THE OPERATIONAL CHARACTERISTICS OF INLINE SKATERS

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THE OPERATIONAL CHARACTERISTICS OF INLINE SKATERS

Written by

Juan C. Pernia
Research Associate

Jian John Lu, Ph.D, P.E.,
Associate Professor

and

Ellizabeth Birriel
Graduate Student

Transportation Program
Department of Civil and Environmental Engineering
University of South Florida,
4202 E. Fowler Ave., ENB 118,
Tampa, Florida 33620
Phone: (813) 974-5817
Fax (813) 974-2957.

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ABSTRACT

Inline skating is considered to be the fastest growing sport in the United States over the last ten years. Many people view inline skating as a new mode of transportation. Over 30 million people in the United States are participating in inline skating, out of which more than a million are Floridians. Some inline skaters believe that they should be allowed to access the roadway with the same rights as bicyclists. But, the Florida Department of Transportation (FDOT) cannot make an informed decision on the desirability of allowing skaters on the roadway without knowledge on the operating characteristics of inline skaters. The main purpose of the project was to measure the operational characteristics so that FDOT can use the information for the design of trail geometrics. For this reason, over the last year, the Transportation Program of the Department of Civil and Environmental Engineering at the University of South Florida worked on a research project which focused on determining operating speeds, operating space (sweep width), stopping techniques, stopping distance and stopping width for inline skaters both on road facilities and trails. This research project was sponsored by the Florida Department of Transportation. In the project, inline skaters were videotaped on roads and trails located in west and south Florida. Video cameras set at stationary locations enabled recording the desired operational characteristics. The inline skaters' operational characteristics were obtained from the videotapes using reference dimensions placed at each site. The skaters were analyzed for the following categories: male, female, learner, advanced and all together. Logit models were developed to determine the 15^{th}, 50^{th} and 85^{th} percentile values for the operational characteristics. These operational characteristics would impact the desirability of allowing inline skaters on the street system and also will provide important information for geometric design for inline skater paths. In addition to enabling the FDOT make an informed decision on this matter; FDOT would have data for developing multi use trail geometrics and for operational design criteria.

Key Words: Inline skating, Speed, Sweep width, Stopping distance, Stopping techniques

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INTRODUCTION

Inline skating is increasing very rapidly in recent years, not only as a sport but also as a new mode of transportation. The International Inline Skating Association (IISA) gives a list of ten reasons that may explain this increase in this activity (*1*). Some of the reasons listed refers to inline skating as a social activity that helps clean the air, reduces the impact shock on skaters' joins as compared to jogging, and it's easily adjustable to different environments. The site also mentions that it is fun and great for all, including kids and adults of all ages. Inline skating is considered to be the fastest growing sport in the United States from 1988 to 1997 according to the IISA (*2*). Statistics given by IISA indicate that inline skating has grown from 3.6 million people skating in 1990 to 26.6 million in 1997. Recent statistics indicate that over 30 million people perform inline skating in the United States, and over 20 million in the rest of the world (*3*). In reference to the top states for skating in the United States, the statistics show that for 1997 California was number one with 3.6 million skaters, New York second with 1.9 million, and Florida was third with 1.6 million skaters (*4*).

This increase in the number of people practicing inline skating is not only for enjoyment as a sport but also as another viable mode of transportation to and from work or just to run errands. In other words, skating is emerging as an alternative mode of transportation (*5*). Some of the reasons for this new way of looking inline skating are the innovations in skate technology, which have made skating easier to learn, more comfortable, and more efficient. Other factors that have helped to expand the skate market even further include chip-on skates, all-terrain skates, and better braking systems. Another reason for this phenomenon is the spread of pavement, which is a smooth surface that allows inline skaters to go almost anywhere (5). Before pavement was widely used on roads, skating was limited to skating rings due to the fact that skates require a smooth surface. Skating has been also used for some time in college campuses to go around. On the other hand, this impulse of skating as a new mode of transportation has been limited in the streets as a result of unsatisfying path for skaters and the lack of skater's rules for the street. In light of this phenomenon, several cities across the United States, such as New York City, legally allow inline skating on roads with skaters subject to the same rules and laws as bicyclists. Consequently, skaters in Florida believe that they should be allowed on to roads with the same rights as bicyclists. The state of Florida has grappled with this issue, House Bill HB 4089, 1998 was an attempt to grant inline skaters access to roads with the same rights as bicyclists.

Allowing inline skaters to legally share roadways with vehicles and bicyclists presents challenging situations and possible conflicts. Because there is no data on the operating characteristics of inline skaters, Florida Department of Transportation (FDOT) cannot make an informed decision on the desirability of allowing skaters on the road. Consequently, there is a need of operational characteristics' values in order to properly design the geometrics of any separate trail or exclusive lane in the street to accommodate inline skaters on the road. In August 1999, the University of South Florida began working on a research project to evaluate the operational characteristics of inline skaters. The project was funded by the FDOT. The purpose of this research project was to observe inline skaters on roads and trails to gather data on their operational characteristics. There is currently no data existing regarding operating speed, operating space and stopping information. The data collected and analyzed in the research project may help FDOT accommodate skaters, should the Legislature require them to do so.

For the project, a literature search was performed to obtain all available information related to inline skating. The search gave a lot of information in regard of how to skate or in reference to general information about inline skating. During the search, the information related to injuries and safety issues for inline skaters was also found. In regard to previous studies related to operational characteristics of inline skaters, very limited information was found. Two papers that present very good information were the "Skating: An Emerging Mode of Transportation" (*5*) and the "In-line Skating Review. Phase 2" (*6*). The first paper calls for the attention of people working in the transportation area to consider the rapid increase of inline skating, and to look at inline skating as a new mode of transportation. The papers indicate that inline skates will fill a transportation niche for certain people in some cities, and for this reason this activity should be considered when designing new roadway facilities. The second paper is a comprehensive report that addresses several issues of inline skates in Canada. The issues reviewed in the report mostly refer to safety, and some performance characteristics. It also mentions operational characteristics but no field data is presented. Finally, valuable information was found in several inline skater's sites on the Internet, especially at the International Inline Skating Association (IISA) site. This site has a variety of information in reference to basic information for inline skaters, places to skate, media resources, industry tools, and it also has several links to other inline skating sites.

In the project, three sites were selected for observation and data collection for the project. Two of the sites were on trails; the third site was a road where vehicles and skaters interacted. Video cameras were set up at critical locations and inline skaters were filmed as they passed the camera. Inline skaters' operational characteristics were obtained using the measured dimensions seen on the tape. Speed, sweep width and stopping data were obtained this way. The data were reduced and organized into several subcategories such as male, female, advanced, and learner skaters in addition to a category containing all the skaters. Statistical frequency and cumulative distributions were determined and logit models were used to estimate the 15^{th}, 50^{th} and 85^{th} percentile values for the operational characteristics. Different stopping techniques used by skaters were also considered. Typical stopping techniques include the brake pad, T-stop, run outs, spin out, and wall-stop. Stopping technique with the brake pad requires the brake skate be pushed forward and the toe lifted until the brake pad touches the ground (*7*). This stopping technique is very effective, even at high speed. Another advantage of this stopping technique is that the skater can still steer as they come to a stop. The wall-stop stopping technique involves skating towards a wall or any other stationary object and using the arms to cushion the impact (*8*). Using the run out stopping technique entails skating off the path onto grass or dirt adjacent to the path (*8*). The T-stop stopping technique, commonly used as an alternative to the brake pad stop, involves dragging one skate behind the other at a 90-degree angle to the direction of travel (*7*). The disadvantage of the T-stop stopping technique is the wear and tear on the wheels. Applying pressure to the inside edge of the wheels can cause a flat spot on the wheels. In the spin out stopping technique, one skate is used as a pivot point while the other skate traces a circle around it (*8*). This research collected field data for the analysis of different stopping techniques.

This report summarizes the research project to evaluate the operational characteristics of inline skaters. The report is divided into four chapters; the first chapter covers the introduction to the project. The second chapter presents the procedure followed in order to determine the characteristics of inline skaters. The third chapter contains the analysis performed to the data collected. This chapter includes the logit models used to fit the data and the results obtained from the models for each one of the operational characteristics considered. The final chapter contains the summary, conclusions, and recommendations to the research project. A brief summary of the results for the operational characteristics of inline skaters is presented in this chapter also.

RESEARCH PROCEDURE AND FIELD DATA COLLECTION

Selection of Study Sites

The main purpose of this research was to gather information regarding the operational characteristics of inline skaters at designated bicycle trails and on the roadway interacting with other vehicles. As a result, trails and roadways with a significant amount of skaters were chosen. The locations selected were the following:

Bayshore Boulevard in Tampa, Florida

Fort De Soto Park Trail in St. Petersburg, Florida, and

Hugh Taylor Birch State Recreational Area in Fort Lauderdale, Florida

Bayshore Boulevard in Tampa, known as the world longest sidewalk, is 4.5 miles long. This sidewalk is made of concrete portions separated by expansion joints. It goes along a four lane divided street, and along the sea with a separating concrete fence. At this location, runners, bicyclists, walkers, and skaters share the sidewalk. This was a very good location to obtain data for speed and sweep width. However, stopping data were not gathered here, because it is continuous by 4.5 mile long with no designated place for skaters to stop. Fort De Soto path trail in St. Petersburg is an asphalt trail with four-mile long distance. Fort De Soto park is located close to the beach, and the trail is surrounded by grass. The trail is share by runners, walkers, bicyclists and skaters. It is painted with a distinctive lane for bicyclists and another one for everybody on foot. Several roads entering parking lots and tourist places intersect the trail. In these intersections, vehicles have the right of way. Stop signs warn inline skaters at each intersection. This location was ideal to collect data for all the operational characteristics of inline skaters, including stopping data. The two locations mentioned above were chosen because they are bike paths. The third location chosen allow the interaction between inline skaters and motor vehicles. This location is located in Ft. Lauderdale at the Hugh Taylor Birch State Recreational Area. On this 1.7-mile long asphalt road, cars and inline skaters share the roadway. The road is surrounded by trees and grass. This site was very good for speed, sweep width and stopping data collection.

The three sites selected are located in the Miami/Ft Lauderdale area and the Tampa Bay area, which were 2 of the top 20-inline skating areas in the United States in 1996 according to the International Inline Skating Association. Miami/Ft Lauderdale was the area with the 12th highest number of skaters while the Tampa Bay area ranked 18th (*3*). These rankings indicate that all the three sites selected have a good population sample size.

Data Collection

The operational characteristics of inline skaters were collected in the sites selected. These characteristics were speed, sweep width or lateral distance, stopping technique, stopping distance, and stopping width. The data were collected in two steps, the first one included speed and sweep width, and the second step involved the collection of stopping data. The two steps were necessary because of the number of cameras required to collect each operational characteristic, two for speed and sweep width and three for stopping data. Table 1 shows the number of observations and the number of hours of data collection for each operational characteristic per site. The number of hours of data collection does not include the set up time necessary to get the cameras ready and to get the marks on the trail or road to estimate the operational characteristics every time data were collected at each site. Traveling time to each location was not considered either. The following subsections will describe the process used to collect the operational characteristics for inline skaters.

TABLE 1 Observations and Hours Spent for Operational Characteristics of Inline Skaters per Site

Location	Speed		Sweep Width		Stopping Data	
	Observ.	Hours	Observ.	Hours	Observ.	Hours
Bayshore Boulevard, Tampa	216	16	201	16	0	0
Fort De Soto, St. Petersburg	279	16	235	16	245	24
Hugh Taylor Birch Park, Fort Lauderdale	213	12	260	12	97	14
Total	708	44	696	44	342	38

Speed

For the data collection of this characteristic, a part of the trial or road where skaters were not disturbed or forced to slow down was selected on each study site. A distance of 40 feet was chosen to measure the speed of the inline skaters. This distance was selected based on practical purposes. This distance should ensure that the camcorder used in data collection could cover the distance with a real clear view and that there was enough space to set the camcorder. The distance was marked on the path by placing two orange cones on each side. A straight line between the cones on both sides was also drawn. The straight line ensured accuracy when doing data reduction in regard to when the skater started and finished the selected 40 ft distance. Figure 1 shows the layout of the set up for

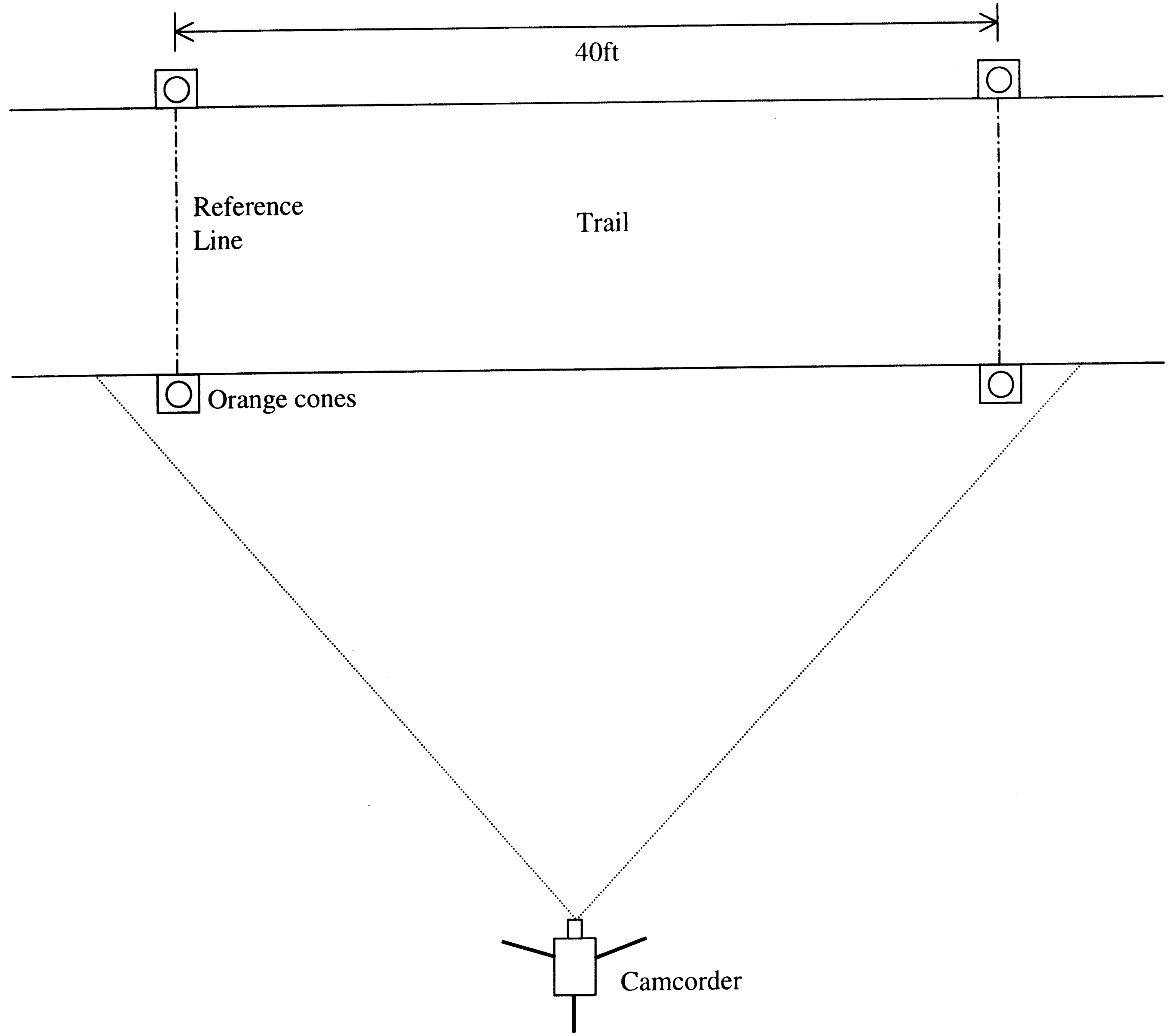

FIGURE 1 Layout for Speed Data Collection

speed data collection. The set up was similar at Bayshore Boulevard, Fort De Soto, and Hugh Taylor Park, respectively. All skaters passing the cones in both directions were videotaped with the camcorder. In order to estimate the speed, the time that each skater took to travel the 40 feet distance was needed. This time was obtained during data reduction at the office. For data reduction, all the observations or skaters video-taped at each site were analyzed. A program was written to compute the speed of each skater by dividing the 40 feet distance by the time required for each skater to travel the distance. The time in seconds for each observation to travel the 40 feet between the cones was automatically estimated by the program when the adequate keys were pressed when observing the videotape. For each skater, the information such as sex, skill level, t-shirt and short colors for reference purpose was also recorded. The skill level was divided into learner and advanced categories, and its determination was based on how the person skated. In other words, base on the video, for each skater the skill level was determined based on the way they skated. If the person presented some difficulties or seemed to be insecure, then he/she was considered in the learner category. If the person looked secure enough and no problem was observed in his/her way of skating, then the person was included in the advanced category. The data reduction time for speed was approximately two hours per each hour of field data. The speed data were collected at all three sites. The site in Fort Lauderdale has a small difference in reference to the other two sites, which consists in taping the skaters going in only one direction due to the fact that the road was one way. A total of 741 observations were captured from all three locations. Table 1 also presents the number of observations per site for speed data. Data collection was done during weekends and under dry weather conditions because rain and wet-slick pavements are dangerous for skaters.

