Characterizing Pedestrian Traffic by Hour-of-Day Periodicities in Commercial Zones

By

ROB R. POAPST

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Department of Civil Engineering
University of Manitoba
Winnipeg, Manitoba

ABSTRACT

The current state of pedestrian traffic monitoring is characterized by short-duration counts over inconsistent time intervals, making it difficult to compare data temporally at a location or spatially between different locations. Practitioners require understanding of hourly pedestrian traffic periodicities in order to maximize the utility of their short-duration counts.

This research deployed six automated pedestrian counters at 12 study sites representing six roadway segments in Winnipeg's commercial zones. Pedestrian traffic data was collected in 2012 over the summer and fall seasons. This research analyzes the influence of temporal and spatial factors on hourly pedestrian traffic periodicities to enable the characterization of hourly pedestrian traffic in commercial zones.

Results indicate that short-duration counts be collected from Tuesday to Thursday on days with less than four hourly precipitation events. Additionally, pedestrian traffic varies seasonally and between adjacent sidewalks in commercial zones. Finally, characterization of pedestrian traffic pattern groups requires detailed land-use data.

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this research is to develop and apply methods to test the influence of temporal and spatial factors on hourly pedestrian traffic periodicities to enable the characterization of hourly pedestrian traffic in commercial zones. The hourly pedestrian traffic periodicity at each study site comprised a set of 18 mean hourly proportions of daily pedestrian traffic during the daytime between 06:00 and 24:00. Results from the temporal factors analysis provide recommendations as to when practitioners should conduct short-duration counts by day-of-week, maximum number of hourly precipitation events per day, and season (summer and fall). Results from the spatial factor analysis reveal where short-duration counts should be collected within commercial zones and between adjacent sidewalks. Ultimately, this research contributes knowledge to the continued development of pedestrian traffic monitoring in urban areas.

1.2 BACKGROUND AND NEED

Walking is a paramount activity which requires suitable infrastructure in the provision of a sustainable, equitable, and safe transportation system. To properly accommodate pedestrians, transportation professionals require an understanding of the influence of temporal and spatial factors on pedestrian travel characteristics. However, the lack of pedestrian traffic data is one of the most significant barriers to conducting pedestrian research (Zegeer, Nabors, Gelinne, Lefler, & Bushell, 2010). To highlight this deficiency, the U.S. Federal Highway Administration (FHWA) has included a new chapter in the 2013 *Traffic Monitoring Guide* that discusses non-motorized traffic monitoring for the first time. The guide notes that “the monitoring of non-motorized traffic has not been systematic or widespread in the U.S. and, even today, is not nearly as comprehensive as motorized traffic monitoring." (2013). Understanding pedestrian traffic characteristics enables the effective collection and analysis of pedestrian traffic data so they can properly accommodate them in urban infrastructure.

Pedestrian traffic data can be used to (Zegeer, Nabors, Gelinne, Lefler, & Bushell, 2010):

- determine pedestrian exposure for safety analyses to identify areas of high risk and to allow safe accommodation of pedestrians in the transportation system;
- aid in prioritization of infrastructure improvements and evaluation of the effectiveness of their implementation;
- develop models to predict pedestrian traffic volumes after a land use development or other implemented changes;
- raise the priority of pedestrian issues in the planning process; and
- guide the design facilities to accommodate pedestrian traffic.

The current state of pedestrian monitoring practice is characterised by short-duration counts over inconsistent time intervals. These short-duration counts are typically counted for only a few hours in duration and at different hours-of-day, making it difficult to analyze pedestrian traffic data temporally at a specific study site or spatially between different locations. The FHWA reveals that continuous pedestrian traffic counts are necessary "so that the limitations of short-duration (e.g., two hour) counts can be understood and interpreted" (2013, pp. 4-21). Similarly, Aultman-Hall et al. (2009) indicate there is insufficient data available to extrapolate short-duration counts to obtain daily pedestrian traffic volumes. Further, Sherry and Lindsay (2013) identify topics that require research as the integration of automated and manual count programs, the choice of counting locations across regions and within municipalities, and the development and application of adjustment factors for extrapolating short-duration counts to annual totals.

This research helps transportation professionals maximize the utility of short-duration, partial-day pedestrian counts. Ultimately, this research will aid in the development of pedestrian traffic monitoring practice for planning, design, operation, and maintenance of urban transportation infrastructure that seeks to accommodate pedestrians in a safe, sustainable, and equitable manner.

1.3 OBJECTIVES AND SCOPE

Specific objectives of this research are to:

1. Understand current practices regarding the collection and expansion of short-duration pedestrian traffic data, especially in commercial zones.
2. Understand what other jurisdictions in Canada and the U.S. have done or are doing regarding pedestrian traffic monitoring.
3. Identify the leading technologies currently available for pedestrian traffic counting.
4. Design a method to collect and analyze pedestrian traffic data that includes the selection of an Automated Pedestrian Counter (APC), selection of study sites, creation of a data collection system, and validation of the APCs performance.
5. Determine the influence of temporal factors (day-of-week, precipitation, and seasonality) and spatial factors (adjacent sidewalks and commercial zones) on hourly pedestrian traffic periodicities.

The scope of this research is defined by sidewalk segments that are surrounded by greater than 85 percent commercial zoning districts and run adjacent to road segments that are classified as four lane major or minor arterials with an AADT greater than 10,000 veh/day and less than 30,000 veh/day. The research takes place in Winnipeg, a city characterised by long cold winters, short hot summers, and home to 704,800 citizens as of the year 2012 (Statistics Canada, 2013). The data analyzed in this research was collected in 2012 over the four-month period beginning July 14th and ending November 3rd.

1.4 THESIS ORGANIZATION

This thesis is divided into five chapters.

