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Pedestrians' Crossing Behaviors and Crossing Preferences: A Field Study

SENA ÇINAR[a], ŞERIFE YILMAZ[b], BAHAR ÖZ[b]

a. Graduate School of Natural and Applied Sciences, Middle East Technical University, City Planning, Ankara, Turkey
b. Safety Research Unit, Department of Psychology, Middle East Technical University, 06800, Ankara, Turkey

ABSTRACT: Pedestrians are one of the most vulnerable road user groups in traffic and face many risky situations in traffic, especially when pedestrians cross the street, where a pedestrians-vehicle interaction or conflict is most likely. Different from the previous studies on pedestrian behavior, the current study targeted exploring pedestrian behavior and safety at a specific street in Ankara-Tunalı Hilmi Street Turkey employing two different data collection methods. Specifically, the current study aimed to understand the behaviors, perceptions, and crossing preferences of pedestrians in the study area. In addition to the above, it aimed to identify situations that create safety concerns for pedestrians in the area and offer area-specific countermeasures addressing these concerns. For this purpose, an online survey study and an observational study were conducted. The results of the survey based on investigations of the crossing preferences of 96 pedestrians revealed an understanding of the participants' motivation when crossing the street, their attitudes toward traffic rules, and their safety perceptions about the area. Additionally, it targeted to understand the situations that negatively affect road safety in the area for pedestrians. According to the survey respondents, the study area was unsafe for pedestrians and the biggest problem in terms of pedestrian safety is vehicle traffic and parking. The observation study presented significant differences in crosswalk use, compliance with the signal between pedestrians who cross alone or in a pair and those who cross in a group. People who cross the street as a group use crosswalk and comply with the traffic signal more than people crossing alone or in a pair. In addition, considering the illegal crossing rate, it can be said that jaywalkers – people who do not use crosswalk – are the majority in the study area. As a result, the current study helps to arrange crossing facilities according to pedestrian preference because the proper design of facilities contributes to pedestrian safety and encourages walking without sacrificing safety and comfort. Accordingly, reducing vehicle traffic, increasing and arranging parking areas, and increasing number of pedestrian facilities are suggested to increase pedestrian safety in the area.

KEYWORDS: Pedestrian crossing, pedestrian behaviors, pedestrian pereferences, signalized crosswalk, observational study, survey

1. INTRODUCTION

Pedestrian circulation is an essential part of urban networks. By interacting with other modes of transport (car, bicycle, public transport), it has a significant impact on the functionality of sidewalks and crosswalks, as well as the entire transport network. Additionally, pedestrian mode helps to reduce car traffic and air pollution (Şişman & Etli, 2007). Pedestrian roads have become a necessity for the people of the cities, which are overbuilding day by day. Because of this, pedestrian roads create spaces for city dwellers to breathe and create space for movement. (Şişman & Etli, 2007). Pedestrians are vulnerable road users who are easily injured in a car-dominated road area because they are not protected by steel armor as drivers. But more importantly, studies show that the real vulnerability for pedestrians lies in transport planning that is more focused on the needs of motorized transport (Khayesi, 2020). As a result of car-oriented planning, pedestrians often face unsafe urban environments such as high-speed traffic and the limited number of facilities such as pedestrian crossing and pedestrian signals (Soathong et al., 2021). Looking at the traffic accidents in Turkey, 21 765 pedestrians versus vehicle accidents occurred in 2020 (Turkish Statistical Institute [TUIK], 2021). The reason for the 1487 of these accidents was that drivers did not slow down at the pedestrian and school crossings and did not give pedestrians the right to pass (TUIK, 2021). In addition to these, considering the pedestrian faults in the pedestrian versus vehicle accidents, 3727 of these accidents were caused by the pedestrians violating the traffic lights and signs, and 338 of them are due to violating the traffic rules while crossing the street. It is observed that pedestrian versus vehicle accidents occurs due to both driver and pedestrian faults when pedestrians have to share the road with vehicles (TUIK, 2021). In this regard, in the planning of cities, designs, and applications that take the pedestrian safety dimension in the foreground should be carried out, as well as the functions of pedestrian crossings should be emphasized. Therefore, this study examined several variables on pedestrian preferences and pedestrian crossing behavior and explored pedestrian behavior at signalized pedestrian crossings. This study can be helpful for understanding the pedestrian crossing behavior and suggesting countermeasures that can increase pedestrian safety in Ankara, Tunalı Hilmi Street. The literature review has been divided in three categories. Then, the methodology of the study, planned in the light of the previous literature, is mentioned. The survey and observation study results carried out within the scope of these purposes are given in detail. The paper ends with a discussion of these results. The following section provides an overview of key findings in the relevant literature.

2. LITERATURE REVIEW

2.1 Pedestrian Safety

In Turkey, projects on pedestrian safety have also recently gained importance. For example, in 2018, pedestrian priority in traffic and pedestrian crossings was included in the law. The amendment made in the 74th article of the Highway Traffic Law numbered 2918 to draw attention to pedestrians in traffic. "Drivers must slow down when approaching pedes-

trians and school crossings with intersection entrances and exits that do not have a person in charge or an illuminated traffic sign, but with traffic signs or signs, and they must give way to pedestrians who are passing through or about to pass through them." (Ministry of Interior, 2019). The year 2019 has been declared as "Pedestrian Priority Year" with the slogan of "Priority is life, priority is pedestrian" by the Ministry of Internal Affairs of Turkey. Also, there is another campaign of the Ministry of Interior for pedestrian awareness in traffic, called "We are the Watch for Pedestrian Safety."

