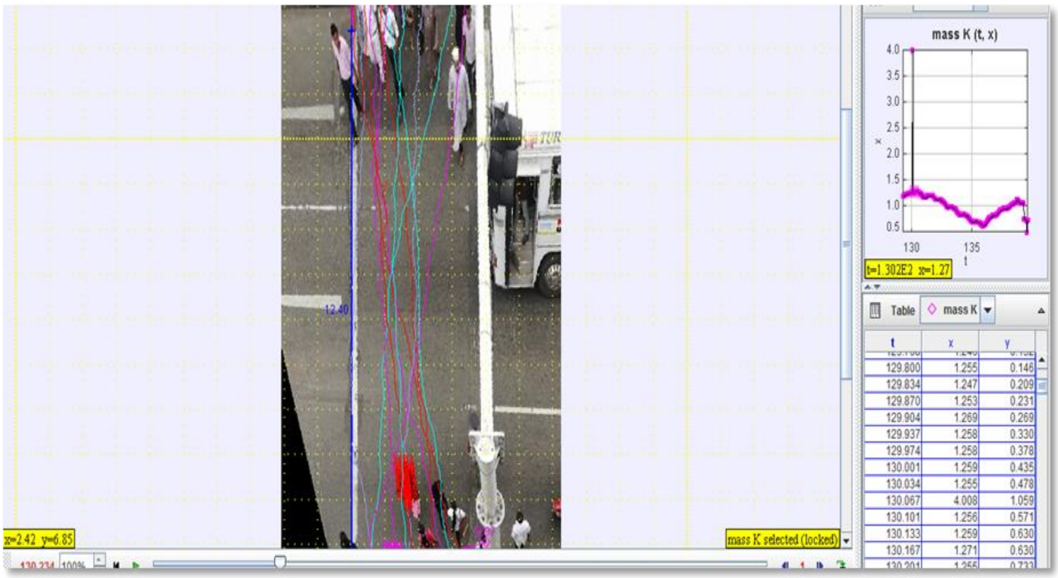

Figure 4: Tracked pedestrian crossing paths

4. RESULTS AND DISCUSSION

Both descriptive and statistical analyses were carried out. The average crossing speeds of the pedestrians as per their entering time to the crosswalk were tabulated for both with and without countdown situations as shown in Table 1. For each time slot, ten pedestrians were randomly selected and average crossing speed value is taken for the analysis.

Table 1: Average crossing speeds

Entering time[Time past the start of countdown] (s)	Average crossing speeds (m/s)	
	With countdown	Without countdown
0	1.37	1.32
1	1.37	1.32
2	1.24	1.24
3	1.31	1.25
4	1.28	1.21
5	1.34	1.26
6	1.50	1.48
7	1.52	1.51
8	1.49	1.39
9	1.54	1.32
10	1.63	1.42
11	1.68	1.37
12	1.73	1.39
13	1.79	1.55
14	1.82	1.49
15	2.01	1.52
16	2.02	1.55
17	2.15	1.64
18	2.24	1.69
19	2.38	1.73
20	2.49	2.21
21	2.61	2.32
22	2.58	2.38
23	2.63	2.49
24	2.72	2.58

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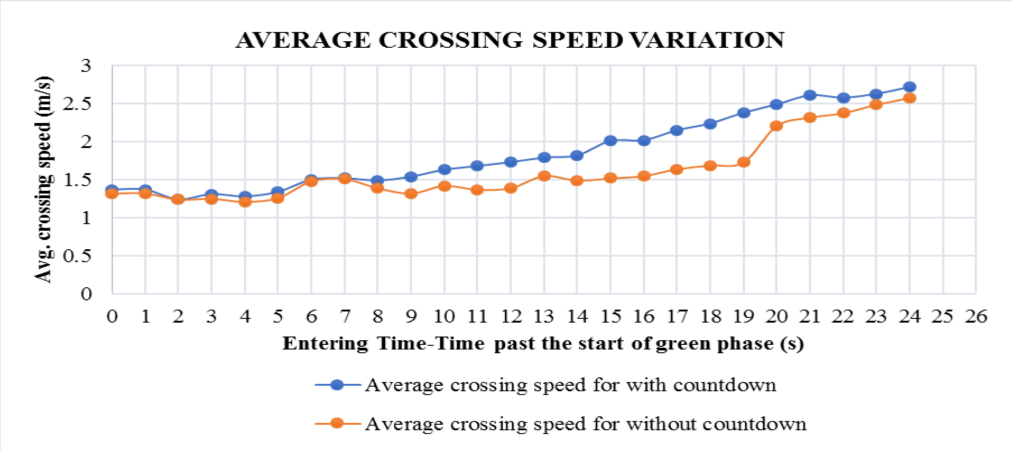