Chapter 2 summarizes findings from the environmental scan regarding pedestrian traffic data collection. The environmental scan comprises a literature review and a jurisdictional survey including Canada and the U.S. The chapter addresses the following: (1) technologies currently available to collect pedestrian traffic data and their application; (2) current practices regarding the collection and expansion of pedestrian traffic data; and (3) pedestrian trip patterns.

Chapter 3 outlines the methodology developed for this research to collect and analyze pedestrian traffic data. The methodology includes the: (1) selection of APC; (2) selection of study site; (3) data collection system; (4) APC calibration; and (5) data sampling and review.

Chapter 4 presents the analysis and results found from the statistical testing of temporal and spatial factors affecting hourly pedestrian traffic periodicities. The following temporal factors were evaluated: (1) typical days-of-week for hourly pedestrian traffic periodicities; (2) effect of precipitation conditions on pedestrian traffic, and (3) effect of seasonality on pedestrian traffic. The spatial factors evaluated: (4) if pedestrian traffic is different on adjacent sidewalks; and (5) if commercial zones (as defined in this research) represent a consistent hourly pedestrian traffic periodicity.

Chapter 5 discusses research findings and conclusions, and opportunities for future research.

1.5 TERMINOLOGY

The following terms are used throughout the thesis.

AADT – annual average daily traffic is a common metric used to represent typical traffic.

Adjacent Sidewalks - refer to sidewalks that run parallel to each other on either side of the same roadway.

Automated Pedestrian Counter (APC) - refers to an automated method of counting the passage of a pedestrian along a sidewalk remotely.

Commercial Zoning District – refers to commercial and institutional districts as defined in the City of Winnipeg's Zoning By-laws (Planning, Property and Development, 2008). This includes commercial neighbourhood, commercial community, and commercial regional districts.

Commercial Zone – sidewalk segments that are surrounded by greater than 85 percent commercial zoning districts and run adjacent to road segments that are classified as four lane major or minor arterials with an ADT greater than 10,000 veh/day and less than 30,000 veh/day.

Hourly Pedestrian Traffic Periodicity - comprises a set of 18 mean hourly proportions of daily pedestrian traffic during the daytime between 06:00 and 24:00.

Hourly Precipitation Event – an hourly precipitation event is an hour where the weather condition as reported by Environment Canada included the words rain, drizzle, or snow.

Mean Hourly Proportion – is the average of hourly proportions for a given hour.

Pedestrians - those who navigate infrastructure on foot or with the use of an aid device such as a wheelchair.

Periodicity – a recurring pattern. See *hourly pedestrian traffic periodicity.*

Spatial Factors – influence pedestrian traffic between different study sites. This research evaluates the effects of surrounding commercial zone use, and the effect of side of roadway the sidewalk is on.

Temporal Factors – influence pedestrian traffic at an individual study site. This research evaluates the effects of day-of-week, level of precipitation, and seasonal temporal factors.

2 ENVIRONMENTAL SCAN

This chapter summarizes findings from the environmental scan regarding pedestrian traffic monitoring programs. The environmental scan is comprised of a literature review and a jurisdictional survey including Canada, and the United States.

2.1 LITERATURE REVIEW

The literature review addresses the following: technologies currently available to automatically collect pedestrian volume data; current practices regarding the collection and expansion of pedestrian traffic data, and pedestrian trip patterns.

2.1.1 Automated Pedestrian Count Technologies

The literature identified multiple automated pedestrian counting technologies and six key technologies emerged. These include: (1) infrared beam counters, (2) passive infrared counters, (3) piezoelectric pads, (4) laser scanners, (5) computer vision, and (6) microwave. These technologies will be the focus for this portion of the literature review. Alta Planning and Design (2009) describe the usefulness of automated counting technologies as being appropriate for longer-term counts, determining daily, weekly, or monthly variations and typically requiring fewer person-hours as opposed to manually counting pedestrians.

2.1.1.1 Infrared beam counters

Infrared beam counters are composed of an active infrared beam transmitter, infrared beam receiver and a data logger. The data logger registers a count when there is an interruption in the constant beam emitted from the infrared transmitter.

Bu et al. (2007) describe infrared beam counters as being both popular and commercially available. The authors identify three different types of infrared beam counters: (1) separated infrared beam transmitter and receiver, (2) infrared beam counter with the transmitter and receiver in the same housing, and (3) infrared beam counter with two beam setup to provide directional counts. Infrared beam counters have a typical range of around 30 metres.

Bu et al. (2007) discuss some of limitations of the infrared beam counters. The counters are not capable of differentiating between pedestrians and other objects such as bicyclists or raindrops. It is essential that the transmitter and receiver are aligned carefully for operations; however, disruptions may occur in situations where the device is mounted on a flexible structure. The devices undercount pedestrians when multiple pedestrians arrive at the counter simultaneously. Ozbay et al. (2010) state that since the accuracy of the device is impacted by outdoor environment factors such as wind and rain, they are best suited for indoor applications.

2.1.1.2 Passive infrared counters

Passive infrared counters identify moving objects by detecting the heat they emit. The devices record a count when an object emits a temperature higher than a certain threshold (Ozbay, Bartin, Yang, Walla, & Williams, 2010). Bu et al. (2007) report that the devices cannot identify pedestrians from vehicles or bicyclists. The counters may undercount pedestrians when traveling in groups; however, the authors' state that this drawback may be helped by using a pyroelectric sensor array to create infrared images. Dharmaraju et al. (2000) state that passive infrared devices are also contingent in favourable weather conditions. Donlon & Berkow (2009) identify passive infrared counters as being best suited for screen-line sidewalk counts.

2.1.1.3 Piezoelectric

Dharmaraju et al. (2000) describe piezoelectric technology as weight sensitive rubber surfaces incorporating piezo cables, imbedded in a detection zone. The pressure exerted on the mat from footsteps detects the presence of a pedestrian. Ozbay et al. (2010) indicate that the technology incorporates a timer to prevent over-counting if a person should step twice on the mat however the detector cannot differentiate between a single pedestrian and multiple pedestrians.