Accidents involving pedestrians usually occur at where pedestrians' movements and motorized / non-motorized vehicles intersect in traffic. Kadali & Vedagiri (2013) assessed pedestrian-vehicle accidents using a pedestrian safety margin, which is defined as the time that a vehicle needs to arrive to the point where the pedestrian crosses. In a study aiming to increase pedestrian safety, Demiroz et al., (2015) stated that the area where pedestrian accidents occurred and the time of collision should be examined together to better understand the pedestrian safety conditions. In this study, pedestrians' crossing speeds and the factors affecting pedestrians' crossing speed were investigated. It has been argued that the results obtained will positively affect the arrangement of pedestrian crossings. The results of the study showed that age is associated with both safety margin and crossing time. Moreover, the study showed that pedestrians feel safer when crossing the road when the vehicle speed is low (Demiroz et al., 2015). According to Carter et al. (2006) the safety level of a road element can be assessed in three different ways as follows; accident frequency, representative measures about the behavior of road users and experts or road users' opinions. Although many researchers have studied pedestrians, few of them have taken into account the compliance rate of pedestrian facilities and pedestrian crossing behavior in Turkey. In addition, there are few studies focusing on pedestrian safety through pedestrian behaviors at a specific street. Therefore, the present study is targeted exploring pedestrian behavior and pedestrian safety on a particular street in Turkey using two different data collection methods.

2.2 Pedestrian Behaviors and Preferences

Pedestrians display various behaviors in everyday situations while crossing the street (Soathong et al., 2021). There are many studies examining pedestrian behavior to analyze the traffic environment better ,such as waiting time (Hamed, 2001; Yannis et al., 2013), crossing time (Demiroz et al., 2015), crossing speed (Aghabayk et al., 2021; Demiroz et al., 2015), delay (Holland & Hill, 2010), gap acceptance (Demiroz et al., 2015; Yannis et al., 2013), crossing compliance (Demiroz et al., 2015; Holland & Hill, 2010; Papadimitriou et al., 2017; Sisiopiku & Akin, 2003; Yagil, 2000), route and crossing choice (Holland & Hill, 2010; Papadimitriou et al., 2017; Schultz et al., 2015; Sisiopiku & Akin, 2003), etc. In addition, gender and age differences in these pedestrian crossing behaviors and preferences have been widely reported in the literature (Herrero-Fernández et al., 2016; Holland & Hill, 2010; Yagil, 2000).

According to Yagil (2000), the number and speed of vehicles appear to be important variables in male pedestrians' decisions to cross. However, the presence and behaviors of other pedestrians appear to be more important in female's decisions. It has also been found that male pedestrians are prone to making dangerous crossings (Herrero-Fernández et al., 2016; Holland & Hill, 2010). Herrero-Fernández et al. (2016) examine the frequency of seven potentially dangerous behaviors such as crossing when the signal is red if no vehicle is visible, not looking in both directions before crossing pedestrian crosswalks, and crossing the road in places where there is not a pedestrian crosswalk (i.e., jaywalking). The results showed that, there are significant differences between men and women in terms of self-reported risky pedestrian behavior (Herrero-Fernández et al.,2016). According to Holland & Hill (2010), male pedestrians are more likely to cross carelessly (60%) and during a red signal (64%) than female pedestrians (40% and 36%, respectively). In terms of age, according to the results of the observation study conducted at the signalized pedestrian crossing, the probability of obeying both the pedestrian crossing and the traffic light is higher among people estimated to be younger than 18 years old than the middle-aged pedestrians (Ren et al., 2011).

Waiting time is an essential measure that, in addition to being used to design signals, has an impact on pedestrian safety and crossing risk. Hamed (2001) developed models in order to understand pedestrian crossing behavior on divided (separated with a barrier or median strip) and undivided (there is nothing separating the two lanes) roads. The pedestrians' starting and destination points, crossing frequency, age, gender, group crossing behavior, and whether they had an accident before were examined. The results of this study showed that as pedestrian flow increases, road-crossing wait time for them decrease. This indicated that pedestrians tend to cross the street in groups. In addition, according to Hamed (2001), if pedestrians wait too long to cross, their impatience to cross increase, and they become impatient. Impatient pedestrians take more risks and accept shorter intervals. Therefore, the waiting time is considered a critical variable that affect the pedestrian crossing behavior (Ferenchak, 2016) because the main reasons for choosing to pass through places without pedestrian crossings are time saving and convenience (Demiroz et al., 2015). Understanding how long pedestrians are able to wait at mid-block crossings and their risk tolerance leads to design considerations that account for their safety needs (Ferenchak, 2016). Yannis et al. (2013) examined pedestrians' decision-making processes for crossing under actual traffic conditions and the variables that affect these decisions. They examined vehicle speeds, the size of the intervals accepted and rejected by pedestrians, waiting times and crossing attempts associated with these periods, and pedestrians' individual characteristics such as age and gender. In this study, while the individual characteristics of pedestrians were not found to be significant, traffic conditions (distance from the incoming vehicle, the size of the vehicle, the presence of illegal parking, whether they are accompanied by another pedestrian) were found to be the most important determinant factor of crossing behavior. Another important component for behavior analysis is pedestrian walking speed and crossing speed. In their study, Aghabayk et al. (2021) examined the effects of gender, age category, group crossing, use of technological devices on the crossing behaviors of pedestrians in both signalized and unsignalized pedestrian crossings. According to the results of the study, alone pedestrians were more careful and crossed the crosswalk faster than groups. Tarawneh (2001) evaluates the effects of age, gender, street width and the number of pedestrians crossing as a group (group size) on their speed. According to the results of the study, it was found that the average walking speed of pedestrians in groups of three or more people was significantly higher than those walking alone or in pairs.

Environmental factors are also related to pedestrian behavior. Schultz et al. (2015) investigated how the built environment affects crossing behaviors and traffic speeds. Accordingly, the installation of a signalized pedestrian crossing resulted in an increase in safe street crossings and calmed traffic volume and speed in an underserved neighborhood compared to a control area without infrastructure changes. According to Hamed (2001), the risk-taking decisions of pedestrians when crossing may differ according to environmental factors. These

environmental impacts can be land use or traffic, or road features. According to Southworth (2005), environmental designs play an important role in the behavior of pedestrians during the circulation of the city. It is common for pedestrians to take risks and cross the road without using any pedestrian crossings. Such behavior can be attributed to several factors. For example, pedestrians often react to environmental situations and evaluate the traffic situation before crossing. These decisions taken as a result of motivation constitute the situation of taking risks. The distance of the pedestrian to the destination is also important since pedestrians are more likely to choose the shortest route (Sisiopiku & Akin, 2003).