Sweep Width

The sweep width or lateral distance occupied by each skater was obtained by reviewing the number of longitudinal lines the skater crossed. The longitudinal lines were drawn with chalk every foot from side to side on the sidewalk, trail or road for a length of 20 feet. This 20 feet length ensures that at least three or four steps or sweeps were observed for each skater. The selection of the part of the trail or road where these data were collected was based on two factors. The first one was the consideration of locating the camcorder in a curve along the path where a straight view of the sweep width on the marked area was ensured. The second factor was the consideration of a location along the path where the skaters can go at a regular pace, which means no interruptions in their rhythm. Video cameras focused on the skaters and captured the number of longitudinal lines crossed by the skaters using the skates or hands. Figure 2 shows the layout of the set up for data collection for sweep width. This set up was the same for other locations. For this characteristic, both lower body and lower/upper body sweep width or lateral distances were measured for skaters going in both directions. Lower body sweep width basically was determined by looking only at the lateral extension of each skater with reference to his or her feet. For lower/upper body sweep width, the lateral extension was determined based on the maximum extension when considering feet, hands or feet and hands. Most of the skaters achieved their maximum extension with their feet. In some cases the lateral extension obtained by the hands while skating can exceeded the leg

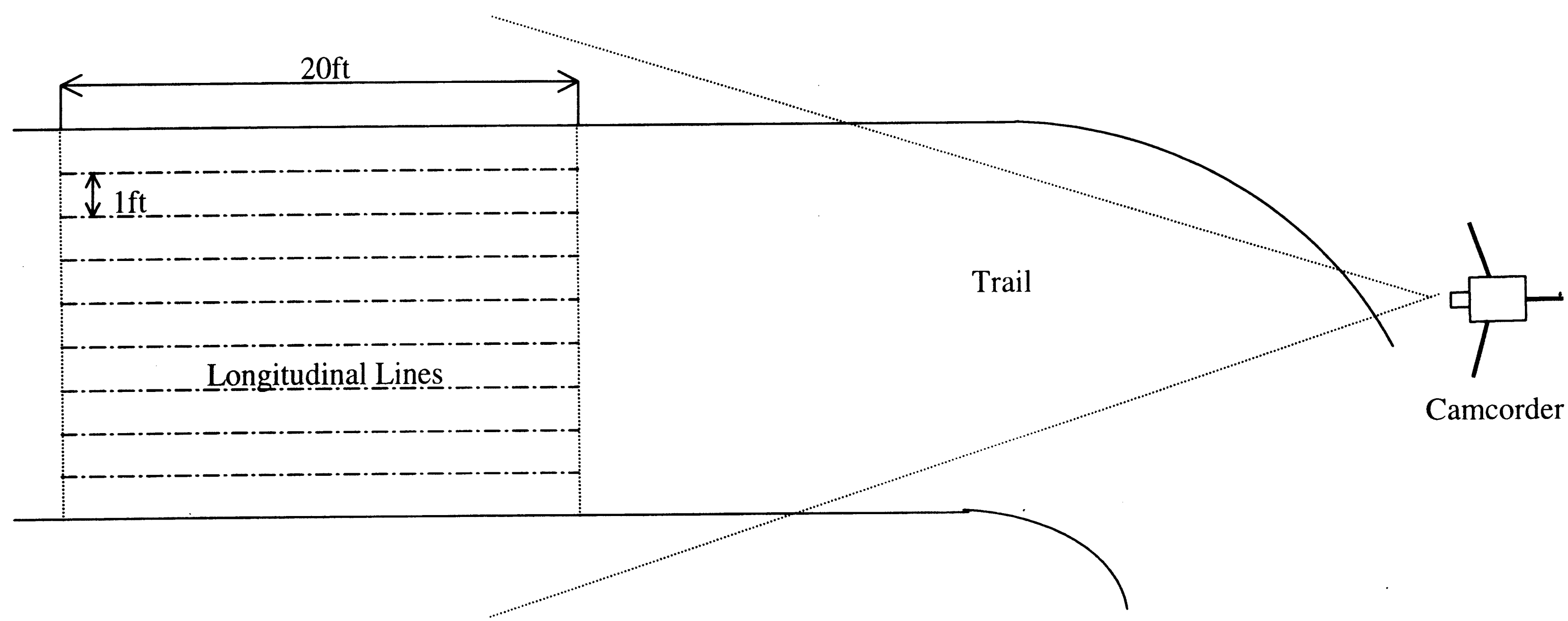

FIGURE 2 Layout for Sweep Width Data Collection

extensions while skating. The critical values are the lower/upper sweep width values, as they will determine the maximum space needed by the skaters sharing the roadway with vehicles or moving on a trail. The video camera also recorded the information such as the sex, skill level, t-shirt and short color for each skater. A total of 698 observations were captured from all three locations. At Fort Lauderdale, skaters were recorded only going in one direction due to the fact that the road was a one-way only road. Table 1 also shows the number of observations and number of hours of data collection per site for sweep width. In reference to data reduction, it took approximately four hours for every one hour of field data. It was necessary to play the videotape several times per skater to ensure the correct sweep width for each one. Data collection occurred during weekends and dry weather conditions. Sweep width and speed data were collected at the same time in each site.

Stopping Technique, Stopping Distance, and Stopping Width

The data collection for stopping purposes was the most comprehensive and complicated task. These data were collected after speed and sweep width data were finished. It was comprehensive because three different stopping operating characteristics were collected at the same time and at the same place. It was also complicated because the place to be selected should allow skaters to stop and have enough space to set the three cameras necessary to gather all the information at the same time. Three cameras were set up simultaneously in order to collect all the stopping data at the same time and be able to match all the different aspects of stopping when doing the data reduction. One camera was used to capture different stopping techniques and stopping width. This camera was placed facing the stop sign of the site, or in other words, looking at the skaters from behind at Fort De Soto Park. In Fort Lauderdale, this camera was set looking at the skaters on the face. Because its purpose was to capture stopping technique and width, it was located in a position such that the view was straight to the stop sign. The other two cameras were used to gather stopping distance. The stopping distance refers to the distance required for each skater to apply a specific stopping technique and come to a complete stop. One of these two cameras was also used to check the stopping technique used. A total distance of 100 feet was selected to collect this stopping distance. One camera was placed on the first 60 feet to capture skaters that stopped far from the stop sign. The second camera was set on the last 40 feet to estimate the stopping distance and also the stopping techniques. The second camera was closer in order to ensure a clear view when estimating the stopping distance and looking at the stopping technique. The stopping distance required was measured by setting orange stakes at both sides of the trail every five feet within a distance of 100 feet before the stop sign. The stopping width was measured by reviewing the number of longitudinal lines crossed. The longitudinal lines were two feet apart from side to side on the path for the last 30 feet. The width was obtained by analyzing the number of lines crossed by the skater as they stopped. Stopping data were obtained at Fort De Soto Park and Hugh Taylor Birch State Recreation area. Figures 3 and 4 show the layout for data collection at Fort De Soto Park and Hugh Taylor Park, respectively. Obtaining stopping data at Bayshore Boulevard proved to be difficult because the sidewalk is continuous with no stopping locations. At Fort De Soto, data were gathered where the trail intersects a road used by cars. The vehicles had the right of way forcing the skaters to stop. As an extra measure to ensure that skaters stopped, a

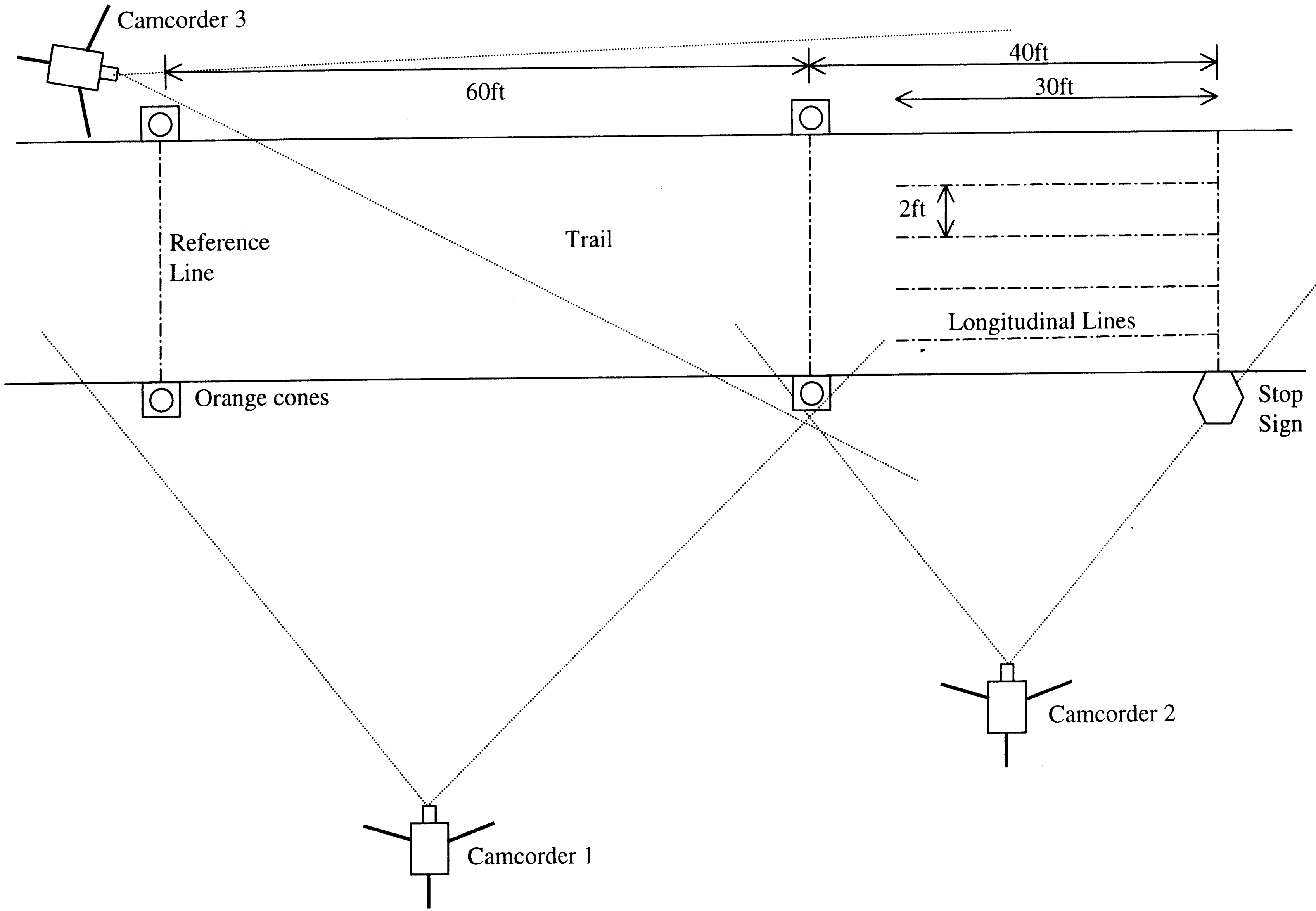

FIGURE 3 Layout for Stopping Data Collection at Fort De Soto

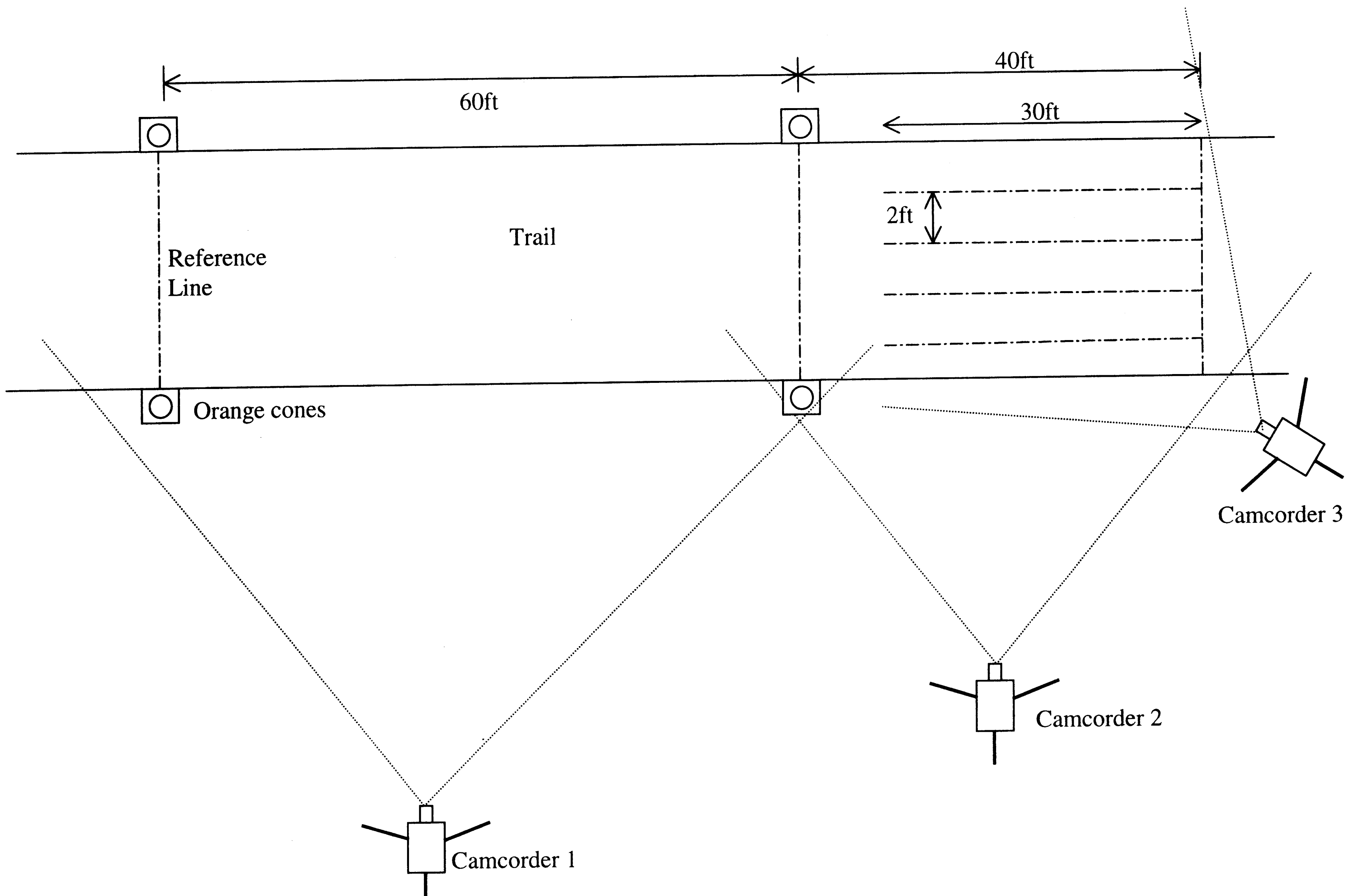

FIGURE 4 Layout for Stopping Data Collection at Fort Lauderdale

research assistant stood at the intersection point with a hand holding the Stop sign. Although the intersection already had a sign, it was not being obeyed regularly. A similar situation occurred at Hugh Taylor Birch State Recreation area. The portion of the path selected for the research project did not have a stop location. At each site, two message signs were located on side of the path to instruct the people using the paths that a survey was on process. The first sign was located at about 200 ft from the stop sign, or 100 ft before the distance selected for stopping data collection. This sign had a warning of "Survey Crew Ahead". The sign used is similar to the sign used in work zones. The second sign was about 120 ft from the stop sign or 20 before the selected stopping distance. This sign had the message of "Inline Skaters Please Stop Ahead". This sign was a wood board and was placed on the ground. As mentioned previously, the skaters were prompted to stop at the stop sign by using a stop/slow paddle. As the skaters stopped, the stopping technique, stopping distance and stopping width were recorded. All stopping techniques were filmed and then categorized. The majority of stops were of controlled nature. The video camera also recorded the sex, skill level, t-shirt and short color for each skater for matching purposes. A total of 342 observations were obtained for the two locations. Table 1 also shows the number of observations and number of hours for data collection per site. In reference to data reduction, ten hours were required for each one-hour field data to effectively determine all the stopping characteristics.