Bu et al. (2007) state that piezoelectric pads are a simple reliable sensor for pedestrian counting. When a larger coverage area is required, multiple pads can be buried together. The technology does not require complex signal processing but does require physical contact between the pedestrian and mat. The authors state the technology is ideal for locations where pedestrians are channelled into a crossing. Ozbay et al. (2010) note the technology is best suited for rural environments and that the subsurface installation makes the devices costly for cement or asphalt surfaces.

2.1.1.4 Laser scanners

Laser scanners emit infrared laser pulses and then detect the pulses once they reflect back. Ozbay et al. (2010) state that the technology is well suited for both urban and rural applications. Specific installation requirements need to be addressed as the horizontal laser scanner needs an open detection area and should be free of obstructions such as trees or plants while the vertical device must be mounted above the detection zone.

The optical nature of the devices can be impacted by weather conditions which can in turn negatively affect the accuracy of the data. Bu and Chan (2005) also reveal that a dedicated computer processor may be required to process the laser scanners complex signal.

Bu et al. (2007) identify two classes of laser scanners: (1) horizontal scanning, and (2) vertical scanning. Horizontal scanning is capable of detecting and counting pedestrians within a 15-metre radius. Vertical scanning is capable of passage width of up to 26 metres and can provide directional counts and classification of pedestrians according to height. The scanners have very good range accuracy and fine angular resolution making them suitable when high-resolution of surroundings is sought.

2.1.1.5 Video Image Processing

Computer vision technology obtains information from images and can make use of existing closed-circuit television cameras (Ozbay, Bartin, Yang, Walla, & Williams, 2010). A processor subtracts the static background from an image in order to track the remaining moving objects to determine if they are pedestrians (Bu, Greene-Roesel, Diogenes, & Ragland, 2007). The image sequences alone cannot be used directly without additional effort. Bu et al. (2007) describe the process of extracting this information as being complex requiring a controlled outdoor environment in terms of lighting condition, and urban environment factors such as street furniture and buildings. The authors have broken the tracking and counting procedure for video imaging down to three key steps: (1) determine if there are any interesting objects entering the field of view, (2) track their motion until they reach the counting line, and (3) establish how many people correspond to the tracked objects.

Bu et al. (2007) discuss how variations in individual pedestrians pose challenges as pedestrians have different clothes, motion, size and skin colour. The technology also has difficulty distinguishing among independent moving bodies when a high volume of pedestrians is present. The technology is capable of obtaining greater information on the surrounding environment if this type of information is sought. Ozbay et al. (2010) state that the technology is unsuitable for urban environments due to the required light, external power source, and overhead installation. Donlon & Berkow (2009) state that video imaging is a suitable technology when information on user type, behaviour, or demographics is required.

2.1.1.6 Microwave

Microwave detectors transmit electromagnetic radiation toward an area of interest from an antenna, mounted overhead or on the side, to reveal approaching or departing objects (Dharmaraju, Noyce, & Lehman, 2000). When an object passes through the beam a portion of the radiation is reflected back to the antenna. The authors describe two types of microwave radar detectors: (1) continuous wave transmission, (2) saw-tooth waveform transmission (frequency modulated continuous wave). The continuous wave transmission is at constant frequency and the change in frequency in the reflected wave is used to calculate the speed of the object based on the Doppler principle. The saw-tooth waveform transmits a continuously changing frequency.

A summary of the different automatic pedestrian technologies can be seen in Table 1.

Table 1: Summary of Counting Technologies from Literature Review

Counter	Technology	Pros	Cons	Manufacturer and Cost
Infrared beam counter	Detects obstruction in beam [2]	Cheap and commercially available[1] Low power consumption[1] Easy installation[1] Highly portable[1] Can be used on a sidewalk or path[2]	Infrared beam counter cannot differentiate pedestrian and other objects[1] Transmitter and receiver need to be aligned carefully[1] When several pedestrians cross the counting beam simultaneously, they are registered as only one count[1]	JAMAR Technologies Inc. \$790[1] Average technology cost \$800-\$7,000[2]
Passive infrared counter	Detects change in thermal contrast given off of objects passing by the detector.	Counter with multiple sensor arrays could achieve performance comparable to computer vision[1] Low power consumption[1] Not affected by wet or foggy weather[1] Cheap and widely available commercially[1] Can be used on a sidewalk or path[2]	Single or double sensor counter cannot distinguish between individuals and groups[1] Temperature can affect counter performance[1] Limited coverage area[1]	Irisys \$1,400 for counter with multiple sensor array[1] EcoCounter \$3,000 for counter, \$600 for software[1] Average technology cost \$2,000-\$3,000[2]
Piezoelectric pad	Senses pressure on underground sensor [2]	Low maintenance cost[1] Capable of counting pedestrians on sidewalks[1] Low power consumption[1]	Need physical contact between pedestrian and pad[1] Some products cannot differentiate between single pedestrians and groups[1] Subsurface installation is expensive[1] Limited coverage area[1]	EcoCounter cost estimate not available[1] Average technology cost \$2,000 -\$3,000[2]
Laser Scanner	Emits infrared laser pulses and detects reflected pulses[3]	Accurate range measurement[1] Can differentiate pedestrians according to their height[1] Easy setup[1] Large coverage area[1]	Expensive[1] Performance could be affected by weather conditions[1]	LASE GmbH Around \$9,000 for counter only[1]
Computer vision	Processes digital images of pedestrians captured with a video camera[1]	Large coverage area[1] Potential to count accurately in various conditions: crowded pedestrians, different lighting[1] Can be manually reviewed to collect pedestrian characteristics[1] Easy installation[1]	Most commercially available products are intended for indoor setting[1] The difficulty of counting pedestrians in crowded settings has not been resolved[1] The performance can be affected by different environmental conditions if not designed properly[1]	Video Turnstile Start from \$1,230[1]

1 - (Ozbay, Bartin, Yang, Walla, & Williams, 2010);
2 - (Bu, Greene-Roesel, Diogenes, & Ragland, 2007);
3 - (Donlon & Berkow, 2009);

2.1.2 Automated Pedestrian Count Device Applications

The following summarizes the application of automatic pedestrian counters.