2.3 Pedestrian Crossing

In terms of maintaining or increasing pedestrian safety in urban roads, some aspects should be considered in the design. There is a need to determine what characteristics impact the accessibility, safety, and attractiveness of walking conditions for all pedestrians in order to make street areas more walkable. Different features of the road crossing, such as signalized and unsignalized intersections, marked and unmarked pedestrian crossings, crosswalks with and without medians, they all impact pedestrian crossing behaviors (Sisiopiku & Akin, 2003). Zegeer et al. (2001) emphasized that 17.6% of pedestrian crashes at marked crosswalks were multiple-threat crashes, but none at unmarked crosswalks. Aghabayk et al. (2021) found that while elderly pedestrians showed more cautious behaviors at signalized intersections, they displayed less cautious behaviors at unsignalized intersections. Sisiopiku & Akin (2003) revealed that the 83% of participants in their study preferred unsignalized midblock crosswalks to cross the street.

In the context of the continuity of urban pedestrian movement and contribution to urban space life, the pedestrian crossings at the intersection appear as important urban parts that need to be examined. As mentioned above, the design elements of pedestrian crossings are important. In the standard numbered TS 12576, which regulates structural steps and design rules for accessibility of sidewalks and pedestrian crossings on urban roads, the Turkish Standards Institute (TSI) specifies that level crossings should be constructed in areas where drivers are approaching the crossing. It also states that pedestrian crossings should be visible to pedestrians from a sufficient and safe distance (TSI, 2012). With or without light control along the road or at intersections, pedestrian crossings that pedestrians can cross on any road can be planned.

2.4 Aim of The Study

The first aim of this study was to examine the crossing behaviors, perceptions and behaviors of pedestrians on Tunalı Hilmi Street, in Ankara. It also aimed to examine whether different demographic characteristics such as age and gender differences in pedestrian' crossing behaviors and preferences. The second aim of this study was to understand the illegal road crossing behavior of pedestrians on the street and the factors associated with illegal crossing behavior, based on the part of Tunalı Hilmi Street. It also aimed to understand the motivations influencing pedestrians' crossing preferences. In addition, it aimed to understand the group crossing behavior at signalized crosswalks. Finally, it aimed to identify pedestrians' safety perceptions about the study area, to identify the situations that cause safety concerns, and to offer suggestions for these concerns.

3. FIELD STUDY

3.1 Study Site

The study site is one of the city's commercial streets, approximately 3 km away from the city center. Tunalı Hilmi Street has an approximate length of 1.5 km and a width of 16.10- 29.53 m. The sidewalk width is about 3.67 m. Due to the fact that it is located close to the city center, it is an area with high traffic and pedestrian density. This is mostly due to the business and commercial functions that serve to pedestrians' daily needs. According to a one-day observation, the traffic volume on Tunalı Hilmi Street is estimated 6000 vehicle/hour (Traffic volume was calculated by the number of vehicles passing through the study area in 15 minutes). In addition to that, the speed limit in the study area is 50 km / h. A 250-meter-long section starting from Tunalı Hilmi Street to Tunus Street was selected as the study area. The study site includes one signalized pedestrian crossing.

3.2 Methods

After ethical approval was obtained from the Middle East Technical University Human Research Ethics Committee, data were collected through online survey and field observations.

3.2.1 Design and Procedure of Survey Study

The survey was designed as a questionnaire similar to the one developed by Sisiopiku and Akın (2003). The survey was conducted using SurveyMonkey, a web-based application. In order to reach more people, the survey was designed online in such a way that the participants can reach it from the internet address or using a QR code. Different methods were used to reach the participants. A survey brochure was distributed to pedestrians in the study area on four different days and hours. In this brochure, brief information about the title and subject of the survey was given and a QR code of the online survey had been added. In addition, participants living in the neighborhood of the study area were recruited via social media groups. At the beginning of the survey, the participants were informed about the study and those who confirmed that they volunteered to participate in the study were able to access the rest of the survey. Online survey data were collected between September 16, 2021, and October 7, 2021.

The survey instrument was created to meet the following criteria: (1) a clear description of the study's objective and the necessity of participation; (2) a reasonable length; (3) a clear definition of the questions; (4) no personal or sensitive questions; (5) a format suitable for social media dissemination; and (6) a format suitable for easy data coding. The survey is designed to last 5-6 minutes. There are 17 questions in the survey. Answers were provided with rating scales, single checkboxes, multiple checkboxes (the respondent has the possibility to give more than one answer), yes/no questions, or open-ended questions.

The contents of the questions in the survey were sectioned as follow:

- Profile of users (age group, gender, and frequency of use of the facility);
  - What is your age group? (Grouped into three categories: 18-34, 35-55, and older than 55)
  - What is your gender? (Female, Male)
  - How often do you use Tunalı Hilmi Caddesi as a pedestrian? (Likert scale ranging from 1 = almost never to 4 = every day).

- Crossing patterns of users (crossing location, conditions, availability);
  - How often do you use the pedestrian crossings to cross the Tunalı Hilmi Street? (Likert scale ranging from 1 = never to 5 = always).
  - If you choose to cross anywhere rather than a pedestrian crossing, what is usually the main reason? (Sin-

gle checkboxes: seven categories: to save time or for convenience, because others passed, since I've done this before, it wasn't an accident, because there is no or little traffic on the road, because the crossing points are not well organized, because there is no traffic police, because I didn't see the traffic light, other)
- How often do you have to deviate from your path to cross the pedestrian crossings on Tunalı Hilmi Street? (Likert scale ranging from 1 = never to 5 = always)
- When do you usually cross the Tunalı Hilmi Street? (Multiple checkboxes, 4 categories: when traffic is completely cut off, when I feel like I can get through with little interference in automobile traffic, only when vehicles give way, only when the pedestrian traffic light is green)
- Do you cross the Tunalı Hilmi Street on a red light as a pedestrian? (Yes/No question)
- When do you think drivers should give way to pedestrians? (Three categories: never, vehicles take priority at pedestrian crossings, always)

– Factors affecting pedestrian crossing preferences;
  - Which of the following affects your decision to cross the street in the study area? (Multiple checkboxes, 6 categories: presence of pedestrian traffic light, presence of a pedestrian crossing, presence of other pedestrians trying to cross, distance to target, traffic at the crossing point, other)