Data Analysis

The data were reduced and analyzed by looking at all the skaters videotaped for speed, sweep width, stopping distance, stopping width, and stopping techniques. The analysis was based on several important subgroups, which included all skaters, male skaters, female skaters, learner skaters and advanced skaters. Different operational characteristics were expected for all these subgroups. The data analysis for speed and stopping distance contained frequency distribution, cumulative frequency distribution curves, and the 15^{th}, 50^{th} and 85^{th} percentile values. For sweep width and stopping width, the analysis presents the frequency distribution, frequency distribution curves, the 15^{th}, 50^{th} and 85^{th} percentile values, and the percent of observation less than or equal to 4 feet and less than or equal to 5 feet. Logit models were used to model cumulative distribution curves and to determine the 15^{th}, 50^{th} and 85^{th} percentile values for the operational characteristics. Linear regression method was used to estimate the logit models. The data analysis also included a tabular breakdown of stopping techniques with the number of stops per technique and the percentage of stops per technique.

ANALYSIS

Speed

For the calculation of speed, data were collected at the field by recording inline skaters while traveling a predetermined 40 feet distance. This distance, as mentioned in the previous chapter, was marked by setting up two orange cones on each side of the distance on the path. The camcorder was set in a way that the 40 ft distance was covered clearly, but the angle of vision of the lens of the camera could not be avoid. For this reason, a straight line was also drawn from cone to cone on each side to ensure accuracy when doing data reduction in regard to when the skater started and finished crossing the distance. The data reduction was done at the office by reviewing the tapes. A computer program was used to record the time it took for each skater to travel the 40 ft distance. Speed was calculated by dividing the 40 ft distance by the time obtained for each skater.

Based on these characteristics, several subcategories of interests were determined. They were male skaters, female skaters, learning skaters and advanced skaters. The frequency of each one of the categories, including the all skaters category, was obtained. Also the cumulative frequency curve for each one of the categories was determined. As an example, Figure 5 presents the frequency distribution for all skater category. It could be observed that the lowest speed estimated was 3 mph, and the highest over 20 mph. Figures 6 and 7 show the differences between male and female skaters and between learner and advanced skaters distributions, respectively.

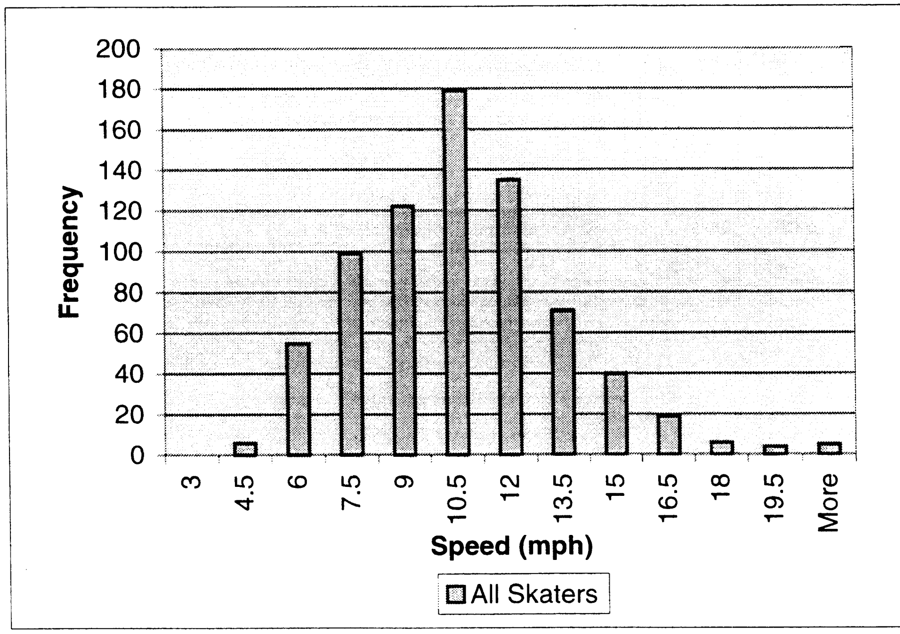

FIGURE 5 Speed Distribution for All Skaters

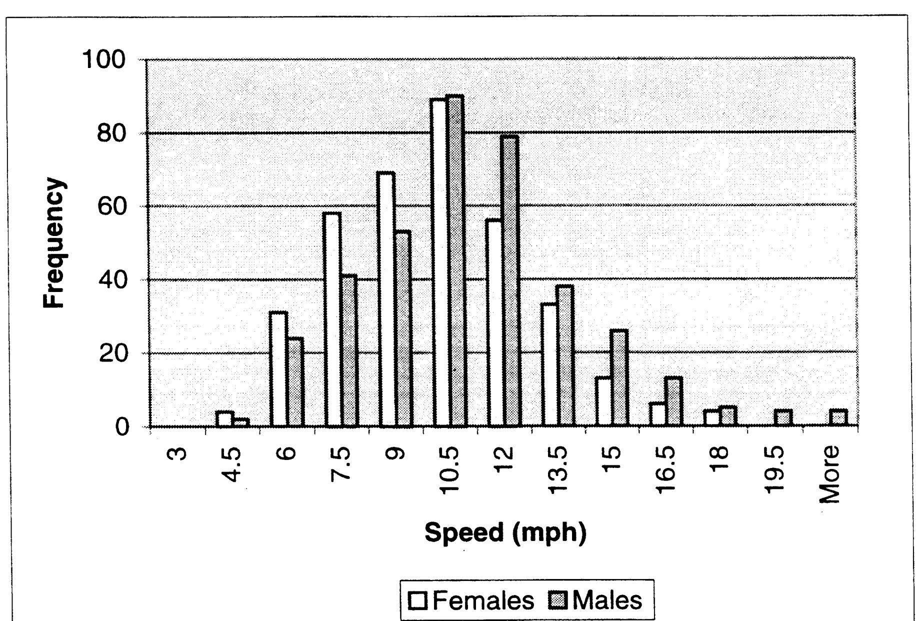

FIGURE 6 Speed Distribution for Male and Female Skaters

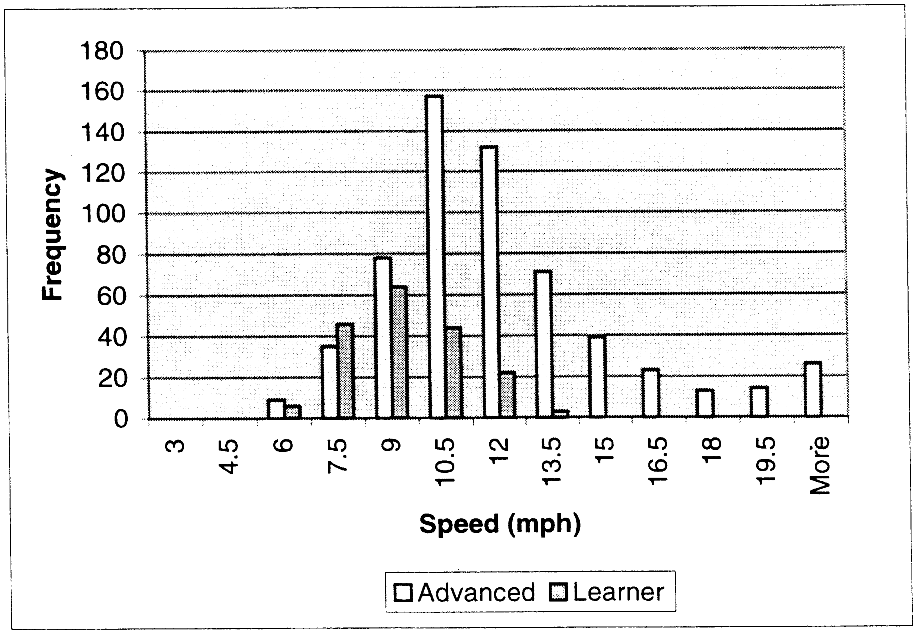

FIGURE 7 Speed Distributions for Learner and Advanced Skaters

In order to obtain the 15th, 50th, and 85th percentile values for speed; a logit model was developed from the original data. The logit model was used to calculate the cumulative probability of speed distribution for each category. This model was chosen because of the simplicity of the calibration for the fitting of the cumulative distribution curves. This model was also chosen because of the ease of use and the high accuracy of the results. For this analysis, the logit model equation has the following form:

$$p = \frac{e^{f(x)}}{1 + e^{f(x)}}$$

where f(x) is a function with the form of a + bx, x represents speed, and p is the probability of speed x in the form decimal. Taking this equation and substituting a + bx for f(x) and manipulating it further yields the following:

$$e^{(a+bx)} = p(1 + e^{(a+bx)})$$

$$\Rightarrow e^{(a+bx)}(1 - p) = p$$

$$\Rightarrow e^{(a+bx)} = \frac{P}{(1 - P)}$$

Taking the natural logarithm of both sides of the equation and setting one side equal to y gives the following result:

$$a + bx = y = \ln\left(\frac{p}{1 - p}\right)$$

The coefficients of the logit model (a and b) were estimated by linear regression. Figures 8 to 10 present the cumulative curves fitted by the logit model for all skaters category, male and female skaters, and learner and advanced skaters, respectively. When estimating the percentile speeds, the logit model equation was used with the estimated coefficients "a" and "b", and by substituting p for 15%, 50%, or 85%. Table 2 presents the 15^{th}, 50^{th} and 85^{th} percentile speeds for all skaters and for each category. The percentile speeds for male skaters are slightly higher than for female skaters. The differences between learners and advanced skaters are more significant. It is also observed that the difference between male and advanced percentile speed values is very small. The percentile values for all skaters most closely resembled the numbers obtained for the female skaters. The number of observations for male and female were very similar, but that is not the case for the number of observations for learners and advanced skaters.

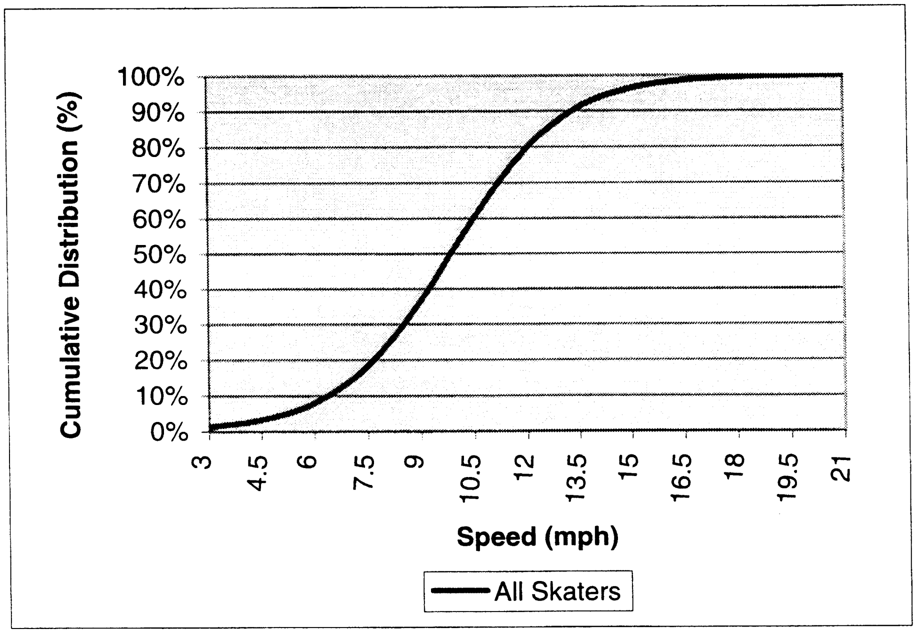

FIGURE 8 Cumulative Distribution Curve for Speed for All Skaters

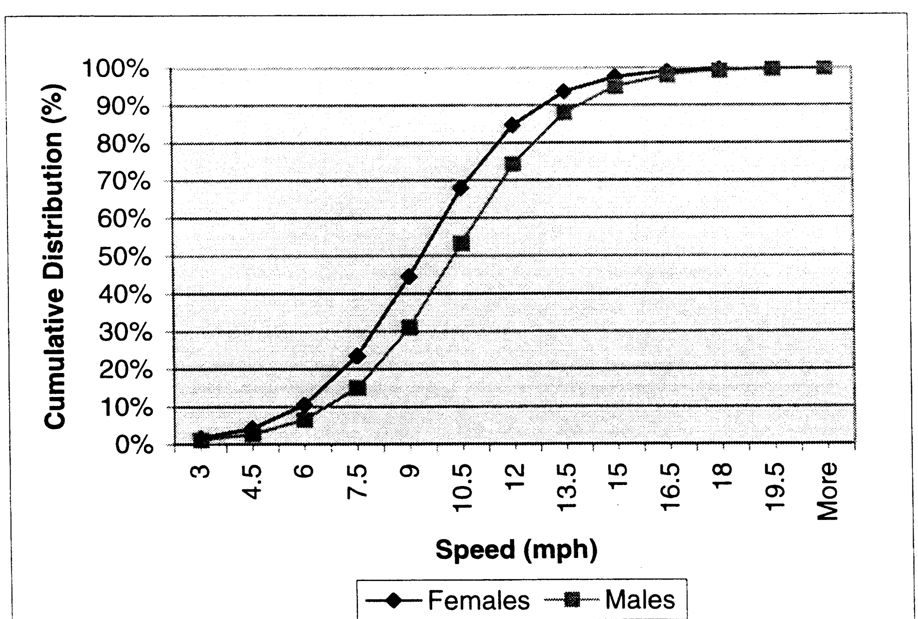

FIGURE 9 Cumulative Distribution Curves for Speed for Male and Female Skaters

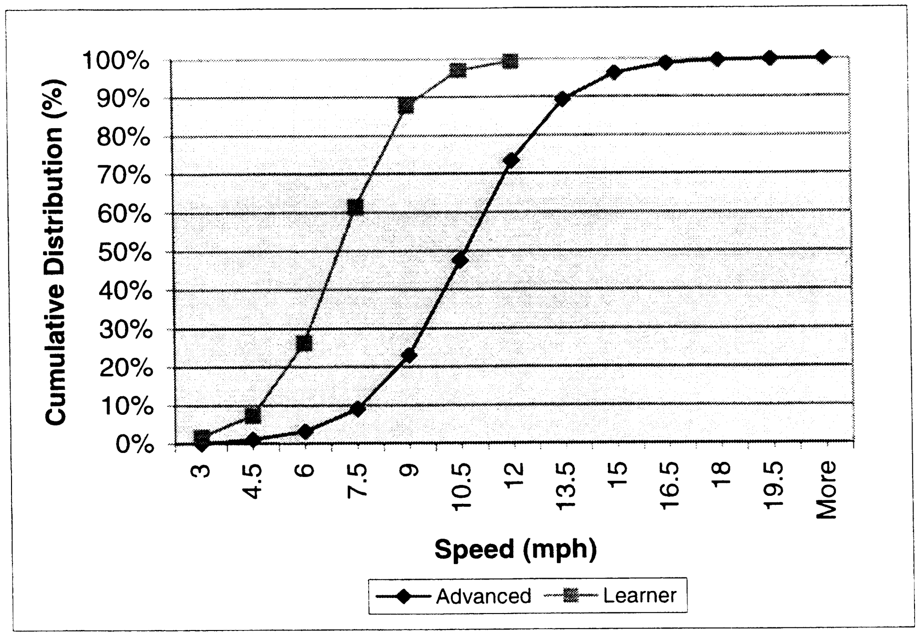

FIGURE 10 Cumulative Distribution Curves for Speed for Learner and Advanced Skaters

TABLE 2 Speed Characteristics of Inline Skaters

Categories	Number of Skaters	Speed Characteristics of Inline Skaters Speed (mph)		
		15^{th} Perc	50^{th} Perc.	85^{th} Perc.
All	741	7.13	9.86	12.59
Male	378	7.49	10.28	13.07
Female	363	6.64	9.34	12.04
Learner	185	5.30	7.03	8.76
Advanced	556	8.29	10.63	12.97

Sweep Width

For sweep width or lateral clearance, data were collected by taping skaters while traversing a part of the path marked with longitudinal lines which were 1 foot apart for a length of at least 20 ft. The camcorder was located in a way that a straight view of the marked part of the path was ensured. The data reduction for this characteristic was also done at the office by reviewing the tapes. The lateral distance covered by skaters was determined by counting the number of lines crossed by the skater using either arms and/or legs. This data reduction was time consuming because the tape had to be played several times for each skater in order to be sure about the number of lines crossed. Data were reduced for lower body sweep width (only feet) and for lower/upper body sweep width (arms and feet). Besides the sweep width, the information related to sex and skill level for each skater was also recorded.