- Hankey et al. (2014) used TrailMaster counters with active infrared technology to collect continuous non-motorized traffic data for a complete year in 2011 at six locations on off-street trails in Minneapolis, MN. The purpose of the research was to determine the error associated with day-of-year scaling factors compared to standard factors for estimating AADT.

- Rutgers University in New Jersey (Ozbay, Bartin, Yang, Walla, & Williams, 2010), conducted a study to understand the performance of two automatic pedestrian detectors using passive infrared sensor technologies. The detectors tested are;

    - the double pyroelectric sensor (pyro) without vision by EcoCounter, and
    - the thermal sensor with imaging technology by TrafSys.

  The study consisted of five sites in New Jersey including three sites at high-volume locations (crosswalks) and two on low-volume trails. The two detector types were used under the same experimental conditions to compare their individual performances which included a range of weather conditions, specifically, rain, snow, and clear weather. The study concluded that the pyro counter exhibited a mean absolute percent error 1.5 to 2 times that of the thermal sensor if both sensors were deployed at a high volume site and aggregated into large time intervals (>15 minutes). The pyro counter was found to consistently undercount pedestrians in most cases. A calibration procedure was found to be effective in increasing the accuracy of the pyro counter.

The study also concluded that both counters are capable of counting and determining the pedestrian direction of travel. Both counters were unable to time-stamp individual pedestrians as counts were aggregated in predetermined time intervals. The pyro counter has one time interval of 15 minutes while the thermal sensor allows aggregation of counts into one-minute intervals. Both counters are commercially available and can be obtained within two weeks. The thermal sensor required technical support from the vendor during installation for calibration and data retraction. The pyro counter can be installed and deployed using manuals provided by the vendor and the data is extracted using a pocket PC or smart phone. The authors' note that although the thermal sensor is more complex to setup it can remotely receive real-time counts.

The authors also state that the pyro counter performs best on trails and sidewalks as it is sensitive to pedestrian arrival patterns. These counters are not recommended for high volume sites as it has been found to undercount at these locations. Missed counts and over counting occur in complex pedestrian arrival patterns for both counters. The thermal sensor failed three times due to early depletion of battery supply due to cold weather. The pyro counter has a battery life of up to ten years continuous counting.

- Hudson et al. (2010) also deployed the EcoCounter's pyro counter at a trail location in Wolf Pen Creek, College Station and compared the results to test results from previous studies. The testing looked specifically at the counters capability in terms of counting both pedestrians and cyclists. The EcoCounter testing comprised two different settings: (1) standard mode and (2) crowd mode. The other counters used for comparison consisted of: JAMAR scanner (larger infrared counter), TrafX Sensor (small infrared counter), and Diamond Trail Counter (break-beam with target).

Overall, all four sensors were capable of accurately detecting a single pedestrian at typical walking speed although they all had difficulty counting trail users who were closely spaced. The pyro counter was found to perform better under the crowd mode rather than the standard mode in terms of overall error rate. The authors note that the standard setting results are consistent in both overcounting and undercounting. Overall the authors conclude that the pyro counter shows better overall results when compared to the other three counters.

- Schneider et al. (2009a) present a methodology for estimating weekly pedestrian intersection crossing volumes based on two-hour counts. Manual counts were conducted at 50 intersections in Alameda County, California. Automatic pedestrian counters operated near 13 of the 50 sites to adjust the manual counts for time-of-day and day-of-week, surrounding land use characteristics, and weather conditions. The EcoCounter's passive infrared pyro counter was selected for the automatic counts. The pyro counter was selected due to its low undercounting performance, data storage capabilities, battery life, and ease of installation.

  Four infrared counters were rotated among 12 of the locations and a fifth counter remained at one location. Ideally the authors were looking for pedestrian counters that could operate at intersections; however, at the time of the research, technology of this nature was not available. Instead of intersection counts the automatic pedestrian counters were located on the approach to the intersection within 100 feet. The authors made the assumption that daily pedestrian patterns experienced on the sidewalk approach would be similar to that of the intersection. The counters were mounted on street signs or parking meters at a height of 76 to 102 centimetres and had a range of 4.6 metres which covered the entire sidewalk. Data from the counters was downloaded at the site of each counter using an HP Pocket PC equipped with EcoPocket software. Data was then uploaded and exported to spreadsheets in hourly increments.

Two of the eleven sites were deemed to have unreliable data for analysis, one due to its proximity to a bus stop and one due to permitting issues which delayed its installation. The EcoCounter was shown to consistently undercount during high-volume (>400 pedestrian per hour) and low-volume (<100 pedestrians per hour) periods. It was also found to undercount at locations with different sidewalk widths, and during sunny, cloudy, rainy, and dark conditions. The authors note that despite these findings the percentage of undercounting is not related to the pedestrian volume because as pedestrian volumes increased the rate of undercounting remained in the same range. The authors conclude that there is no indication that the distribution of hourly pedestrian volumes throughout the week should be adjusted. Although the counters recorded slightly lower pedestrians than the actual number of pedestrians the proportions of pedestrians counted during each hour remains unchanged. Other issues experienced with the counters include disruptions due to bicycles parking in front of the counters, and people standing or walking back and forth in front of the counters.