– Perceptions and suggestions of users on right of way and safety;
  - Which of the following statements is true for the study area? Multiple checkboxes 4 categories: drivers generally give way to pedestrians at pedestrian crossing, drivers generally do not give way to pedestrians at pedestrian crossing, pedestrians often cross pedestrian crossing, pedestrians do not usually cross pedestrian crossing.
  - Do you consider this area to be safe for pedestrians? (Yes/No question)
  - How safe do you think this area is for pedestrians? (Likert scale: 1 = not safe to 7 = very safe)
  - As a pedestrian, what do you think is the biggest traffic problem in this area? (Open-ended question)
  - What environmental implementations do you think can be made to increase pedestrian safety in this area? (Open-ended question)

A serial number is assigned to the appropriate surveys. This allowed future monitoring of surveys to check for coding errors when any suspicious or unusual code was encountered. The Statistical Package for the Social Sciences (SPSS) version 26 program was used to produce graphs and data summaries as well as performing statistical analysis.

3.2.2 Design and Procedure of Observation Study

Field data collected through direct observations of pedestrian crossing activity at the study area. Data collection was performed using cameras located at three different points to cover all possible pedestrian movements across all study area. A total of three recordings was made, one of them at the signalized pedestrian crossing (3rd observation point at Figure 1) and two of them from the point where pedestrians cross most frequently and having no pedestrian facilities (1st and 2nd observation points at Figure 1). The shooting was made with the phone camera placed on a tripod. Each video recording session lasted 30 minutes. Then, the cameras were moved to the other section.

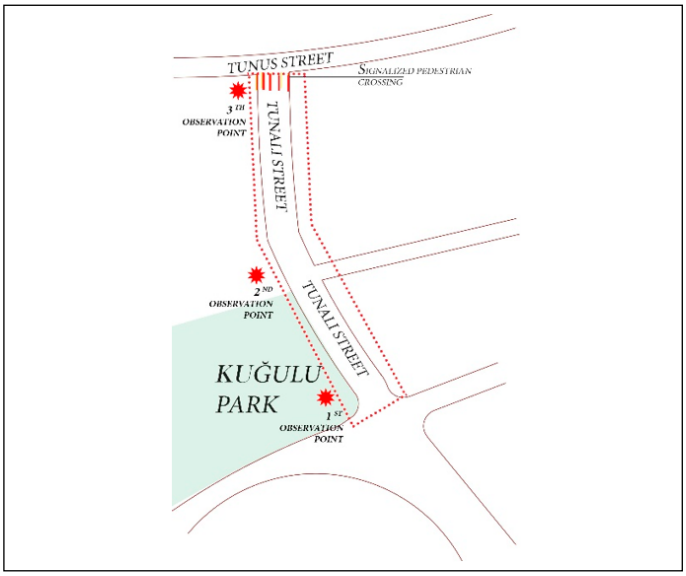

Figure 1. Study site and observation points.

Camera recordings started on October 2, 2021 (Saturday), at 13:00. Pedestrian movements were observed and recorded during peak periods (13.00-15.00) to avoid very low pedestrian movements. For the same reason, the weekend was chosen for data collection. In order to protect the video recorders from electrical damage due to rain, it was filmed on a day when the weather was suitable. Video recordings were started at the 1st observation point. After half an hour of recording, the camera was moved to the other observation point. This required a minimum of 2 hours of work to film alone in the field, with the time required to operate the equipment and move from place to place and set up correctly. As a result of this process, a 1.5-hour recording was obtained, along with the images of three different points. The field data were collected by direct observation of pedestrian activities. Then, slowed down and analyzed by taking notes.

The procedure allows the collecting of a variety of data types. The speed data collected were average crossing speeds, which were calculated by dividing the crossing distance by the crossing duration. The pedestrian's crossing time only includes the time spent walking on the roadway, not the time spent waiting on the curb or in the middle of the street. The data collector used stopwatches to time the crossing time while watching the video. Pedestrians' waiting time refers to the time between when they stop to wait and when they move to cross the street. Additionally, data on crossing behavior were gathered. The term "crossing in a group" refers to any circumstance in which three or more pedestrians are present at the crosswalk, not simply those when pedestrians are traveling in a group with friends or family. Pedestrians "crossing alone and crossing in a pair" are terms used to describe circumstances in which only one or two pedestrians are present in the crosswalk. Using the data received from the videotape analysis, the pedestrian compliance rate may subsequently be determined. Crossing within 0.5 m of either side of the crosswalk is deemed to be complying with the crossing location. The crossings at a distance of 3 m from both sides of the pedestrian crossing were partially complying with the crossing location. Compliance with the signal is defined as crossing completely during the green light time. Compliance status may subsequently be calculated using the data obtained from the videotape analysis. Those passing through the crosswalk area are considered to fit the crosswalk location. The compliance of signal is defined as a complete crossing during the green light time. As a result, the degree of pedestrian compliance at signalized intersections (i.e., com-

pliance rate) is defined as the ratio of pedestrians crossing at a crosswalk area and during the green light to the total number of pedestrians in the crosswalk area.

3.3. Survey Results

The survey reached a total of 119 people. After eliminating incomplete survey forms, a total of 107 surveys remained. It was decided not to include the answers from users who said they almost never use the study area. Therefore, 11 questionnaires were excluded from the study because they expressed the opinions of non-users and, thus, could introduce some bias to the results. In other words, people who used the area for the first time are assumed to have difficulty in making evaluations in cases such as the safety of the area and whether they use the pedestrian crossing in the area. For this reason, participants who actively used the study area, which is 96 participants, constitute the study sample.

Of the 96 participants, 62 are female (64,6%), and 34 are male (35,4%). Besides, 18 pedestrians (18,8%) used the study area "daily," 28 (29,2%) stated that they used 2-3 days a week, and the rest (50 pedestrians or 52,1%) are occasional users, using it 1-2 per month. Participants whose age is 18-35 are 29,2% (n=28), 35-55 years old are 36,5% (n=35), and the remaining 34,4% (n=33) are over 55 years old. The number of participants in each age group was relatively equal.