Frequency distributions and cumulative frequency curves were determined for each one of the categories for lower and lower/upper sweep widths. The lowest sweep width value observed was 2 ft and the highest was over 6 ft. The lower/upper sweep width defined in the research is the maximum lateral distance used by skaters including the space occupied by arms, feet, and arms and feet. The lower/upper sweep width is usually larger or equal to the lower sweep width. Figures 11 and 12 show the frequency distributions for the category of all skaters for lower/upper and lower sweep width, respectively. Figures 13 and 14 present the comparison frequency distributions of male and female skaters for both sweep widths. The comparison of frequency distributions between learner and advanced skaters are shown in Figures 15 and 16, for both body sweep widths. The total number of skaters and the number of skaters per each category are presented in Table 3. The number of skaters for the female and male categories are very similar, but not for the learner and advanced skaters. This consideration has to be taken into account when making comparisons. Table 3 also shows the 15th, 50th and 85th percentile values for lower and lower/upper sweep widths for all skaters and for the rest of categories of skaters. Logit models were used to obtain the cumulative distribution curves and the percentile values for each category for both sweep widths considered. The coefficients for the logit models were estimated from the field data by using the linear regression. Figures 17 and 18 show the cumulative distribution curves for the all skaters category for lower sweep width, and lower/upper sweep width, respectively. Figures 19 through 22 present the cumulative distribution curves for lower sweep width and lower/upper sweep width for male and female skaters, and for learner and advanced skaters, respectively.

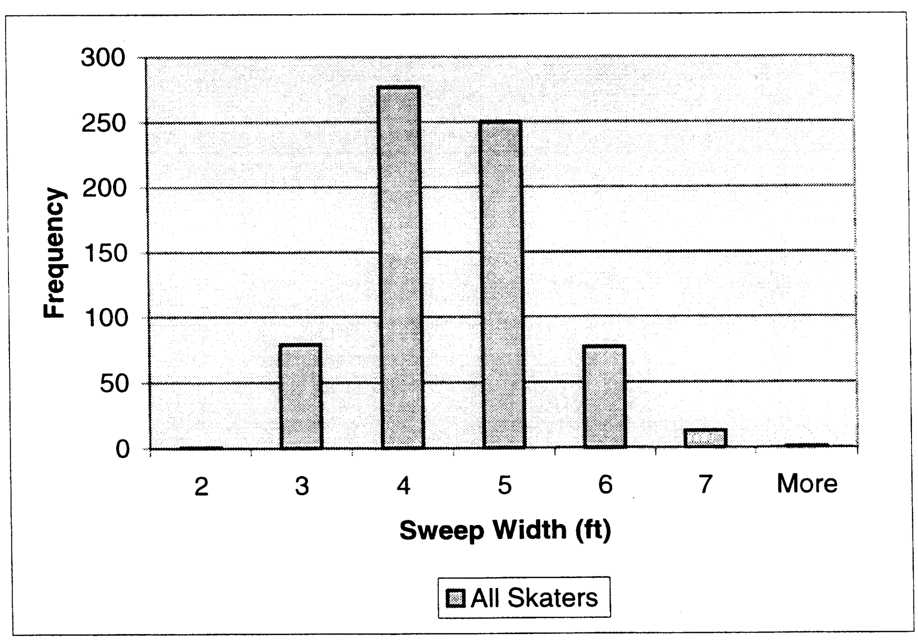

FIGURE 11 Lower & Upper Sweep Width Distribution for All Skaters

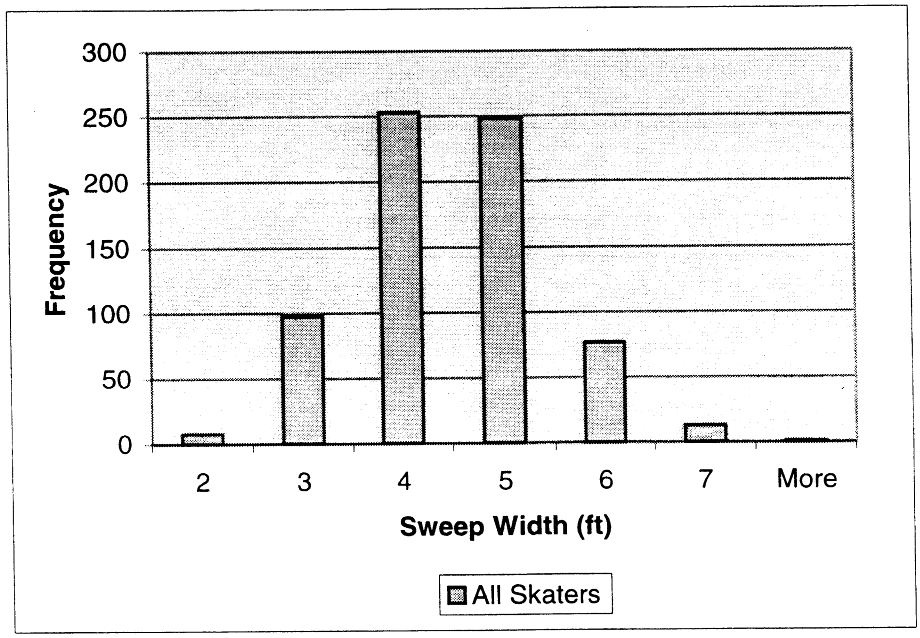

FIGURE 12 Lower Sweep Width Distribution for All Skaters

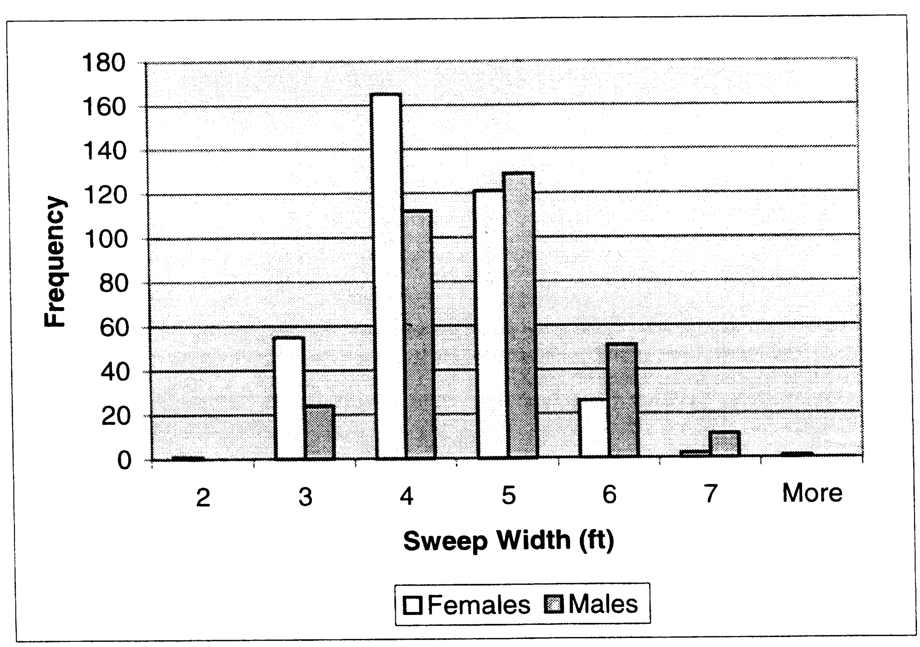

FIGURE 13 Lower & Upper Sweep Width Distributions for Male and Female Skaters

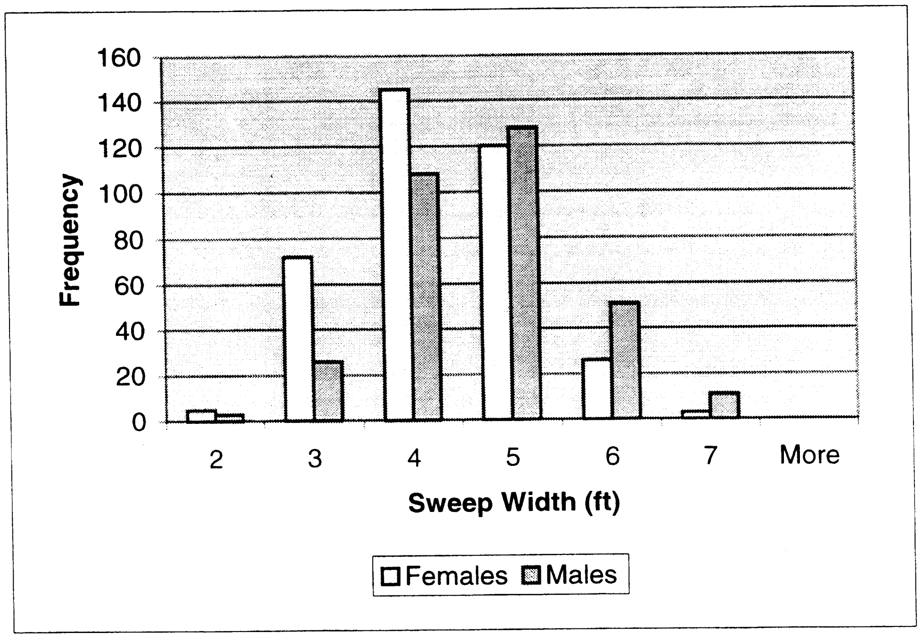

FIGURE 14 Lower Sweep Width Distributions for Male and Female Skaters

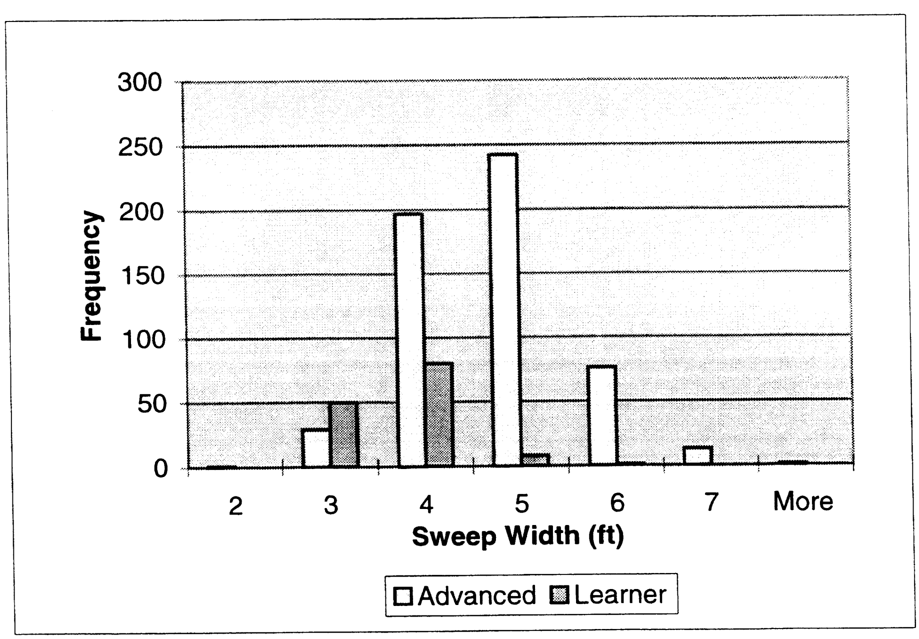

FIGURE 15 Lower & Upper Sweep Width Distributions for Learner and Advanced Skaters

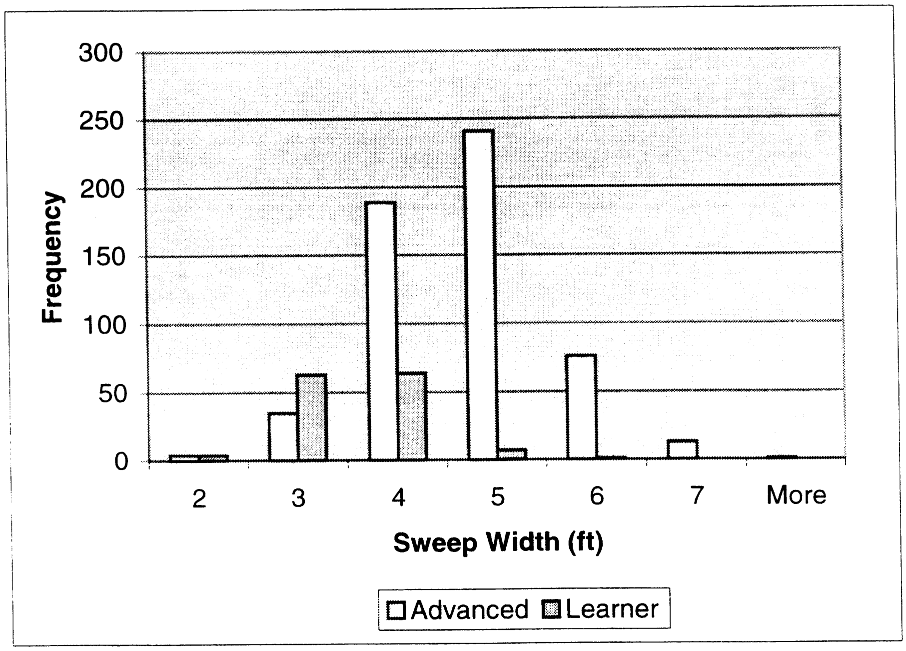

FIGURE 16 Lower Sweep Width Distributions for Learner and Advanced Skaters

TABLE 3 Sweep Width Characteristics of Inline Skaters

Categories	Number of Skaters	Sweep Width Characteristics of Inline Skaters					
		Lower Sweep Width (ft)			Lower & Upper Sweep Width (ft)		
		15th Perc.	50th Perc.	85th Perc.	15th Perc.	50th Perc.	85th Perc.
All	698	3.00	3.93	4.86	3.09	4.00	4.91
Male	327	3.33	4.24	5.15	3.40	4.28	5.16
Female	371	3.00	3.82	4.63	3.01	3.82	4.63
Learner	139	2.48	3.15	3.82	2.69	3.21	3.84
Advanced	559	3.29	4.17	5.05	3.40	4.23	5.05

By analyzing the values for speed and sweep width for each one of the categories selected, it could be observed that there is a correlation between speed and sweep width. The two groups with the highest speeds also had the largest sweep width values. The learner group who had the lowest speeds also had the lowest sweep width value. This confirms field observations made where it appeared skaters moving at faster speeds also covered more lateral distance.