- Schneider et al. (2005) conducted a study to gather information of pedestrian data collection efforts. The authors summarized key findings from the eight different communities using automated counters. The emerging findings include:

    - the use of automated counters can significantly reduce labour costs,
    - the devices must be positioned and adjusted precisely to maximize accuracy,
    - the results and accuracy of the devices should be reported on,

- the placement of the devices should consider potential for vandalism and minimize interference with pedestrians and bicyclists,
- the devices should operate in rain, wind and a range of temperatures, and
- most of the devices did not count all types of non-motorized users and only a few devices were capable to observe behaviours.

Specifically, they found that Licking County, Ohio implemented three TRAFx passive infrared counting devices as a component of their pedestrian data collection efforts. The counters operated at eleven different sites annually on shared use paths and additional counts were taken at 20 to 50 locations each year. The sensors were hidden under branches or camouflage at each site to reduce losing or damaging the devices. When in operation each user is recorded with a time stamp. The TRAFx device has a docking module for a laptop computer where the raw data can be downloaded directly into a spreadsheet for analysis.

Limitations included that the devices do not differentiate between pedestrians, bicyclists, and animals. Some reliability issues were identified, although when compared to manual counts the devices were found to be accurate 90 percent of the time. Pedestrians crossing the beam at the same time may be counted as only one pedestrian as the device requires a delay between records. Many of these limitations were identified as being limitations in similar automated counters. Overall, those that implemented the counters were satisfied with the data collection and analysis resulting from the counters.

2.1.3 Pedestrian Traffic Collection

Pedestrian traffic data can be collected both (1) manually and (2) automatically using devices outlined in the previous section. A summary of the literature regarding these two ways of collecting pedestrian traffic data is found below.

2.1.3.1 Manual Counts

Manual counts are performed by persons generally using a counting tool such as a clicker. They are resource intensive and vary by duration, time, frequency, location, and purpose.

2.1.3.1.1 Duration, Timing, and Frequency

- Cottrell and Pal (2003) report on a survey of 21 U.S. jurisdictions in 2001 revealing that the most common counting times were 7 a.m. – 9 a.m. and 4 p.m. – 6 p.m., with the goal of understanding peak period activity. The average count duration per location from the survey was 4.8 hours with a coefficient of variation of 116 percent.

- The San Francisco Metropolitan Transportation Commission et al. (2003) developed a handbook for bicyclist and pedestrian counts. The handbook recommends two two-hour counting periods during the day: the morning peak from 7 a.m. to 9 a.m., the afternoon peak from 4 p.m. to 6 p.m., and if the location is near a school the afternoon count can be extended to run from 2 p.m. to 6 p.m.. It also suggests a manual counting approach to be employed at intersections and recommends avoiding counts during winter, inclement weather, holidays, and special events. The handbook does not provide any guidance on the selection of counting locations.

- Frequency of manual counts was found to vary widely in a recent TTI survey (Hudson, Qu, & Turner, 2010). St. Paul reported annual counting in September; Tucson also reported annual counts. Cincinnati and the Boston Metro area reported counting sporadically or on an as-needed basis. The Virginia DOT reported counting every 1-3 years.

- The Traffic Monitoring Guide (FHWA, 2013) indicates the prevailing practice is to collect short-duration counts (usually manual) during dates and times when conditions are believed to be average to reduce the need for factoring. Jurisdictions typically count two consecutive hours on a single day. The minimum suggested duration for short term counts is 4 to 6 hours during the peak period of pedestrian activity. The preferred length of short-duration counts is 12-hours to facilitate the creation of time-of-day use profiles.

- Jackson et al. (2015) recommend short-duration counts for non-motorized traffic be seven days in length but indicate that the minimum duration should be 24 consecutive hours.

2.1.3.1.2 Location

- Cottrell and Pal (2003) report on count location information from 60 U.S. jurisdictions. They found that counts were conducted at the following locations:

    - Activity Centres (downtown, business centre, school zones, campus, large factors, park, community centre, retirement community, stadium, or nightclub district)
    - At major events
    - At intersections for traffic signal timing or warrant studies
    - Along paths
    - At crosswalks where safety is an issue
    - At proposed development sites

- Schneider, Arnold, and Ragland (2009b) used a sample of 50 short term counts to calibrate a model that produces county-wide estimates. They designed a structured location selection process to achieve broad coverage in terms of: geography, income groups, population density, and commercial density. The broad coverage was sought to avoid bias in the model from over-representation. The structured location process also contained a buffer exclusion criteria of 400 metres between sites to avoid the loss of sample independence and autocorrelation effects associated with adjacent sites. More details on the model and its use are provided in a subsequent section.

- The National Bicycle and Pedestrian Documentation Project (Alta Planning and Design & ITE Pedestrian and Bicycle Council, 2009) has focused its work on locations that are either high pedestrian density areas or specific pedestrian/bicyclist pathways.

- The Traffic Monitoring Guide (FHWA, 2013) indicates that currently short-duration counts are collected at locations where activity levels and professional interest are highest as they provide more efficient use of limited resources. They warn that this method of selecting count locations may not represent area wide use levels and trends.

- In their research regarding the development of a non-motorized data collection program for Oregon, Figliozzi et al. (2014) indicate that pedestrian count location should represent high pedestrian crash areas, future smart growth zones, locations near transit stops, recently completed pedestrian facilities, multiple land-uses, and various population demographics.

2.1.3.1.3 Purpose

Schneider et al. (2005), through a study of 29 data collection efforts in the U.S., identified the following purposes for pedestrian data: documenting changes in activity, identifying locations for improvements, and integrating pedestrian data into planning documents. A more recent TTI survey of 11 U.S. jurisdictions found that count data is used for baseline information, trend measurement, and project evaluation (Hudson, Qu, & Turner, 2010).

2.1.3.2 Continuous Counts

Continuous counts require automated pedestrian counting devices to collect data every hour of the year. The current situation of continuous counts is revealed through literature indicating the lack of temporal pedestrian traffic data.