3.3.1 Pedestrians' Crossing Behaviors

Pedestrian non-compliance behaviors were investigated in the survey. As presented in Figure 2, 49% of the pedestrians in the survey stated that they always or frequently use the pedestrian crossing while crossing Tunalı Hilmi Street. While 35.4% stated that they used it sometimes, 25.6% stated that they rarely or never used it. While 36.5% of the participants stated that they crossed the Tunalı Hilmi Street when the pedestrian light was red, 63.5% stated that it did not cross In addition, Chi-Square tests were conducted to examine whether there was a significant difference in pedestrians' responses regarding pedestrian crossing patterns in different age groups or gender classifications. In conclusion, the differences in the answers obtained by age classification and gender, were not found to be statistically significant.

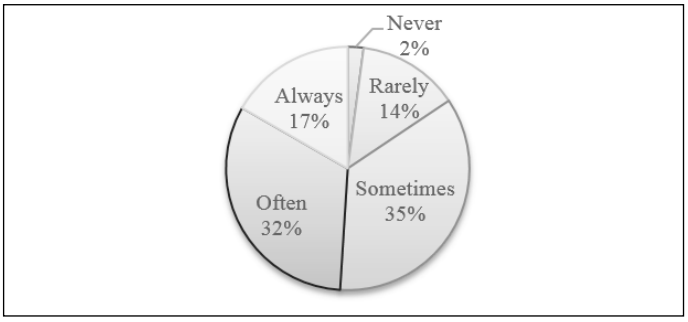

Figure 2. Frequency of participant' crosswalk use.

To investigate the reasons for pedestrians' crossing preferences, they were asked to state the main reason why they decided to cross from an unspecified pedestrian crossing location. According to users' responses, less traffic is one of the most favored reasons with 47,9%, whereas time savings and convenience were of paramount importance to 23% of respondents. 16.9% of the participants stated that they prefer any place when crossing the street because the crossing points are not well organized (see Figure 3)

These results were also related to their tendency to deviate from their path to use the pedestrian crossing. While 26% of the users stated that they always or usually deviated from their path on Tunalı Hilmi Street, 33,4% stated that they never or rarely deviated. Also, 40,6% of users said they would sometimes deviate from their path to use a pedestrian crossing (see Figure 4).

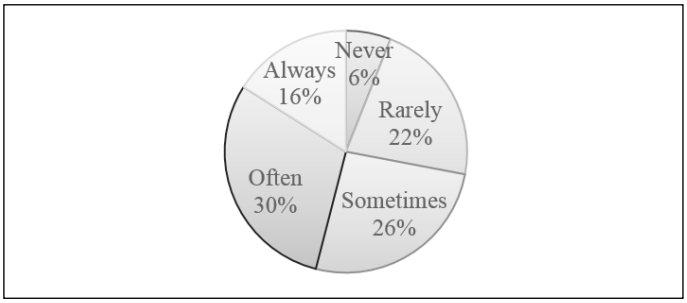

Figure 4. Frequency of participant' deviation from their path.

3.3.2 Factors Related to Pedestrian Crossing Preferences

In order to investigate the crossing preferences of pedestrians, answers were sought regarding the preferred crossing times and the factors related to their crossing preferences. As shown in Figure 5, 60,4% of the pedestrians stated they crossed the road when the traffic was completely cut, 49% of the pedestrians stated they preferred to cross in a situation where there would be little interference to traffic. 45,8% of pedestrians reported they crossed the street only when the vehicles gave way. Additionally, half of the participants stated that they prefer to cross when the pedestrian traffic light is green. In addition to above, participants were asked which practices affected their decision to pass a particular place. Participants stated that the presence of pedestrian facilities such as pedestrian traffic light and pedestrian crossing, affect their crossing decisions. It is presented in Figure 6 that 65,6% of the pedestrians stated the presence of a pedestrian traffic light affects the decisions of crossing through the pedestrian crossing. 59,4% of the pedestrian considered having a pedestrian crossing as a motivation to cross the street. Additionally, 45,8% emphasized that the distance from the destination point is important. While 21,9% of the pedestrians reported that the presence of other pedestrians trying to cross affects their decision to cross it, the traffic at the crossing point is a reason for the preference for 50% of the participants.

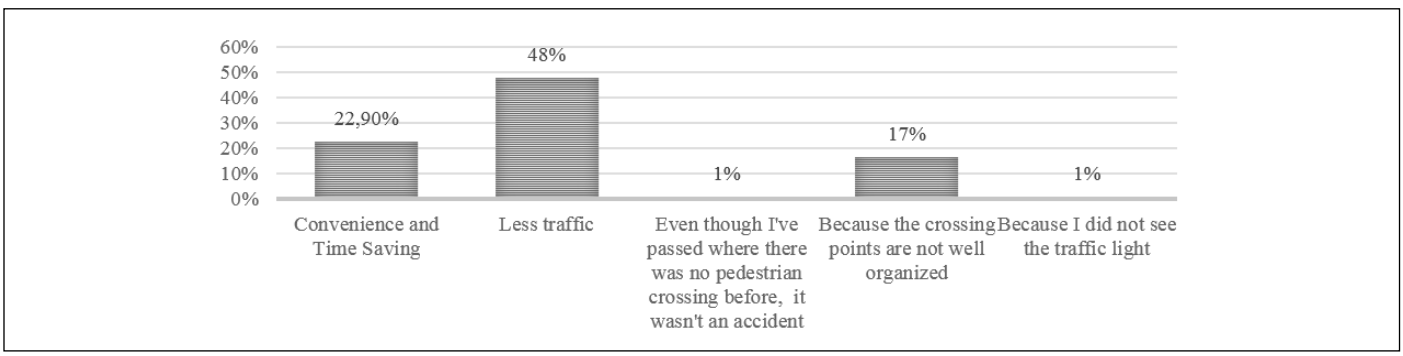

Figure 3. The main reasons why pedestrians do not cross at the pedestrian crossing

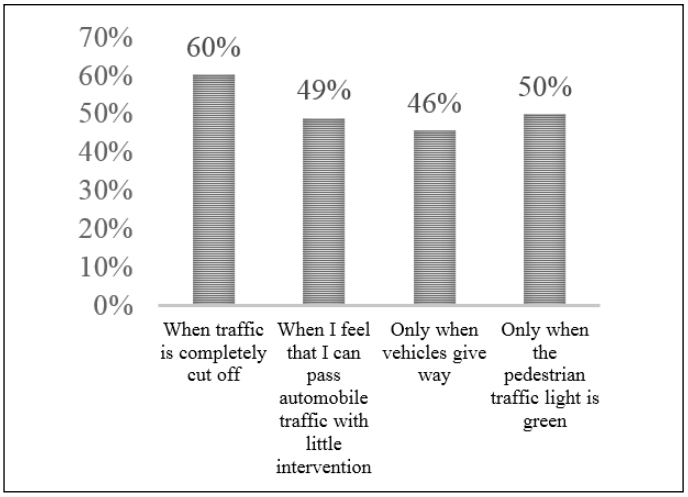

Figure 5. Crossing conditions of pedestrians.