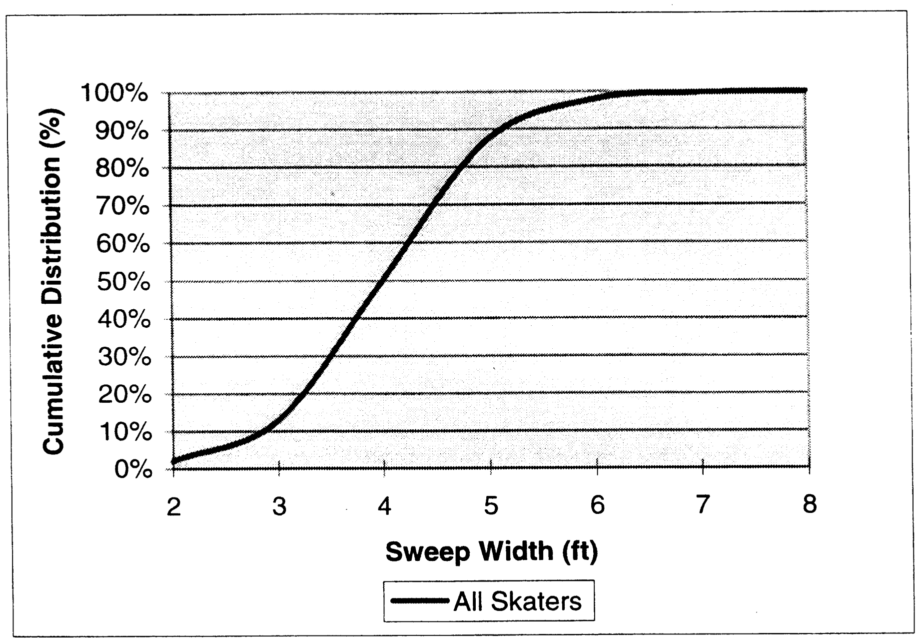

FIGURE 17 Cumulative Distribution Curve for Lower & Upper Sweep Width for All Skaters

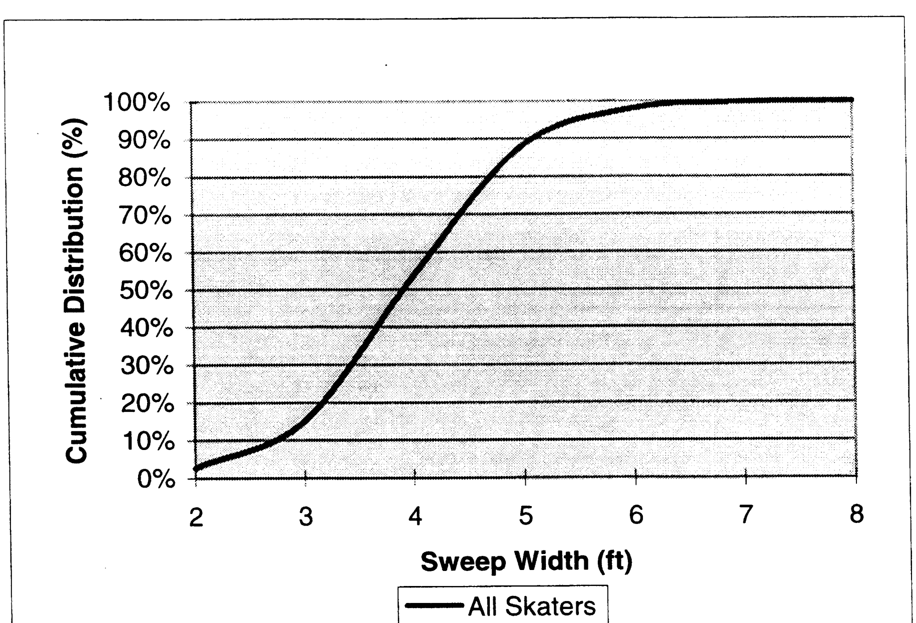

FIGURE 18 Cumulative Distribution Curve for Lower Sweep Width for All Skaters

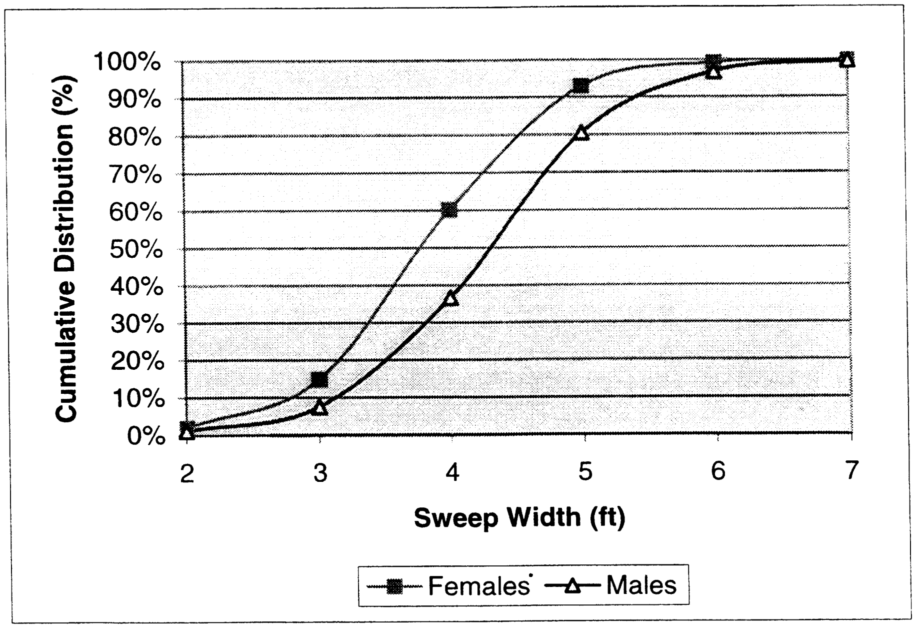

FIGURE 19 Cumulative Distribution Curves for Lower & Upper Sweep Width for Male and Female Skaters

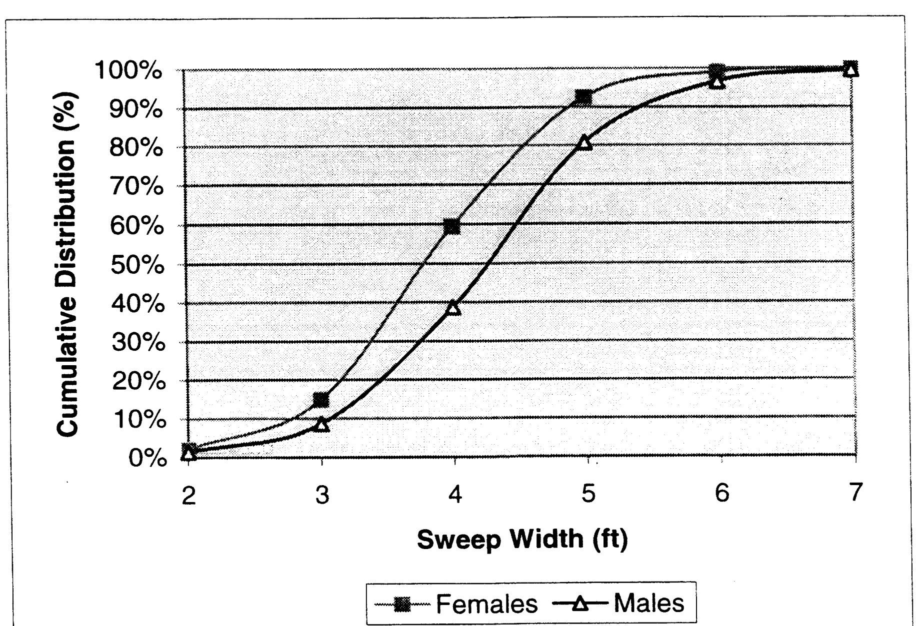

FIGURE 20 Cumulative Distribution Curves for Lower Sweep Width for Male and Female Skaters

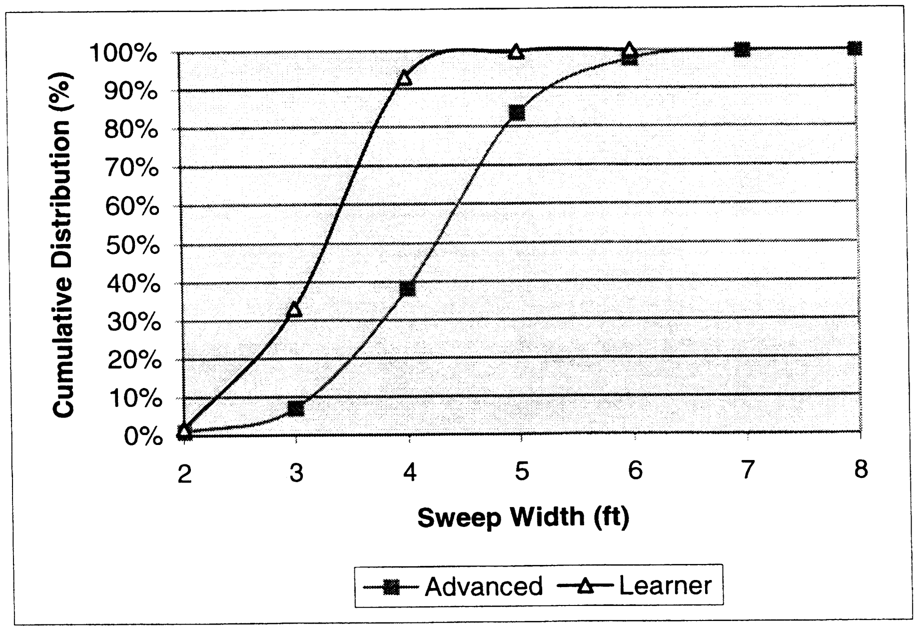

FIGURE 21 Cumulative Distribution Curves for Lower & Upper Sweep Width for Learner and Advanced Skaters

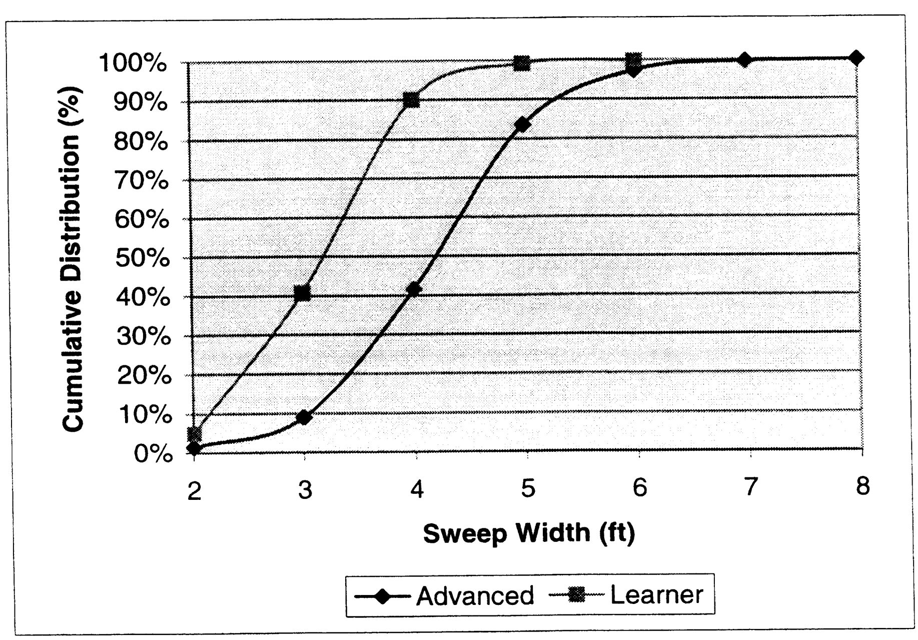

FIGURE 22 Cumulative Distribution Curves for Lower Sweep Width for Learner and Advanced Skaters

This project also analyzed the percent of skaters using 4 feet sweep width or less and the percent of skaters using 5 feet sweep width or less for each category. These percentages were calculated for lower body sweep width and for lower/upper sweep width. For all skaters, 51.15 % had 4 feet or less of lower/upper sweep width while 86.96 % had 5 feet or less of lower/upper sweep width. For lower sweep width, there is a small difference for the percentage of 4 ft or less but no difference for 5 ft or less with respect to lower/upper sweep width for all skaters category and for the rest of the categories. The sweep width values for female skaters were the closest one to the values for all skaters. In regard to male and advanced skaters, the percentage of skaters with 4 ft or less of sweep width was relatively small as compare to the other categories but similar for the 5 ft or under. The learner category showed a very high percentage of skaters with 4 ft or less sweep width, which seems to be related to the lower speed values. Table 4 presents the results for all categories of data.

TABLE 4 Percentage of Skaters with a Sweep Width of 4 ft or less, or 5 ft or less

Categories	Percentage of Inline Skaters with 4 or 5 ft or less			
	Lower Sweep Width		Lower/Upper Sweep Width	
	Percent 4 ft or less	Percent 5 ft or less	Percent 4 ft or less	Percent 5 ft or less
All	51.43%	86.96%	51.15%	86.96%
Male	41.90%	81.04%	41.60%	81.04%
Female	59.84%	92.18%	59.57%	92.18%
Learner	94.24%	99.28%	93.53%	99.28%
Advanced	40.79%	83.90%	40.61%	83.90%

Stopping Width

Data collection for different stopping characteristics was performed at each location. Three cameras were used to tape the different aspects related to stopping information. One of the cameras recorded the stopping width, and was located in such a way that a straight view to the skaters was ensured. The distance selected to collect the stopping data was 100 ft, measured from the stop sign located in the selected location on the path. The last 30 ft of this distance were marked with longitudinal lines across the 12-foot wide pavement. The last 30 ft were selected to analyze this characteristic with the purpose of determining the sweep width or lateral clearance required by the skaters when applying the stopping technique. The video camera taped skaters as they were traveling through the longitudinal lines. The stopping sweep width was determined during data reduction at the office by counting the number of lines the skaters' feet crossed. For stopping width, there is no lower body sweep width or lower/upper body sweep width. The reason relays on the fact that when skaters are stopping, they do not move their arms, and that means that their feet or body contexture basically determines the width. In other words, there is only one stopping width to be measured. As for the previous characteristics, sex and skill levels were also recorded. Frequency distributions and cumulative frequency curves were developed for each category considered. Figure 23 shows the data for the all skater category. Figures 24 and 25 present the frequency distributions for male and female skaters, and for learner and advanced skaters, respectively. Table 5 shows the number of observations for each category. Similar to the previous characteristics, the number of observations for male and female were similar. But that is not the case for learner and advanced skaters.