2.1.3.2.1 Lack of Temporal Data and Need for Temporal Data

Several researchers have pointed out the lack of data on temporal variation pedestrian activity and the limited use of expansion factors applied to pedestrian counts.

- In an earlier survey of 60 U.S. jurisdictions, Cottrell and Pal (2003) found no use of automated counting systems, but their findings from the survey did indicate that permanent counting sites may increase collection efficiency in addition to providing seasonal information that would be useful to understand exposure in safety analyses.

- Raford and Ragland (2004) describe the lack of detailed pedestrian exposure data as a major challenge facing transportation engineers, and they cite the U.S. FHWA and NHTSA, which found that accurate pedestrian data was the least understood and most important area of research for pedestrian planners and decision-makers.

- Schneider et al. (2005) surveyed 29 different pedestrian and bicycle data collection efforts in the United States, and while they did list the development of expansion factors for volume estimates as one of the data collection purposes, the practice was limited to bicycle activity in Boulder, Colorado.

- Alta Planning and Design and the ITE Pedestrian and Bicycle Council (2009) comment that, with respect to the development of expansion factors for short-term counts, more year-long count data is needed, especially for pedestrians.

- Aultman-Hall et al. (2009) explain that there is a small but growing base of data on temporal variation in pedestrian traffic volumes.

- Schneider et al. (2009b) mention that overall, better pedestrian data is needed, and that although some work extrapolates two hour counts to annual volumes, these volumes may not be accurate because the use of continuous counts to develop hourly, day-of-week, and seasonal adjustment factors is rare.

- The Transportation Research Board of the National Academies created the Bicycle and Pedestrian Data Subcommittee in 2011 to focus on "non-motorized travel data acquisition including volume counting, understanding traveler behavior, and capturing relevant supporting transportation data." (2011).

- One of the most important barriers to increasing active transportation activity identified by the Transportation Association of Canada (TAC) is traffic data on active transportation users, trip purposes, route choices and personal motivators (2012). In September 2014, TAC reached its funding goals for a pooled funds project entitled "Synthesis of Traffic Monitoring Best Practices for Canadian Provinces and Municipalities" which includes active transportation monitoring.

- In their research brief for Active Living Research, Sherry and Lindsay (2013) identify topics that require further research as the integration of automated and manual count programs; the choice of counting locations across regions and within municipalities;

and the development and application of adjustment factors for extrapolating short-duration counts to annual totals.

2.1.4 Data Expansion Methods

- The Manual of Transportation Engineering Studies (2000) provides an expansion model developed for the Federal Highway Administration (FHWA) to extrapolate short term counts of 5-, 10-, 15-, or 30-minute to 1-, 2-, 3-, or 4-hour time periods. The count intervals are to be done in the middle of the selected time period with 15- and 60-minute counts being the most typical. The model is as follows:

$$Volume = a * count * \ b$$

  Where ‘a’ and ‘b’ are derived parameters and are selected based on the count interval and time period. The range of values with which the actual volumes fall may be determined using provided factors presented in the manual.

  The method does not provide expansion factors for longer than 4-hour time periods and has a relatively low level of accuracy. However it is adequate to determine proper pedestrian control or accommodation.

- Zegeer et al. (2002) conducted a collision analysis on marked and unmarked crosswalks in 30 cities across the U.S. For this, pedestrian volumes were estimated by expanding one hour pedestrian counts using adjustment factors. The counts were conducted in 15-minute intervals for a total of 1-hour at each site. The hourly adjustment factors were estimated based on the hourly pedestrian activity patterns obtained from continuous 8- to 12-hour pedestrian counts at 22 comparison crosswalks considering the findings from Zegeer et al. (1985) that determined 86 percent of the daily pedestrian volume in Seattle, WA is represented by the 12 hours of 7 a.m. to 7 p.m. Hourly adjustment factors were determined for the three land use types of central business district (CBD), fringe, and residential. To obtain the 24-hour daily pedestrian volume for a certain land use type, the one hour pedestrian counts are divided by the designated hourly adjustment factor.

- Desyllas et al. (2003) conducted counts similar to the method of Behnam et al. (1977) to develop a pedestrian demand model for Central London. Counts were conducted by sampling 5-minute counts per hour on the midpoint of specified St segments. The counts were then multiplied by 12 to obtain hourly pedestrian volumes.

- Lindsey and Lindsey (2004) develop expansion equations for predicting pedestrian volumes along the Indiana trail system, consisting of the Monon trail and the White River trail, based on 166 hours of data collection. The accuracy of this model is compared to the accuracy of a Davis et al. (1991) model for crosswalk volumes. Counts were conducted at four locations on the Monon Trail and two locations on the White River Trail on three weekdays from 7 a.m. to 7 p.m.. The data was collected in continuous 5-minute intervals and were later grouped to develop models for 10-, 15-, and 30-minute intervals. The regression equations, called the Greenway equations, were developed for the first, middle, last, and random 5-, 10-, 15-, and 30-minute time intervals in the hour using only the Monon Trail data. The following general equation is developed where x is the sample count, y is the expanded volume, and m and b are constants:

$$y = (x * m)e^{b}$$

The highest accuracy of volume expansion based on the R squared value was obtained from the 30-minute count interval. In addition, it was found that the 30-minute interval counts can simply be doubled to obtain the hourly volume for quick and reasonably accurate volume estimation. However, conducting 5-minute counts is the most cost effective and is also acceptably accurate, with the second mid 5-minute count of the hour (30^{th} to 35^{th} minute) yielding the best fit. The higher accuracy of the model developed by the counts conducted at mid hour is only associated with the 5-minute interval counts and are not a general rule. For instance, among the 15-minute interval counts, the last 15 minutes provide the best fit.