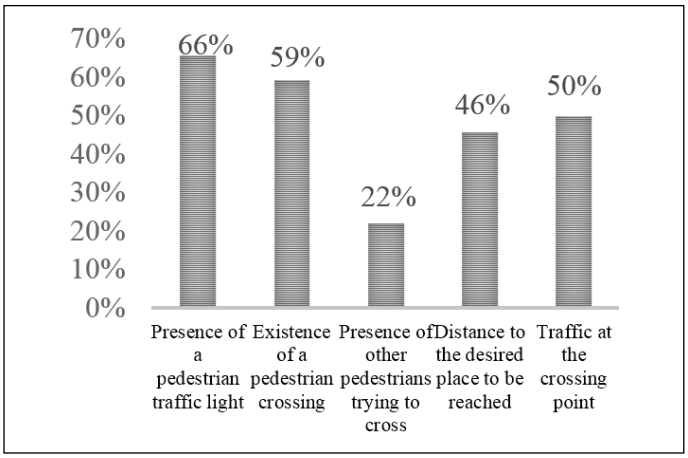

Figure 6. Situations affecting the crossing of pedestrians.

3.3.3. Pedestrian Safety

The participants were asked a series of questions to understand their perception regarding pedestrian safety in the study field. The first of these questions was about the right-of-way. Only 36 % of participants thought that vehicles give way to pedestrians at the crosswalk in the study area, while 61 % thought the vehicles generally do not give way to pedestrians. When asked about the crossing behavior of pedestrians, 27 % of the users said that the pedestrians generally use the pedestrian crossing in the study area, while 64 % stated that the pedestrians do not use the pedestrian crossing in the study area (see Figure 7).

54,7% (n = 52) of the pedestrians reported that they do not consider the study field as safe for pedestrians. To the question of how safe this area is for pedestrians, the area received a safety score of 3.3 on a 6-point Likert scale (1 = not safe, 6 =very safe) showing that the perception of safety is not very high for users. When asked about the biggest problem regarding pedestrian safety, people mostly stated the reason is related to the traffic and parking. 35% of users stated that vehicle traffic is the biggest problem for pedestrians in the observed area. Also, the biggest problem for 25% is parking. They stated that double-parked vehicles on the side of the road is a problem for pedestrians to cross the street. In addition to these, the facilities for pedestrians in the study area are reported as limited. 15% of the participants reported that the pedestrian crossing areas were insufficient and 7.2% said narrow sidewalks is a problem for pedestrians. Driver behaviors were also stated as factors that cause problems for pedestrians. While 8.3% stated that drivers do not give way to pedestrians, 2% reported that careless driving is also a problem. There were also those who think that the area is not safe for pedestrians in terms of its spatial characteristics. 9.3% of the participants indicated that the street was narrow and 4.1% stated the road structure plan is a problem.

The participants were also asked about their recommendations regarding environmental adjustments to increase road safety in the area. In order to find a solution to the vehicle density, which was stated as the most problematic issue, 24% of the participants suggested that the street be closed to vehicle traffic and 5.2% suggested the creation of an alternative route for vehicles as a solution. In addition, in order to reduce the car density on the street because of parking, 13.5% of the participants stated that the parking problem would be solved and 4.1% suggested free parking areas as a solution. In order to make the pedestrian flow safer and more comfortable, 20.8% of the participants suggested increasing the number of pedestrian crossings, 10.41% suggested increasing the number of traffic lights, and 7.2% suggested widening the sidewalks. Also, 12.5% of the participants said that the police should be present and sanctions should be applied.

In summary, according to the survey data, when the nonconformity behaviors of the pedestrians on Tunalı Hilmi Street are examined, more than half of the pedestrians who participated in the survey stated that they always or frequently use the pedestrian crossing when crossing the Tunalı Hilmi Street. Additionally, the majority of the participants stated that they did not pass when the red light is on. Chi-square analysis did not reveal any significant differences across age classification and gender. Considering the preference of pedestrians to cross the street without pedestrian crossing, it is

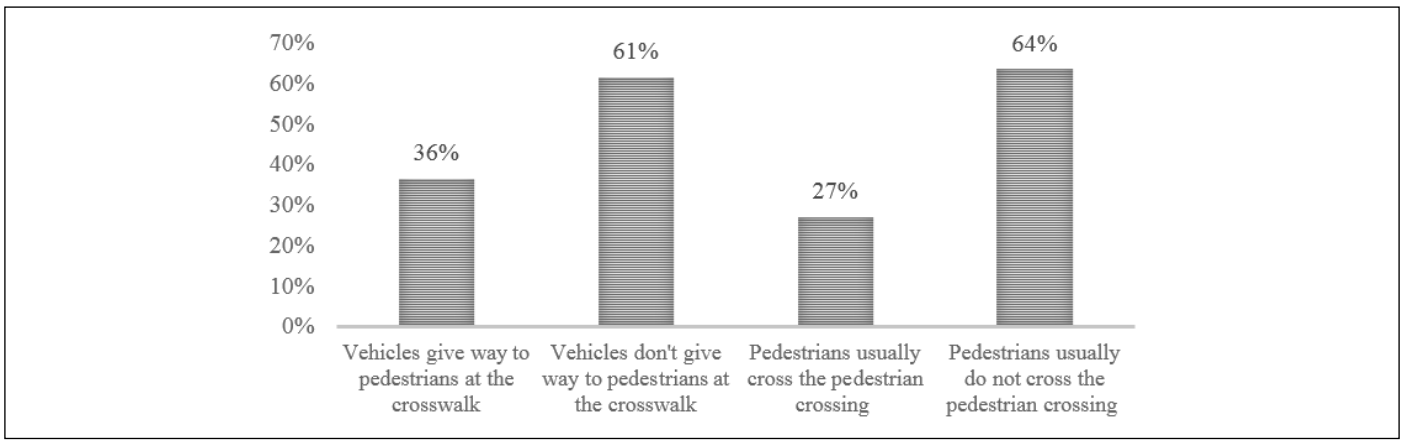

Figure 7. Participants' perceptions of the study area.