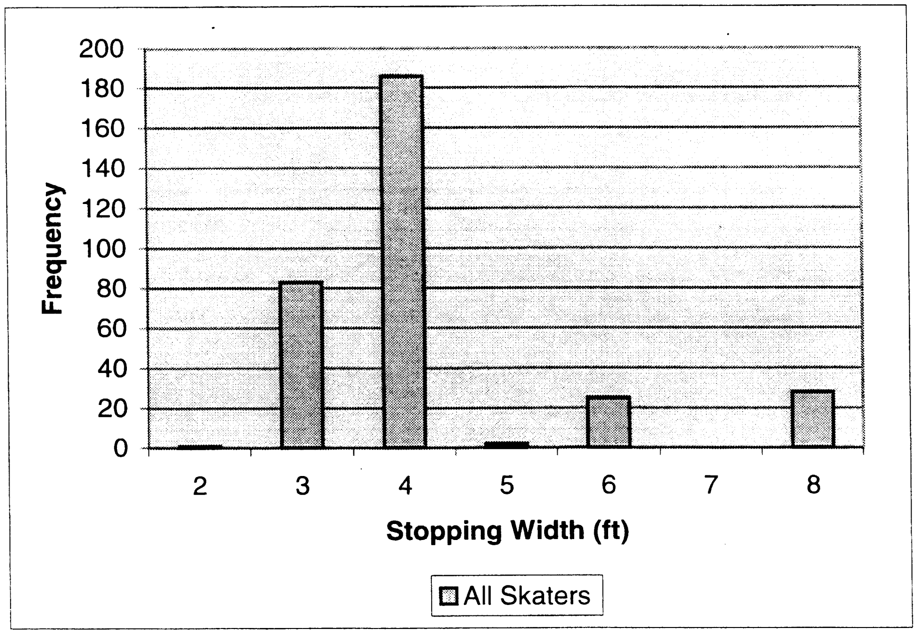

FIGURE 23 Stopping Width Distribution for All Skaters

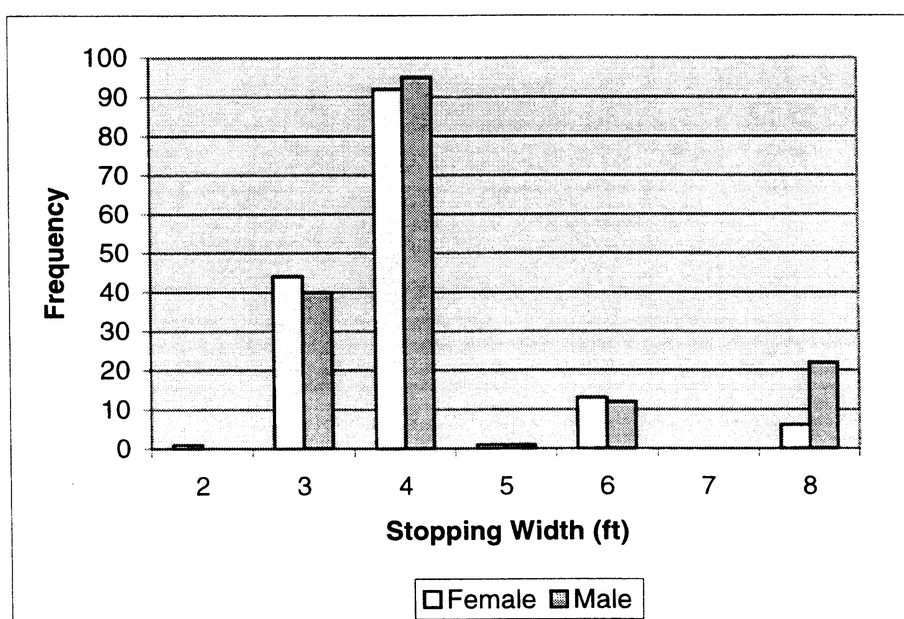

FIGURE 24 Stopping Width Distributions for Male and Female Skaters.

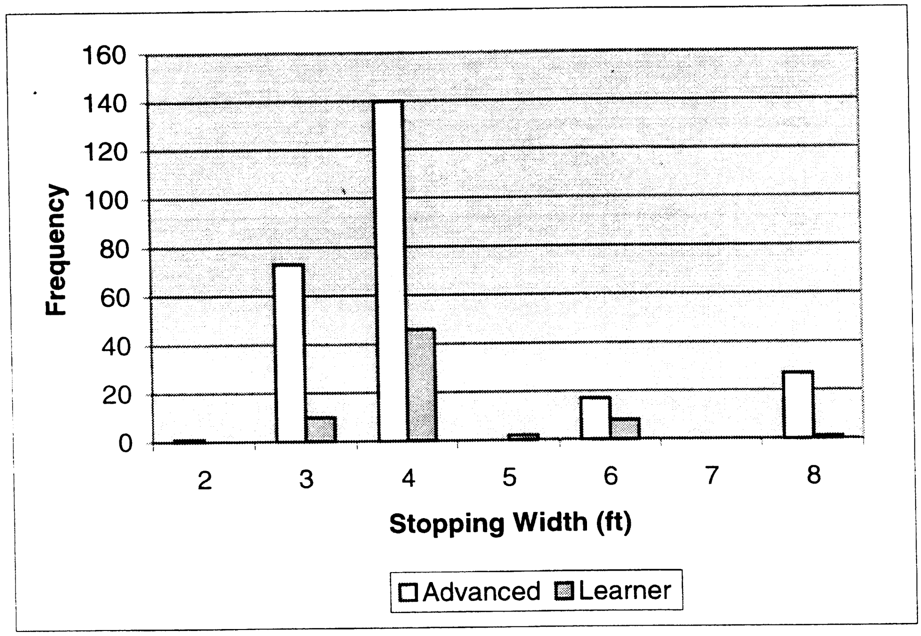

FIGURE 25 Stopping Width Distributions for Learner and Advanced Skaters.

TABLE 5 Stopping Width Characteristics of Inline Skaters

Categories	Number of Skaters	Stopping Width Characteristics of Inline Skaters				
		Stopping Width (ft)			Stopping Width Percentages	
		15th Perc.	50th Perc.	85th Perc.	Percent 4 ft or less	Percent 5 ft or less
All	335	3.23	4.31	5.36	80.41%	81.00%
Male	175	3.55	4.55	5.56	76.27%	76.84%
Female	160	2.94	3.87	4.78	84.85%	85.45%
Learner	70	3.41	4.27	5.14	80.00%	82.86%
Advanced	265	3.17	4.28	5.38	80.81%	80.81%

Table 5 also shows the 15th, 50th and 85th percentile values for stopping sweep width for all categories. These percentile values were also obtained from logit models, which were estimated by linear regression from field data. The 15th, 50th and 85th percentile values for all the categories were very similar. It should be mentioned specially that the differences in values for learners and advanced skaters was very small, which implies that the skaters' skill level did not influence this characteristic. Figures 26 through 28 show the cumulative distribution curves for the categories of all skaters, male and female skaters, and learner and advanced skaters, respectively.

The percentages of skaters using 4 feet or less or 5 ft or less for stopping width were also determined. The results are also presented in Table 5. The percentage values for stopping sweep width of 4 ft or less and 5 ft or less were extremely close, which indicates that there were few sweep width observations between the range of 4 feet and 5 feet. This was true for all the categories.

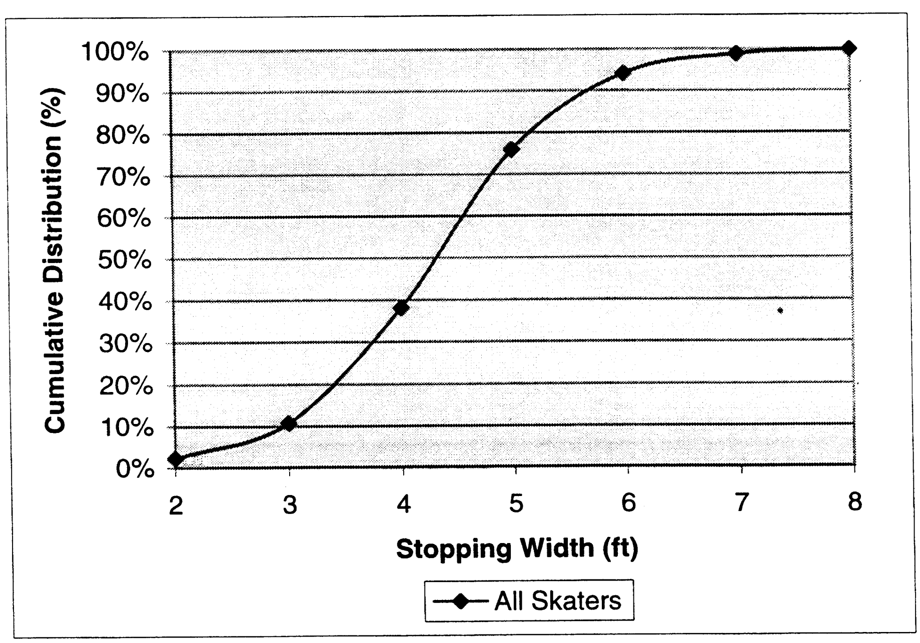

FIGURE 26 Cumulative Distribution Curve for Stopping Width for All Skaters

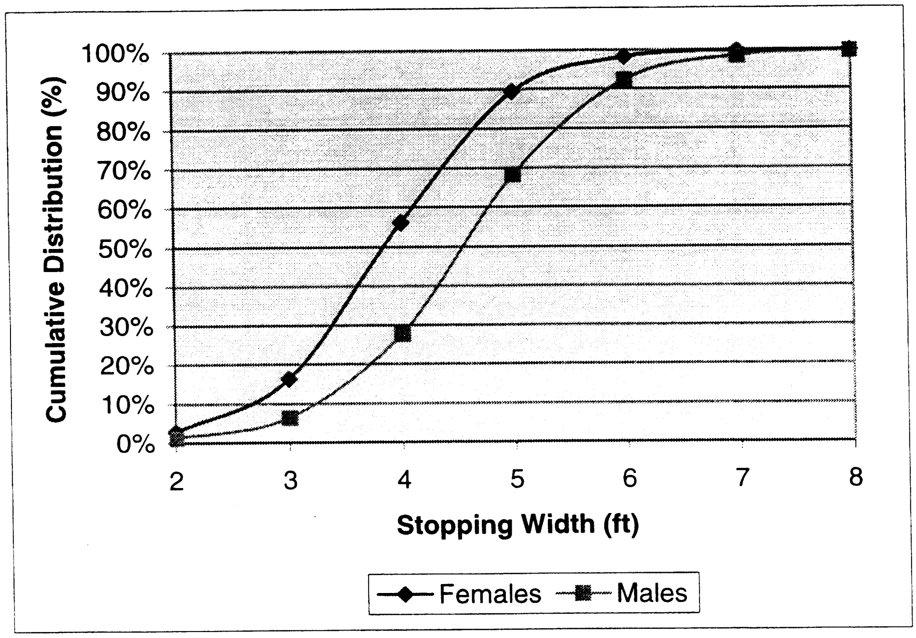

FIGURE 27 Cumulative Distribution Curves for Stopping Width for Male and Female Skaters

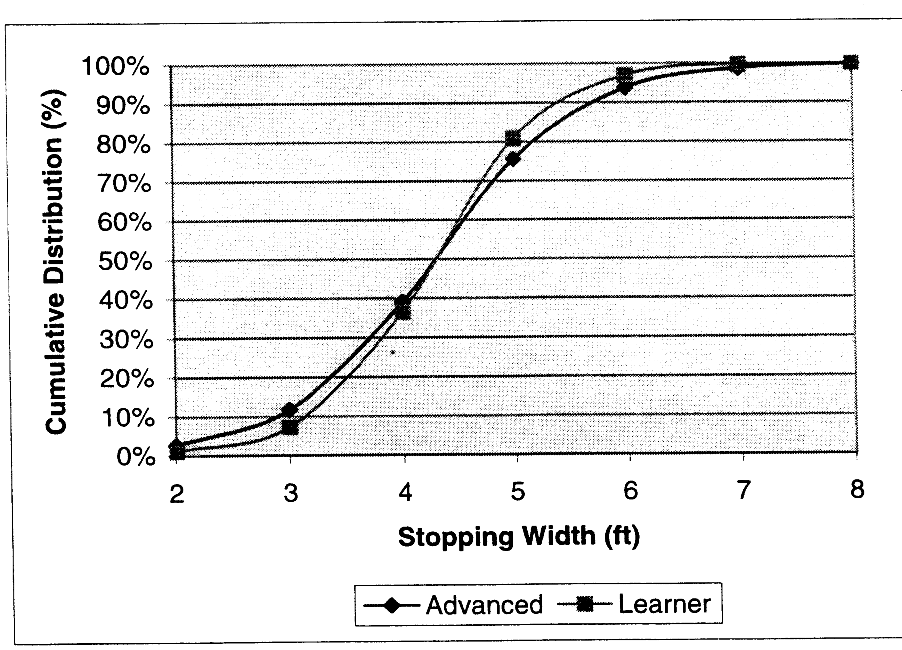

FIGURE 28 Cumulative Distribution Curves for Stopping Width for Learner and Advanced Skaters

Stopping Distance

As mentioned previously, three cameras were used to collect the stopping data. Two of them were utilized to collect the stopping distance. The stopping distance is the portion of the stopping process where the skaters apply a stopping technique to come to a complete stop. One of the two cameras used for this data collection was set on the first 60 ft of the 100 ft distance selected. This camera recorded any skater that started the stopping process on the first 60 ft of the selected distance. The other camera was set to cover the last 40 ft of the distance, in order to have a very clear view of the skaters when they applied the stopping technique to come to a complete stop. The total distance of 100 ft was marked every 5 ft by putting orange stakes along the path. When reducing the data, the stopping distance was estimated by reviewing the number of stakes each skater passed since they started applying the stopping technique until they came to a complete stop. The sex, skill level and dress characteristics of each skater were also recorded. Some matching was necessary to determine the stopping distance of those skaters that started applying the stopping technique on the first 60 ft and finished on the last 40 ft. The matching was performed based on the dress and sex information recorded. This was a time consuming part of the data reduction process. Once all the data were reduced and the stopping distance was obtained, frequency distribution and cumulative frequency curves for stopping distance were determined for each one of the categories. Table 6 shows the number of observations for each category. Figures 29 shows the frequency distribution for all skaters for the stopping characteristic. Figures 30 and 31 present the combined distributions for male and female skaters, and for learner and advanced skaters for the stopping characteristics, respectively.

TABLE 6 Stopping Distance Characteristics of Inline Skaters

Categories	Number of Skaters	Stopping Characteristics of Inline Skaters		
		Stopping Distance (ft)		
		15th Perc.	50th Perc.	85th Perc.
All	335	15.07	31.52	47.97
Male	175	16.40	32.65	48.91
Female	160	13.72	30.26	46.80
Learner	70	10.06	25.24	40.42
Advanced	265	16.68	33.02	49.35

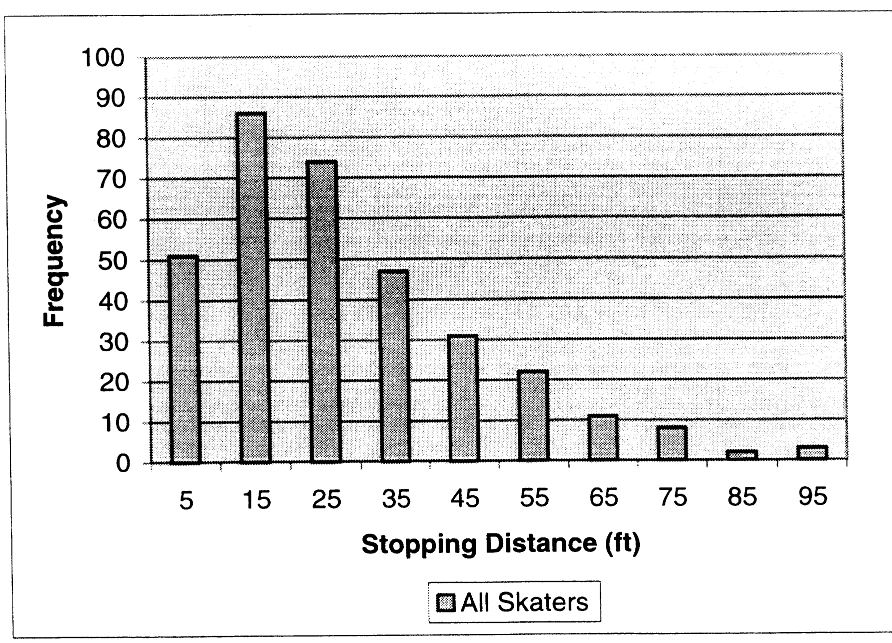

FIGURE 29 Stopping Distance Distribution for All Skaters.