The developed Greenway equation as well as the Davis et al. equation was validated using the independent count data obtained from the White River Trail based on the estimated mean hourly percent error and total percent error. It was found that both equations provide reasonably accurate total traffic predictions when compared to the White River trail's actual pedestrian flow values; however they resulted in high mean hourly percent errors. Therefore, the values could potentially be unreliable for applications requiring accurate hourly pedestrian volumes. It was also noticed that the Davis et al. equation had a larger range of mean hourly error when applied to the trails relative to crosswalks. This indicates differences in the pattern of use of different types of infrastructure since the Davis et al. equation was developed for crosswalks.

Infrared counters had also been installed on the Monon Trail to test their accuracy compared to the manual and predicted counts. It was found that the Davis et al. equation performed better than the adjusted infrared counts for longer sampling intervals of 10, 15, and 30 minutes.

- Alta Planning and Design and the ITE Pedestrian and Bicycle Council (2009) completed the National Bicycle and Pedestrian Documentation Project. The project developed a set of expansion factors based on observations of temporal variations of pedestrian flows throughout the United States at pedestrian paths and higher density pedestrian areas. The expansion factors allow the extrapolation of two hour counts to daily, weekly, monthly, and annual activity estimates. The project documentation does not provide information about the magnitude of the source data underlying the development of the expansion factors except to say that although more data is needed for improvements, there is presently enough information to develop the expansion factors.

- Aultman-Hall et al. (2009) obtained one year of continuous automatic pedestrian count data in downtown Montpelier, Vermont, and found consistent temporal patterns, suggesting that adjustment factors for short term counts can be developed.

- Hudson, Qu, and Turner (2010) analyzed survey responses from 11 U.S. communities. They found that six of the 11 jurisdictions use portable or permanent automatic counters for pedestrian and bicycle data. The most notable uses of permanent counters were found in Minneapolis/St-Paul where 41 were in place, and in San Francisco, where 22 were being installed. Overall, they commented that a small number of jurisdictions are using data to understand temporal variations in pedestrian volumes.

- Hankey et al. (2014) used TrailMaster counters with active infrared technology to collect continuous non-motorized traffic data for a complete year in 2011 at six locations on off-street trails in Minneapolis, MN. The purpose of the research was to determine the error associated with day-of-year scaling factors compared to standard factors for estimating AADT. The authors found that use of day-of-year scaling factors result in less error, extrapolation error decreases when the length of short-duration count increases (with only marginal gains beyond a one week duration), extrapolation error is lowest when short-duration counts are taken during peak-traffic volumes, and sampling on non-consecutive days does not result in better AADT estimation than sampling on consecutive days.

- NCHRP report 797 (Ryus, et al., 2014) indicate that expansion factors for non-motorized traffic can be applied to sites sharing the same activity profile. Expansion factors can be developed to adjust non-motorize counts for variance associated with temporal, environmental, and land-use characteristics.

2.1.5 Pedestrian Trip Patterns

To properly develop a pedestrian traffic expansion factors it is essential to understand where pedestrians make trips, and how pedestrians choose their trip path.

2.1.5.1 Where pedestrians make trips

Identifying what factors attract or deter pedestrians from making trips will assist in defining pedestrian traffic pattern groups. The following reveals the pedestrian attraction factors that the literature identifies:

- Aultman-Hall et al. (2009) conclude from their study in downtown Montpelier, Vermont that precipitation reduces the average hourly pedestrian volume by 13 percent and in the winter months by 16 percent. A combination of weather variables (temperature, humidity, wind speed, and precipitation) were found to account for 30 percent of the hourly pedestrian volume variance at best. Individual weather events, such as cold temperate and precipitation, directly and consistently reduce pedestrian volumes by only 20 percent or less.

The research of Aultman-Hall et al. (2009) also found seasonal variations with peak activity in July at about 118 percent of the annual average and lowest activity in February at about 70 percent of the annual average. The time-of-day distribution at the site gradually builds to a peak at about 12 p.m. and then gradually drops back down to nearly zero at midnight. The day of week pattern consisted of weekday volumes approximately 20 percent higher than weekend volumes, and peak activity occurring on Fridays.

- Livi Smith (2009) characterized pedestrian traffic analysis zones as urban, suburban, or exurban using the built environment index (BEI). The BEI is composed of three domains; development intensity, motorized transportation, and pedestrian and bicycle infrastructure.

- Schneider et al. (2009a) propose three factors that affect pedestrian volumes at intersections; time-of-day and day-of-week, surrounding land use characteristics, and weather conditions. The intersections themselves are grouped into categories using stratification based on three variables: population density, median income, and proximity to commercial properties. Their research found that weekday volumes were about 20 percent higher than weekend volumes. During weekdays, between the hours 8 a.m. and 6 p.m., hourly pedestrian volumes generally ranged from .85 to 1.2 percent of weekly volumes, with a higher a.m. peak on Friday at about 1.3 percent of weekly volume.

- In the work of Miranda-Moreno & Fernandez (2011), pedestrian activity is modelled as a function of land use, density, transit supply, and road connectivity measures. More specifically they observed that commercial space, schools, population, bus stations, number of road segments and the number of four-way intersections all increase the surrounding pedestrian activity. In addition, factors such as large open space (excluding green space) and a large percentage of major arterials were found to decrease pedestrian activity. These factors represent the land use and urban form of the study area and once calibrated with automated counts, are used to predict pedestrian volumes at intersections. The study also showed that pedestrian activity is affected by weather conditions such as humidity and extreme temperatures.

2.1.5.2 How pedestrians choose their trip path

The walking network offers many different options for pedestrians in terms of path choice. This literature indicates how pedestrians choose their trip path:

- In Zacharias (2001) review of urban planning literature he states "The entry experience and the succession of environmental information and activities have a major role in determining the individual itinerary". He also identifies the topological description of a pathway system as contributing to 25 percent of pedestrian activity variance and that the ease in reading the city layout from the moving pedestrian perspective also affects variance.