Note. Since there were 2 participants who did not respond to the vehicles giving way and 9 users who did not respond to the pedestrian use of the pedestrian crossing, the double group percentages do not reach 100%

stated that the main reason is low traffic, while time-saving and comfort are also prominent reasons. According to crossing preferences, more than half of the pedestrians stated that they crossed when the traffic was completely cut off, while half of them stated that they preferred to cross when the pedestrian traffic light was green. In addition to the above, the majority of the participants stated that presence of pedestrian facilities (pedestrian crossing, traffic light) affects their crossing decisions. More than half of the respondents stated that the study area is not safe for pedestrians. They stated that the reason for this was related to traffic and parking spaces. Recommendations on improving pedestrian safety focused on reducing vehicle traffic and increasing pedestrian opportunities.

3.4 Observation Results

A total of 401 pedestrians were observed in the study area. The pedestrian gender, estimated age group, crossing duration, whether the pedestrian is walking or running, whether the pedestrian is alone or in a group, if the pedestrian is in the crosswalk, and whether the pedestrian obeys the signal were all obtained from the observation data.

Pedestrian movement data are used to analyze pedestrian crossing compliance behavior at observed pedestrian crossings. A total of 126 pedestrians were observed in the 1st observation area (no pedestrian facility available) and50% of pedestrians are female and 50% are male. A total of 111 pedestrians were observed in the 2nd observation area (no pedestrian facility available) and 65% of the pedestrians are female and 35% male. As shown in Table 1, a total of 164 pedestrians were observed in the 3th observation area (signalized pedestrian crossing) and 59% of pedestrians are female and 41 % are male. Since the 1st and 2nd observation areas, which do not include any pedestrian facility, are the points where the users cross illegally, only the numbers of people crossing by were reported. The details of crossing behavior were provided for only the 3rd observation point which is a signalized pedestrian crossing (see Table 1).

	Number of Pedestrians Observed	Percent
Characteristics		
Gender		
Female	68	41,5
Male	96	58,5
Behavior		
Walk or not		
Walk	144	87,8
Run	20	12,2
Crossing speed (CS, m/s)		
CS<0,5	31	18,9
0,5 ≤ CS < 1	126	76,8
1 ≤ CS < 1.5	5	3,0
1.5 ≤ CS	2	1,2
Group or not		
Alone or pair	84	51,2
In group	80	48,8
Waiting Time (second)		
WT≤10	107	65,2
10<WT≤30	38	23,2
30<WT<50	17	10,4
50≤WT	2	1,2
Crosswalk		
Complete use	119	72,6
Partial use	20	12,2
Complete not use	25	15,2
Signal		
Comply	116	70,7
Not comply	48	29,3
Compliance status		
Compliance	94	57,31
Violation	70	42,69

Note. When there are a large number of people in the crosswalk, those who cross within 0.5 m of either side of the crosswalk are regarded to be complying with the crossing location. Partial users are about 3 meters from both sides of the crosswalk area.

Table 1. Samples Classified by Pedestrian Characteristics and Behaviors for Signalized Pedestrian Crossing

3.4.1 Pedestrians' Crossing Behaviors

The proportion of female pedestrians was higher than the proportion of male pedestrians among those observed considering 2nd and 3rd observation point. Moreover, half of pedestrians crossed the street at speeds between 0.5 and 1 m/s and the average pedestrian speed being 0.64 m/s. at the 3rd observation point. The proportions of pedestrians crossing alone or in pairs were nearly the same as those crossing in groups. Over 80% of pedestrians used the crossing area, 12.2% using partially at the 3rd observation point. However, it should be noted that data for pedestrians categorized as partially utilizing the crosswalk are merged with data for pedestrians defined as never using the crosswalk to make it easier to examine the variations in behavior. As a result, the study only considers two crosswalk usage patterns: use and not-use. Compared to pedestrians' crosswalk use, pedestrians' compliance with traffic signals was lower, with 70% of observed pedestrians obeying the signal. The waiting time was 9.9 seconds on average.

As shown in Table 2, while 72% of women act according to traffic lights when crossing the street, 69% of men cross the street when the traffic lights are green for pedestrians. Moreover, 79% of the women use the pedestrian crossing, while 63% of the men use the pedestrian crossing to cross the street. The Chi-Square findings for the gender factor show that there are no significant variations in crosswalk usage ($p > .05$). There are no significant differences in compliance with traffic lights between male and female pedestrians ($p > .05$).

In addition, 91% of those crossing the street as a group behave in accordance with the traffic light, while 51% of those who cross alone or in pairs obey the traffic light signal (see Table 2). Besides, 95% of group crossings utilized the pedestrian crossing whereas 56% of those who cross alone or in pairs used the pedestrian crossing to cross the street. As a result, 91% of people crossing the street as a group comply with both the pedestrian crossing and the pedestrian traffic light, while 48% of those who cross alone or in pairs behave in accordance with both pedestrian facilities (see Table 2). The result of the analysis shows significant differences in crosswalk use between pedestrians who cross alone or in a pair and those who cross in a group ($p < .05$). In addition to the above, significant differences in both compliance with the signal ($p < .001$) and compliant behavior ($p < .05$) exist between the two groups.