Table 6 also presents the 15th, 50th and 85th percentile values for stopping distance for each one of the categories analyzed. These values were determined from the logit models

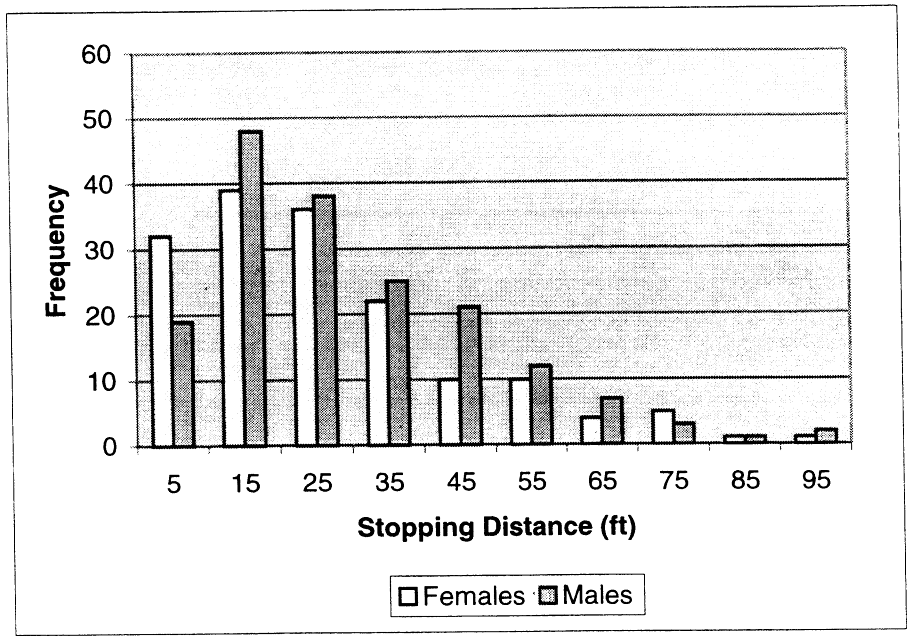

FIGURE 30 Stopping Distance Distributions for Male and Female Skaters.

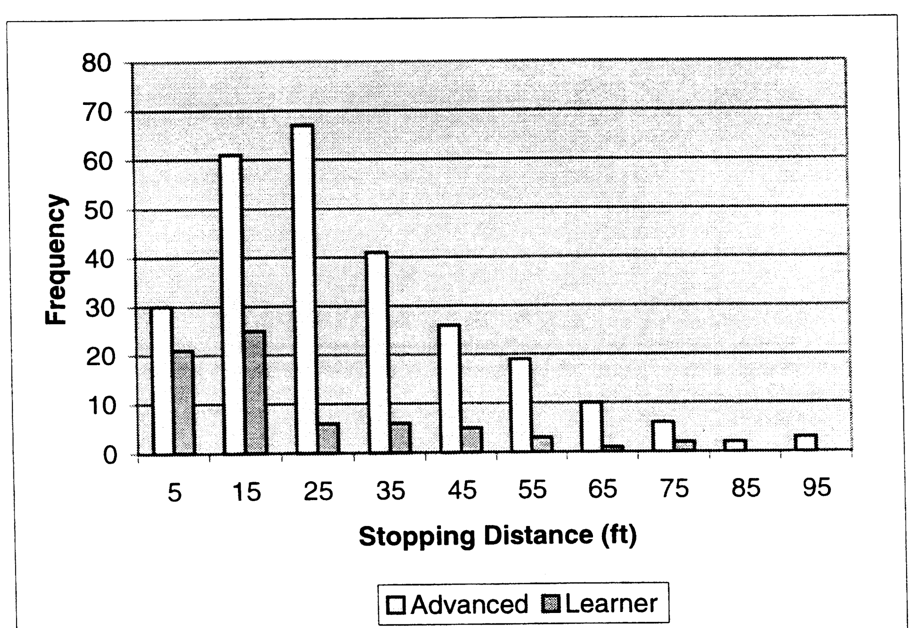

FIGURE 31 Stopping Distance Distributions for Learner and Advanced Skaters.

estimated by linear regression from field data. Figure 32 shows the cumulative distribution curve for stopping distance for the all skater category. Figures 33 and 34 present the cumulative distribution curves for the stopping characteristic for male and female skaters and learner and advanced skaters, respectively. The stopping distance required by the skaters when applying a stopping technique to come to a complete stop present the same trend for all the categories, lower values of speed had lower stopping distances. The difference between the learner category and the other categories for stopping distance is substantially greater than the difference presented between female skaters and the other two categories, male and advanced skaters.

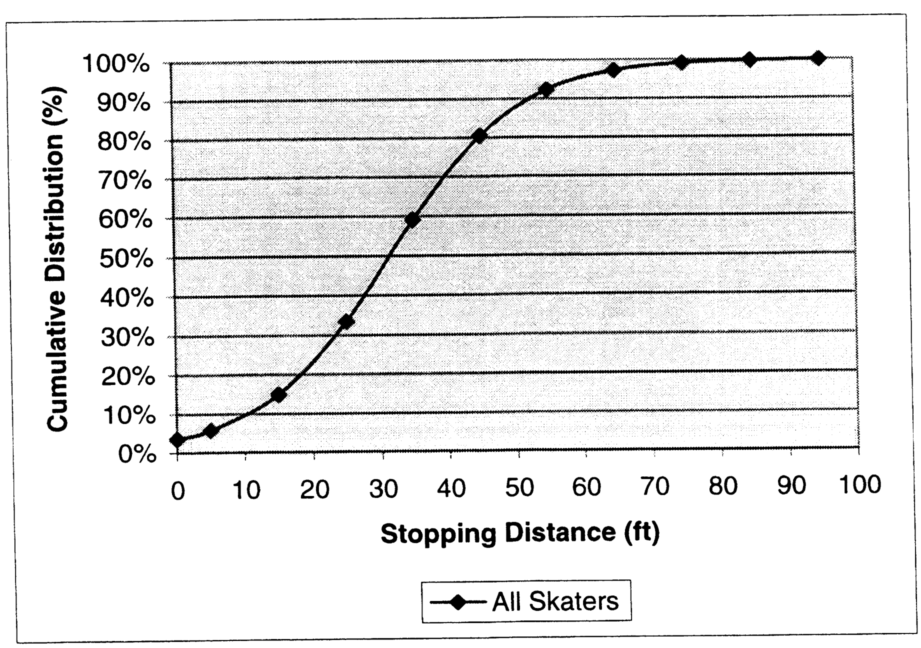

FIGURE 32 Cumulative Distribution Curve for Stopping Distance for All Skaters

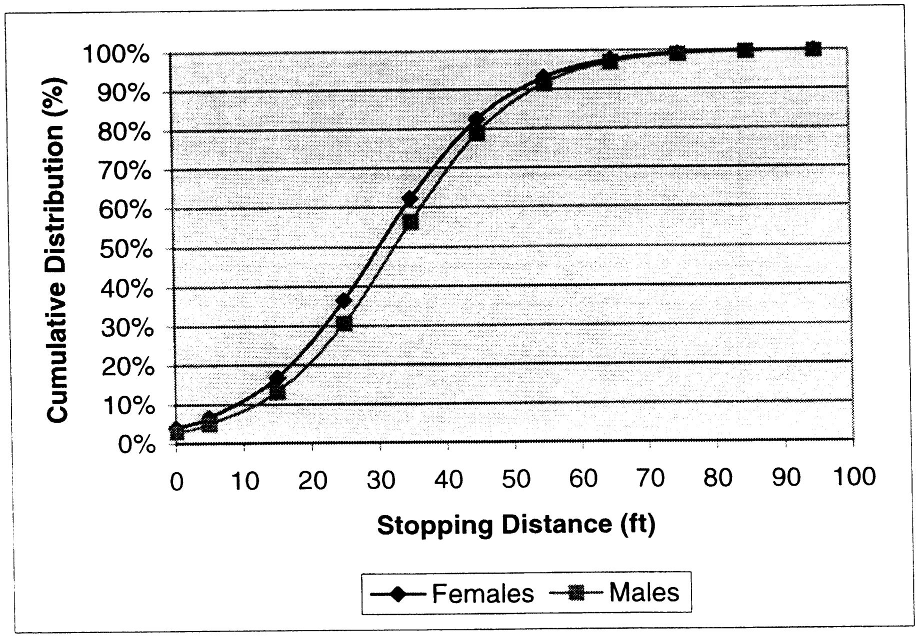

FIGURE 33 Cumulative Distribution Curves for Stopping Distance for Male and Female Skaters

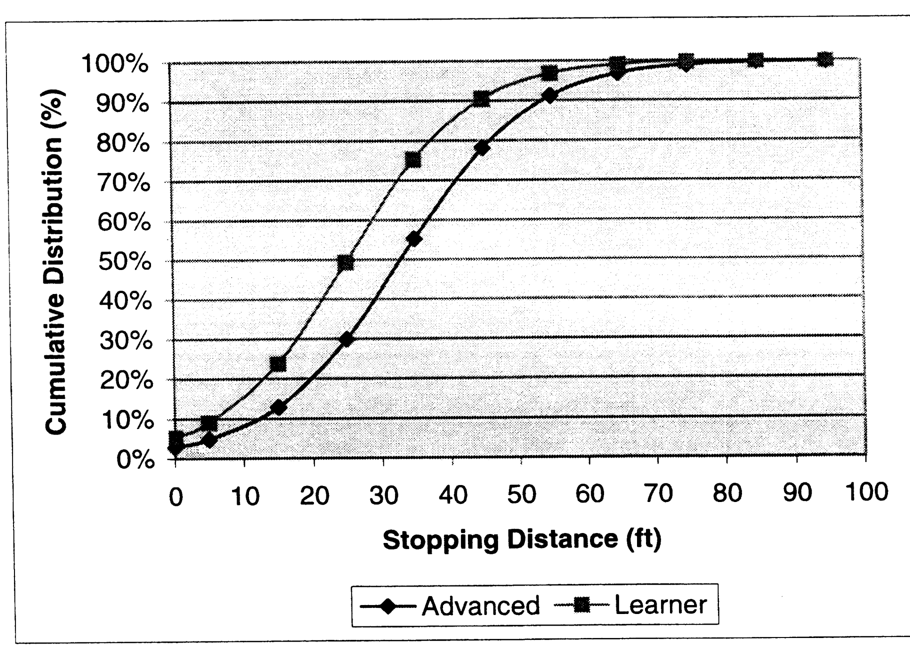

FIGURE 34 Cumulative Distribution Curves for Stopping Distance for Learner and Advanced Skaters

Stopping Techniques

This last stopping characteristic considered was determined by observing the skaters as they applied a specific stopping technique in the last 40 ft of the selected distance. For this purpose, the same videotapes used to determine the stopping sweep width were used. The second camera used in the previous stopping distance data collection was also used to check and ensure that the stopping technique was correctly determined. The second camera was the one located to record the last 40 ft of the selected 100 ft for stopping distance. Six basic stopping techniques were observed alone or in combination with each other to create the 20 stopping techniques. The six techniques observed were the brake pad, T-stop, run outs, spin out, wall-stop, and hockey-stop. The combined techniques observed are listed in the tables to be presented in this section. Table 7 provides a breakdown of the stopping techniques observed for the all skater categories at the two sites and their percentages. The brake pad technique was the most commonly used with 200 observations of the total 342, representing a 59.70 % of the skaters. The T-stop was the second most used technique with 51 observations, representing 15.22 % of the total. Despite being the second most used technique, it was considerably less used as compared to the brake pad technique. The other four techniques, spin out, wall-stop, hockey-stop, and run out, were used very few times but when adding to the brake pad and T-stop techniques the total is 87.26 % of all skaters. While the combined techniques did not have a high percentage if considered one by one, the use of a combination of techniques added to a 12.84 % of the total. Figure 35 shows the stopping technique distribution.

TABLE 7 Breakdown of Stopping Techniques for All Skaters

Stopping Technique	Number of Skaters	Percentage
Using Brake Pads	200	59.70%
Wall-Stop	9	2.69%
Run Out	5	1.49%
T-Stop	51	15.22%
Spin Out	20	5.97%
Hockey-Stop	7	2.09%
Brake + Wall-Stop	5	1.49%
Break + Wall + Run Out	1	0.30%
Brake + Run Out	7	2.09%
Brake + T-Stop	2	0.60%
Brake + Spin Out	9	2.69%
Wall-Stop + Brake	3	0.90%
Wall-Stop + Run Out	1	0.30%
Wall-Stop + T-Stop	2	0.60%
Wall-Stop + Hockey-Stop	1	0.30%
T-Stop + Run Out	2	0.60%
T-Stop + Spin Out	4	1.19%
Spin Out + Run Out	1	0.30%
Hockey-Stop + Run Out	1	0.30%
Hockey-Stop + Spin Out	4	1.19%

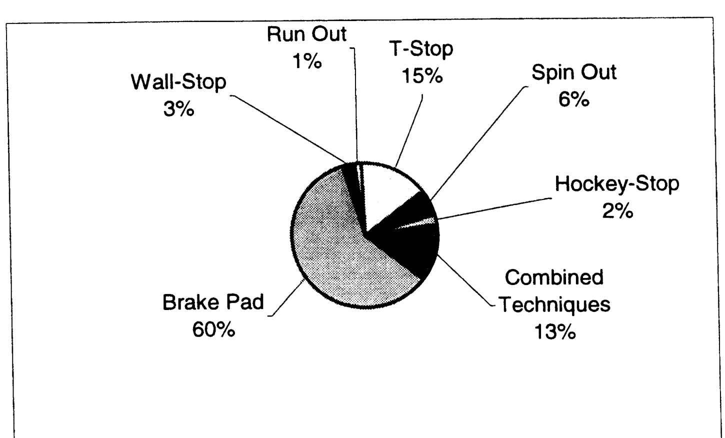

FIGURE 35 Distribution of Stopping Techniques for All Skaters.

Among male skaters, the preferred stopping technique was also the brake pad with 56.00 % of the total. The second most used technique was the T-stop with 18.29 %. 14.86 % of male skaters used combined stopping techniques. Table 8 and Figure 36 show these results in detail. In reference to female skaters, 63.75 % of female skaters used the brake pad technique and 11.88 % of female skaters used the T-stop technique. 10.63 % of female skaters also used combined stopping techniques. Table 9 and Figure 37 present the results for all the stopping techniques considered.

TABLE 8 Breakdown of Stopping Techniques for Male Skaters

Stopping Technique	Number of Skaters	Percentage
Using Brake Pads	98	56.00%
Wall-Stop	1	0.57%
Run Out	1	0.57%
T-Stop	32	18.29%
Spin Out	12	6.86%
Hockey-Stop	5	2.86%
Brake + Wall-Stop	1	0.57%
Break + Wall + Run Out	0	0.00%
Brake + Run Out	4	2.29%
Brake + T-Stop	2	1.14%
Brake + Spin Out	7	4.00%
Wall-Stop + Brake	1	0.57%
Wall-Stop + Run Out	0	0.00%
Wall-Stop + T-Stop	1	0.57%
Wall-Stop + Hockey-Stop	0	0.00%
T-Stop + Run Out	1	0.57%
T-Stop + Spin Out	4	2.29%
Spin Out + Run Out	1	0.57%
Hockey-Stop + Run Out	1	0.57%
Hockey-Stop + Spin Out	3	1.71%

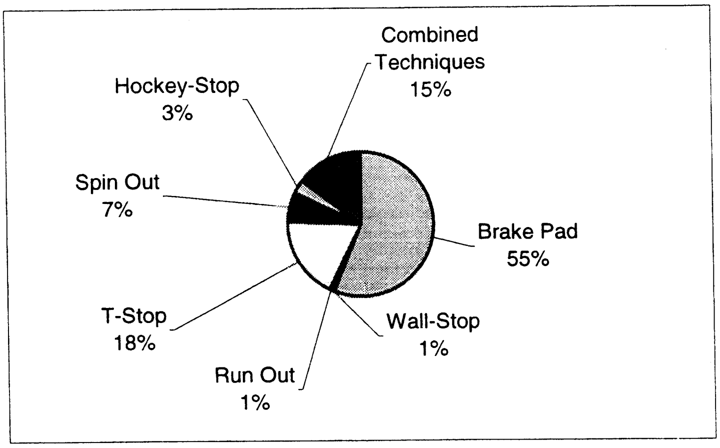

FIGURE 36 Distribution of Stopping Techniques for Male Skaters.