Figure 5: Tracked pedestrian crossing paths

The descriptive analysis results shows that the average crossing speeds of the pedestrians at signalized crosswalks with countdown displays are always greater than that of without countdown displays (Figure 5). The reason might be that pedestrians in crosswalks with countdown displays are trying to adjust their crossing speeds according to the time left such that they could finish crossing within that remaining time. Because of that, their average crossing speeds also were gradually increasing from the beginning to the latter part of the green phase. Although the average crossing speeds of the pedestrians at signalized crosswalks without countdown displays were also gradually increasing, their rate of increment was lower compared to that of with countdown display crosswalks. But, reaching the last five seconds of the signal phase, the pedestrians in crosswalks without countdown showed a sudden increment in their average crossing speeds because they tend to move fast once they see the flashing green light. This sudden speed increment is not safe because, if the crosswalk surface is slippery pedestrians might fall down. Therefore, availability of countdown displays avoid these type of sudden speed increments by indicating people how they should adjust their speeds with the time remaining from the moment they enter to the crosswalk.

With the descriptive analysis performed for both with countdown and without countdown situations, line graphs were obtained, and results were used to divide the green signal phase for pedestrians into three zones as shown in Figure 6.

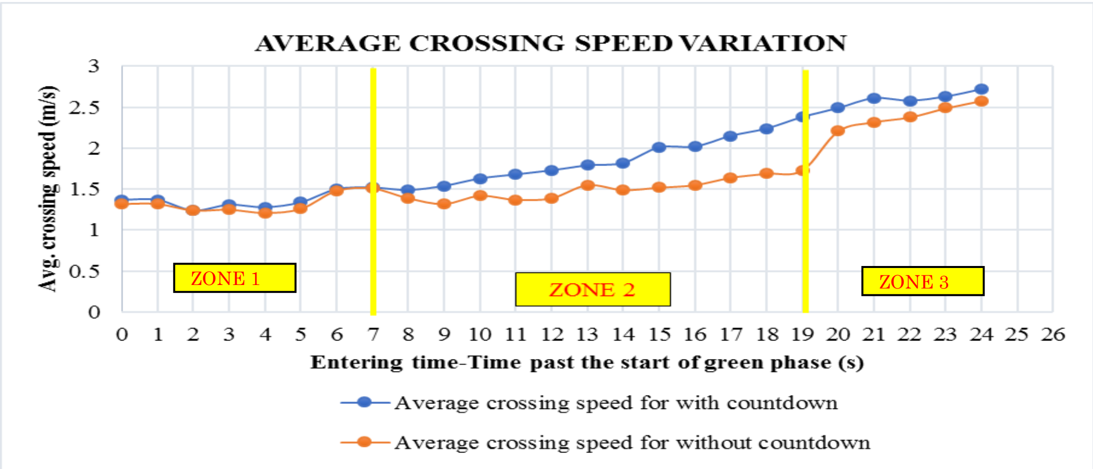

Figure 6: Three time zones of the green signal phase

In order to check whether there exist any significant difference to pedestrians' crossings behavior with and without countdown displays at signalized crosswalks, simple statistical tests were performed. The average crossing speeds of the pedestrians as per their entering time to the crosswalk for with countdown situation and without countdown situation were considered as two samples. Since those two samples are completely independent, the unpaired t-test is used. This test is used to test the mean of two different groups. Accordingly the following hypothesis was developed.

$H_0 : \mu_{withcountdown} - \mu_{withoutcountdown} = 0$
(i.e., there is no any difference between the means of with countdown and without countdown samples)

Vs.