In summary, the average pedestrian speed during crossing was 0.64 m/s. The waiting time was an average of 9.9 seconds. More than 80% of pedestrians used the crossing area. Pedestrian compliance with traffic signals was lower compared to pedestrian use of crosswalks, and 70% of observed pedestrians obeyed the signal. The overall pedestrian compliance rate (i.e., complying both to pedestrian crossing

and traffic signal) was calculated as 57.31 %. The Chi-Square for the gender difference resulted in no significant change in pedestrian crossing use, compliance with traffic lights, waiting time and crossing time. The result of the analysis shows that there are significant differences in pedestrian crossing use, signal and pedestrian crossing compliance between pedestrians crossing alone or in pairs and those crossing in groups.

	Gender		Group	
Statistic	Female N=96	Male N=68	Alone or pair N=84	In group N=80
Signal				
Comply	69	47	43	73
%	71,87	69,11	51,19	91,25
Not Comply	27	21	41	7
%	28,13	30,89	48,81	8,75
Significance	.70	.70	.00	.00
Crosswalk				
Use	76	43	47	76
%	79,16	63,23	55,95	95
Not use	20	25	37	8
%	20,84	36,77	44,05	5
Significance	.79	.79	.00	.00
Compliance status				
Compliance	67	45	40	73
%	69,78	66,17	47,62	91,25
Violation	29	23	44	7
%	30,2	33,83	52,38	8,75

Table 2. Statistics for Gender, Age, and Group Factors on Crossing Behavior

4. DISCUSSION

Different from the previous studies on pedestrian behavior, the current study targeted exploring pedestrian behaviors, perceptions, and crossing preferences at a specific street in Ankara-Tunalı Hilmi Street, Turkey, employing two different data collection methods. Also, area-specific countermeasures addressing concerns related to pedestrian safety had been proposed.

Survey and observation data were obtained separately, but both sets of data were derived from the same study field. Some parallels in both sets of data were found. In many studies, it has been studied how age, gender and demographic characteristics were related to pedestrians' crossing behaviors and preferences (Aghabayk et al., 2021; Hamed, 2001; Ren et al., 2011). However, in this study, basic pedestrian demographics (i.e., age and gender) did not reveal significant relationship with pedestrians' crossing behaviors and preferences. This may be due to the small size of the sample. Additionally, although the observations have been conducted during peak hours and weekend to observe more pedestrians, pedestrian behaviors may vary based on different times of the day and whether it is weekdays or weekends. Therefore, future studies are suggested to consider this variation and arrange observation timing accordingly. This way the results may become more representative of the pedestrian behaviors. In addition to the above, more than half of the participants stated that they always or frequently use pedestrian crossings. Pedestrians mostly declared that they did not cross when the red light is on for pedestrians, and this seems to be consistent with the observation data. Considering the rate of crossing in the 1st and 2nd sections (i.e., no signal, no crosswalk) though, it can be said that illegal crossing is also high in the study area.

Pedestrians reported that they do not cross the pedestrian crossings because majority thought that the risk is low, so they cross illegally. Also, in accordance with the literature, current study showed that time saving and convenience are important factors (Coutts et al., 2019; Demiroz et al., 2015; Ren et al., 2011). If the factors that are related to the pedestrians' crossing preferences are grouped, it can be said that majority of the pedestrians see the presence of pedestrian facilities as a motivation for crossing. This result is line with the literature pointing out the relationship between environmental factors and pedestrian behaviors. For example, according to Hamed (2001), the risk-taking decisions of pedestrians when crossing may differ according to environmental factors. In addition, the distance to the crossing point is also found as an important motivator for pedestrians. According to Sisiopiku and Akin (2003), pedestrians are more likely to pass the suitable walking distance to the target. Similarly, Reason and colleagues reported that accessing to the destination point should be from the shortest distance (1990), which supported our finding.

The concept of accessibility in pedestrian crossings is of great importance within the continuity of the urban pedestrian flow. The pedestrian crossing location is an essential factor that should be taken into consideration for the pedestrian from one place to another (Ghadimkhani, 2011). In pedestrian level crossings where pedestrians and vehicles intersect at the same level are of critical importance. Accordingly, the points where pedestrian crossings are guided should be determined in pedestrian mobility continuity (Ghadimkhani, 2011). In the design of pedestrian crossings, it is necessary to make spatial arrangements that will not cut the pedestrian flow and guide the pedestrian. Also, pedestrian crossings should be supported with several elements that increase walkability as well-designed spaces (Ghadimkhani, 2011). In addition, from the results, it was observed that the majority of pedestrians waited less than 10 seconds to cross the street in the waiting time distribution. This result is also in line with the literature. According to Ferenchak's study (2016), if pedestrians wait too long to cross, their impatience will increase, and they will become annoyed. Impatient and annoyed pedestrians are more likely to take risks and accept shorter intervals. Therefore, the waiting time seems be one of the critical variables that is related to the crossing behaviour, which should be utilized by urban designers while designing pedestrian facilities. Tarawneh (2001) stated that male pedestrians complete the crossing more quickly than female pedestrians in relation to the short waiting time. No related finding was found in this study.

It is found in the current study that people who cross the street as a group behaved more appropriately than those who pass the signal and pedestrian crossings as a single or double. Group crossing was not found to be related to illegal crossing decision, which is inconsistent with the literature. According to Ren et al. (2011) pedestrians in a group tend to cross on red more often than individual or paired pedestrians. However, Aghabayk et al. (2021) showed that group crossing and carrying items have no significant relationship with illegal crossing. Given the inconsistent findings, group crossing versus single or double crossing seem to require more attention from the researchers.

Considering the opinions of the pedestrians about the study area, the majority considered the area not safe for pedestrians. In addition, it was stated by the participants that vehicles do not give way to pedestrians in the whole study area and that pedestrians do not use the pedestrian crossing. As stated by the participants that important problems in the study area are high vehicle traffic, parking on the side of the road and insufficient pedestrian facilities. In line with the participants' suggestions;

1. The study area may be closed to vehicle traffic which would solve the problems with vehicle traffic and to increase the pedestrian safety in the area.
2. Pedestrians should be informed about possible risky situations and education should be given from childhood to increase their awareness about pedestrian safety.
3. Urban design can be used to encourage participants to use the pedestrian crossing because the results showed that by increasing the number of pedestrian crossings and decreasing the waiting time.

All in all, the study results may provide insights city planners and policy makers to increase the pedestrian safety in the study area.

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