TABLE 9 Breakdown of Stopping Techniques for Female Skaters

Stopping Technique	Number of Skaters	Percentage
Using Brake Pads	102	63.75%
Wall-Stop	8	5.00%
Run Out	4	2.50%
T-Stop	19	11.88%
Spin Out	8	5.00%
Hockey-Stop	2	1.25%
Brake + Wall-Stop	4	2.50%
Break + Wall + Run Out	1	0.63%
Brake + Run Out	3	1.88%
Brake + T-Stop	0	0.00%
Brake + Spin Out	2	1.25%
Wall-Stop + Brake	2	1.25%
Wall-Stop + Run Out	1	0.63%
Wall-Stop + T-Stop	1	0.63%
Wall-Stop + Hockey-Stop	1	0.63%
T-Stop + Run Out	1	0.63%
T-Stop + Spin Out	0	0.00%
Spin Out + Run Out	0	0.00%
Hockey-Stop + Run Out	0	0.00%
Hockey-Stop + Spin Out	1	0.63%

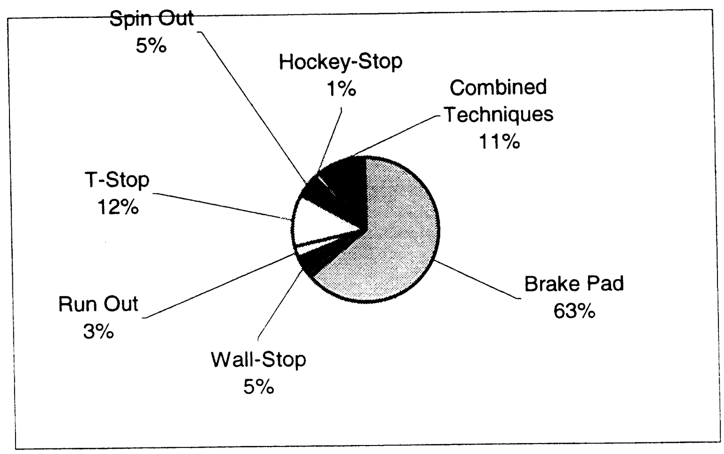

FIGURE 37 Distribution of Stopping Techniques for Female Skaters.

Finally, in reference to learners and advanced skaters, 54.29 % of learners and 61.13 % of advanced skaters used the brake pad stopping technique. 11.43 % learners and 16.23 % of advanced skaters used the T-stop technique. The wall-stop technique was used by 11.43 % of the learner skaters. 15.71 % of learners used combined techniques and 12.08 % of advanced skaters used these combined techniques. Table 10 and Figure 38 present the results for learner skaters, and Table 11 and Figure 39 for advanced skaters.

In summary, six different basic techniques were observed. They were brake pad, wall-stop, run out, T-stop, spin out, and hockey-stop. The brake pad was the most common technique used with a high percentage for all categories. The T-stop, and spin out were the second and third most preferred stopping techniques used. The basic stopping techniques were combined in several ways to produce combination stops. Each combination stop had a very low percentage by the skaters, but when considering all the combined stops together, the percentage was high.

TABLE 10 Breakdown of Stopping Techniques for Learner Skaters

Stopping Technique	Number of Skaters	Percentage
Using Brake Pads	38	54.29%
Wall-Stop	8	11.43%
Run Out	4	5.71%
T-Stop	8	11.43%
Spin Out	1	1.43%
Hockey-Stop	0	0.00%
Brake + Wall-Stop	2	2.86%
Break + Wall + Run Out	1	1.43%
Brake + Run Out	4	5.71%
Brake + T-Stop	0	0.00%
Brake + Spin Out	0	0.00%
Wall-Stop + Brake	1	1.43%
Wall-Stop + Run Out	1	1.43%
Wall-Stop + T-Stop	0	0.00%
Wall-Stop + Hockey-Stop	1	1.43%
T-Stop + Run Out	1	1.43%
T-Stop + Spin Out	0	0.00%
Spin Out + Run Out	0	0.00%
Hockey-Stop + Run Out	0	0.00%
Hockey-Stop + Spin Out	0	0.00%

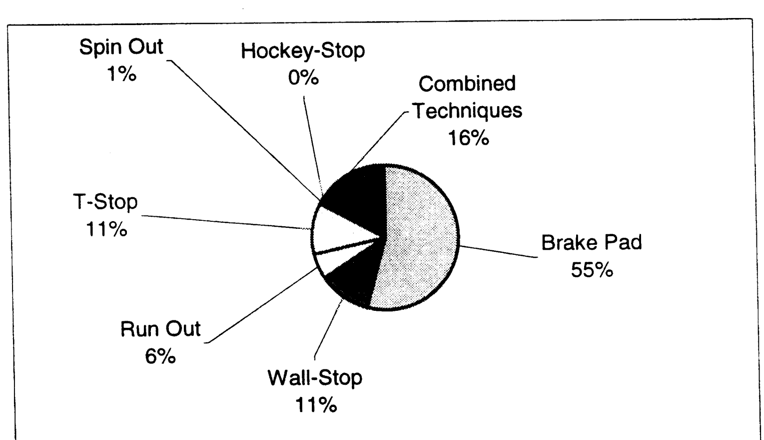

FIGURE 38 Distribution of Stopping Techniques for Learner Skaters.

TABLE 11 Breakdown of Stopping Techniques for Advanced Skaters

Stopping Technique	Number of Skaters	Percentage
Using Brake Pads	162	61.13%
Wall-Stop	1	0.38%
Run Out	1	0.38%
T-Stop	43	16.23%
Spin Out	19	7.17%
Hockey-Stop	7	2.64%
Brake + Wall-Stop	3	1.13%
Break + Wall + Run Out	0	0.00%
Brake + Run Out	3	1.13%
Brake + T-Stop	2	0.75%
Brake + Spin Out	9	3.40%
Wall-Stop + Brake	2	0.75%
Wall-Stop + Run Out	0	0.00%
Wall-Stop + T-Stop	2	0.75%
Wall-Stop + Hockey-Stop	0	0.00%
T-Stop + Run Out	1	0.38%
T-Stop + Spin Out	4	1.51%
Spin Out + Run Out	1	0.38%
Hockey-Stop + Run Out	1	0.38%
Hockey-Stop + Spin Out	4	1.51%

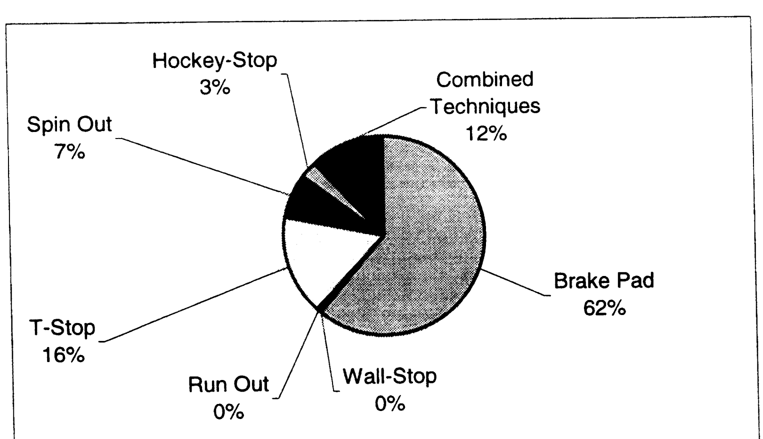

FIGURE 39 Distribution of Stopping Techniques for Advanced Skaters.

Summary

This chapter presented the 15th, 50th, and 85th percentile values for speed, sweep width, stopping width and stopping distance for each category considered for inline skaters. The frequency distributions and cumulative distributions based on logit model results were also presented by categories for each one of the operational characteristics of inline skaters. For sweep width and stopping width, the percentages of skaters with a sweep width equal to 4 ft or less and equal to 5 ft or less were also presented. In reference to stopping techniques, the breakdown of the different basic and combined techniques used by the skaters, and the frequency distributions of the techniques for each category analyzed were also presented in this chapter.

SUMMARIES, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Inline skating is growing rapidly in the United States, not only as a sport activity but also as a new mode of transportation. In order to accommodate inline skaters, either on the road or in trails or paths, it is necessary to have data on operational characteristics of inline skaters for geometric design purposes and policy installation purposes. For this reason, the main purpose of this research project was to measure the operational characteristics of inline skaters, which included operating speeds, operating space (sweep width), stopping techniques, stopping distance and stopping width. In the project, inline skaters were videotaped both on road facilities and trails located in west and south Florida. Video cameras were set at stationary locations to record the desired operational characteristics. The operational characteristics of inline skaters were determined from the videotapes using reference dimensions placed at each site. The skaters were analyzed for different categories, such as male, female, learner, advanced and all together. Logit models were used to fit the cumulative distributions to determine the 15^{th}, 50^{th} and 85^{th} percentile values for the operational characteristics. These operational characteristics would impact the desirability of allowing inline skaters on the street system and also will provide important information for geometric design for inline skater paths. In addition to enabling the FDOT make an informed decision on this matter; FDOT would have data for developing multi use trail geometrics and for operational design criteria.

Conclusions

This project in relation to operational characteristics of inline skaters results in several conclusions. These conclusions are presented in the following paragraphs.

The analysis results indicate that speed, sweep width, and stopping distance seems to be related, due to the fact that the highest speeds also had the highest sweep width, and longest stopping distances. This trend could be observed on Tables 12 and 13.

TABLE 12 Operational Characteristics of Inline Skaters

Categories	Operational Characteristics of Inline Skaters								
	Speed (mph)			Lower Sweep Width (ft)			Lower/Upper Sweep Width (ft)		
	15th Perc	50th Perc.	85th Perc.	15th Perc.	50th Perc.	85th Perc.	15th Perc.	50th Perc.	85th Perc.
All	7.13	9.86	12.59	3.00	3.93	4.86	3.09	4.00	4.91
Male	7.49	10.28	13.07	3.33	4.24	5.15	3.40	4.28	5.16
Female	6.64	9.34	12.04	3.00	3.82	4.63	3.01	3.81	4.61
Learner	5.30	7.03	8.76	2.48	3.15	3.82	2.69	3.21	3.74
Advanced	8.29	10.63	12.97	3.29	4.17	5.05	3.40	4.23	5.05

The speed values for 15th, 50th, and 85th percentiles were 7.13 mph, 9.86 mph, and 12.59 mph, respectively, for the all skaters category as shown in Table 12. These values for the all skater category range between the values of the other categories. The results indicated that males had higher percentile speeds than females, as well as, advanced skaters had higher speeds than learners.

In reference to sweep width, it was found that lower/upper sweep widths values were just a little higher than the values for lower sweep width. The 15th, 50th, and 85th percentile values for lower/upper sweep width for the all skaters category were 3.09 ft, 4.00 ft, and 5.91 ft, respectively. These results are presented in Table 12. Percentile values for lower/upper sweep width for male and advanced skaters were higher than for female and learner skaters.

Furthermore, if looking at the percentage of skaters with sweep width of 4 ft or less or 5 ft or less, the difference between categories is significant, indicating that male and advanced skaters require a bigger lateral clearance than the other two. Table 13 shows that at least for male and advanced categories, the percentage of skaters with 5 or under lower/upper sweep width are 81.04 % and 83.90 %, respectively. This means that a 5 ft lateral clearance will not accommodate 85 % of the skaters in these categories. The values for lower sweep width and lower/upper sweep width with respect to percentage of 4 ft or less and 5 ft or less are very similar.

From the data collected from fields, advanced skaters and male skaters occupied wider sweep width as compared to learner and female skaters, respectively. It could be assumed that wider sweeps are preferred by faster skaters because wider sweeps are more efficient to reach faster speed. Thus, in order to provide wider sweeps, more available space should be provided.

In reference to stopping distances, the difference is high between male and advanced skaters and female and learner skaters. The values for the 15^{th}, 50^{th}, and 85^{th} percentiles for stopping distances for the all skaters category were 15.07 ft, 31.52 ft. and 47.97 ft, respectively. Table 14 presents all these values for stopping distance.

TABLE 13 Percentage of Skaters with a Sweep Width and Stopping Width of 4 ft or less, or 5 ft or less

Categories	Percentage of Skaters with 4 or 5 ft or less					
	Lower Sweep Width		Lower/Upper Sweep Width		Stopping Width	
	Percent 4 ft or less	Percent 5 ft or less	Percent 4 ft or less	Percent 5 ft or less	Percent 4 ft or less	Percent 5 ft or less
All	51.43%	86.96%	51.15%	86.96%	80.41%	81.00%
Male	41.90%	81.04%	41.60%	81.04%	76.27%	76.84%
Female	59.84%	92.18%	59.57%	92.18%	84.85%	85.45%
Learner	94.24%	99.28%	93.53%	99.28%	80.00%	82.86%
Advanced	40.79%	83.90%	40.61%	83.90%	80.81%	80.81%

TABLE 14 Stopping Characteristics of Inline Skaters

Categories	Stopping Characteristics of Inline Skaters					
	Stopping Distance (ft)			Stopping Width (ft)		
	15th Perc.	50th Perc.	85th Perc.	15th Perc.	50th Perc.	85th Perc.
All	15.07	31.52	47.97	3.23	4.31	5.36
Male	16.40	32.65	48.91	3.55	4.55	5.56
Female	13.72	30.26	46.80	2.94	3.87	4.78
Learner	10.06	25.24	40.42	3.41	4.27	5.14
Advanced	16.68	33.02	49.35	3.17	4.28	5.38

For stopping width, the values were very similar for all the categories except for the female category, which had lower values than the rest. The 15th, 50th, and 85th percentiles values for stopping sweep width for the all skaters category were 3.23 ft, 4.31 ft, and 5.36 ft, respectively.

Finally for stopping techniques, the six basic techniques observed were brake pad, wall-stop, run out, T-stop, spin out, and hockey-stop. The brake pad was the most common technique used with a high percentage usage for all categories. The percentage for this stopping technique for the all skaters category was 59.70 %. The T-stop was the second most preferred stopping technique, with a 15.22 % for the all skaters category. It was also observed that the basic stopping techniques were combined in several ways to produce combination stops. The percentage of these techniques combinations was 12.85 % for the all skaters category.

In summary, categories with higher speeds, such as male and advanced skaters, presented also higher sweep widths and higher stopping distances. That difference was not obvious for stopping width. For stopping techniques, the preferred technique was the same for all the categories, the brake pad technique.

Recommendations

Operational characteristics of inline skaters were collected and analyzed in this project but no data were gathered in reference to the characteristics of inline skaters when they start to skate, which may provide interesting information for design purpose also. Other factors such as skaters passing other skaters because they going faster were not considered and data were not collected. This type of maneuver may involve different factors that need to be studied.

A factor that may affect inline skaters is the roughness of the asphalt of the trail or road. This factor may influence the speed of the skaters and this will affect all the other operational characteristics. For this reason, research should be accomplished on this topic. It will also be very interesting to see the effect of wet pavement on inline skaters.

The operational characteristics considered in the project were related to inline skater's performance but no considerations were taken for other factors that may affect skaters. These factors include the behavior of drivers in reference to the presence of skaters in the street. As an example, vehicles that are coming in the street perpendicular to the trail and are making a right turn when the signal is in red will stop on the pedestrian marking. This will block the skaters' path when they are trying to cross the street. This may imply that the car drivers may not be aware of the presence of a skaters trail or do not know the difference in speed and movement between pedestrians and skaters that are using the same crossing markings. Another example to the factors mentioned above is that the cars coming in the street parallel to the trail, and making a right turn into the trail crossing (pedestrian markings) do not have a warning sign indicating that skaters may be crossing or they do not take the sign into consideration. The drivers may not be aware of the differences between skaters and pedestrians that using the crossing markings and could be a hazard for the skaters.

To better set up policies and geometric design procedures for inline skaters, safety issues and safety performance related to inline skaters and trail or path may need to be addressed and evaluated. This includes inline skaters crash analysis and safety countermeasures.

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