$H_1 : \mu_{withcountdown} - \mu_{withoutcountdown} \neq 0$
(i.e., there is a difference between the means of with countdown and without countdown samples)

However, the two samples should be normally distributed to apply the t-test. Anderson Darling test and Shapiro-Wilk test are used to check the normality of two samples of each zone. Accordingly, following hypothesis was developed to check the normality under those two tests.

H_0= Data Normally Distributed

Vs.

H_1=Data Not Normally Distributed

The normality test and the unpaired t-test were performed for each selected zones.

Zone 1: (0 to 7 Seconds)

According to the Anderson Darling Test, obtained p-value > 0.05, and thus, H_0 cannot be rejected. Therefore, data are normally distributed in zone 1. Since the samples are normally distributed, unpaired t-test was used. According to the unpaired t-test, obtained p value > 0.05, and thus, H_0 cannot be rejected. Hence, it can be concluded that there is no any difference in between the means of two samples.

Zone 2: (8 to 19 seconds)

According to the Anderson Darling Test, obtained p-value >0.05, and thus, H_0 cannot be rejected. Therefore, data are normally distributed in zone 2. Since the samples are normally distributed, unpaired t-test was used. According to the unpaired t-test, obtained p value < 0.05 and thus, H_0 can be rejected and enough evidence exists to conclude that there is a difference in between the means of two samples.

Zone 3: (20 to 25 seconds)

Since the sample size is too small (less than or equal 5), Shapiro-Wilk test was used to check the normality of two samples in Zone 3. H_0 cannot be rejected since p-value >0.05. Thus, samples are normally distributed. Since the samples are normally distributed, unpaired t-test was used. According to the unpaired t-test, H_0 cannot be rejected since p-value <0.05. Thus, it can be concluded that there exists a difference in between the means of two samples.

All the statistical tests were performed using R software. The results of the unpaired t-test carried out for comparing the behavior with and without countdown within the three time zones are tabulated in Table 2.

Table 2: Behavior comparison in time zones

Time zone	Time range	P-value	Behavior comparison between two samples
Zone 1	0-7	0.4363	No difference exists
Zone 2	8-19	0.0009	Difference exists
Zone 3	20-25	0.0284	Difference exists

Accordingly, the pedestrians who enter to the crosswalk during time zone 1 where the P-value is 0.437 show no significant difference though countdowns exist or not. At the initial part of the green signal phase the pedestrian behaviour is almost similar saying no impact from countdown.

Going into the time zone 2, the pedestrians entering within this zone display a significant difference in their behavior because when the countdown is available pedestrian know how much time remaining and they adjust their crossing speeds accordingly. Therefore, they tend to gradually and conscientiously increase their crossing speeds depending on the entering time. But, when no countdowns available, pedestrians have no idea when the green signal phase would change. So, the increment rate of the crossing speed is slow while making higher possibility of getting trapped in red phase.

The pedestrians entering during time zone 3 which is the latter part of the green phase also, pedestrian behaviour shows a significant difference. But, that difference is not as higher as time zone 2 because of the flashing green signal saying that the green signal is going to change into red soon. When the countdown is not available, pedestrians only know that the signal phase is going to change soon. But, when the countdown signal is available, pedestrians get to know exactly within how much of time the green signal is going to turn into red. So, the pedestrians have the chance to adjust the crossing speeds such that they can finish crossing before red signal comes. So, there is less possibility for them to get trapped in red signal phase.

5. CONCLUSIONS

At signalized crosswalks with countdown displays, the pedestrians are allowed to make better crossing decisions since they have the chance to know how much time left to cross the road. So, they can either adjust their crossing speed such that they can finish crossing within the remaining time or they can wait until the next green phase comes. But, when there is no any countdown display pedestrians enter the crosswalk once they see the green phase without having any idea whether they have sufficient time left to cross the road or not. Once they have no sufficient time to finish crossing they get trapped at the middle of the crosswalk causing a risk for accidents. In the case of crosswalks with countdown displays, pedestrians are well aware of the time that they have and would leisurely cross the street, except towards the end of green.

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