- Daamen and Hoogendoorn (2003) found the following factors to affect pedestrian walking behaviour; distance to their destination, the personal attributes of the pedestrian, the trip purpose, familiarity with the route, the presence of recreational points of interest, and the environmental conditions.

- Muraleetharan & Hagiwara (2007) completed a stated preference survey to define a sidewalks LOS and identify its influence of pedestrian route choice behaviour in Japan. The attributes that affect the overall level of service (LOS) of sidewalks are: width of sidewalk and lateral separation, obstructions, pedestrian flow rate, and number of encounters with cyclists. The attributes that affect the overall LOS of crosswalks are: space at corner, crossing facilities, turning vehicles, and pedestrian delay. The research found that average overall LOS value of the route has a strong influence on a pedestrian's route choice behaviour. It also reveals that pedestrians do not always choose the routes with the shortest path over the routes whose walking conditions are better. Pedestrians will use links with low LOS when travelling short trip distances and prefer links with a high LOS when travelling longer distances.

2.2 JURISDICTIONAL SURVEY

This section presents the findings from the jurisdictional survey given to major cities in Canadian and the U.S. in June of 2012. The survey's design provides insight as to the current practice of North American cities in regards to pedestrian traffic collection. The survey targets major urban jurisdictions in Canada and only major urban U.S. jurisdictions that lead the way in regards to pedestrian research and innovation. Twenty three Canadian jurisdictions were contacted to represent the major urban centers of the country; 20 of the 23 Canadian jurisdictions responded. Eleven U.S. jurisdictions that have shown innovation in pedestrian traffic collection were contacted; six of the 11 U.S. jurisdictions responded.

2.2.1 Extent of Pedestrian Traffic Collection

For Canadian jurisdictions, 18 of the 20 respondents (90 percent) indicate that they collect pedestrian traffic data. The two jurisdictions that replied 'no' are the only jurisdictions surveyed with populations less than 100,000. Ten of the 18 jurisdictions that count pedestrian traffic specify having a standard pedestrian counting program. Five of the six U.S. jurisdictions indicate they use pedestrian data but only Tucson, Arizona has a pedestrian monitoring program.

2.2.2 Reasons to Collect Pedestrian Traffic Data

The most common reason Canadian jurisdictions collect pedestrian traffic data are for signal warrants (16 of 18). Baseline information and safety concerns are also common reasons for collecting pedestrian data with both being identified by 12 Canadian jurisdictions. Project Planning and Resource Allocation is the least sited use of pedestrian traffic data with only 5 of 18 indicating so. Table 2 illustrates the survey responses for both Canadian and U.S. jurisdictions.

Table 2: Question 3 Response Summary

What are the reasons for collecting pedestrian volume data?

	18 CND Jurisdictions		5 U.S. Jurisdictions	
Response	Total	Percent	Total	Percent
Signal Warrants	16	89%	2	40%
Baseline Information	12	67%	3	60%
Safety Concerns	12	67%	2	40%
Project Evaluation	8	44%	3	60%
Resource Allocation & Planning	5	28%	1	20%

Note: this question is multiple choice so percentages may not add to 100

2.2.3 Count Duration and Frequency

Almost half of Canadian jurisdictions that collect pedestrian data (8 of 18) do so for 8-hour count durations, shown in Table 3. Typically, 8-hour peak counts are composed of three counts that cover the a.m. peak, the mid-day peak, and the p.m. peak. Three Canadian jurisdictions indicate that their count durations are greater than 8 hours; Moncton uses Autoscope® video processing to collect 12-hour pedestrian traffic counts which are then expanded by factors to an annual average daily traffic (AADT), Edmonton deploys Mio-Vision cameras to obtain 48 hour counts, and Calgary uses two observers to manually collect 16 hour counts.

Table 3: Question 4 Response Summary

What are typical count durations?

	18 CND jurisdictions		5 U.S. jurisdictions	
Response	Total	Percent	Total	Percent
1-hour	2	11%	0	0%
2-hour	3	17%	3	60%
4-hour	4	22%	1	20%
6-hour	3	17%	0	0%
8-hour	9*	50%	0	0%
greater than 8-hour	3	17%	2	40%

* includes one 7-hour count.

Note: this question is multiple choice so percentages may not add to 100

Question 5 (Table 4) reveals the periods that jurisdictions repeat counts at locations. It can be seen that a majority of jurisdictions (78 percent) only collect pedestrian traffic data in an as needed basis. However, some jurisdictions (39 percent) collect pedestrian traffic data at specific sites annually or greater, a majority of which do so as part of vehicle intersection turning movement counts. London, Ontario is the only jurisdiction that collects hourly pedestrian data. They are using Eco-Counters to develop their own temporal adjustment factors for short term count expansion. Denver also uses Eco-Counters to collect hourly pedestrian traffic data and develop temporal adjustment factors.

Table 4: Question 5 Response Summary

How often do you collect pedestrian traffic data?

	18 CND jurisdictions		5 U.S. jurisdictions	
Response	Total	Percent	Total	Percent
Hourly	1	6%	1	20%
Seasonal	1	6%	0	0%
Annually and greater	7	39%	1	20%
As Needed	14	78%	3	60%

Note: this question is multiple choice so percentages may not add to 100

2.2.4 Selection of Counting Sites

Canadian respondents indicate, in Table 5, that pedestrian traffic counting sites are primarily selected to inform current projects and to satisfy requests or complaints. This is consistent with the large number of Canadian respondents who indicate they only collect data as needed. The lack of sites being selected by pedestrian count programs and screen line counts reveals the absence of a structured methodology for monitoring pedestrians.

Table 5: Question 6 Response Summary

How were the counting sites selected?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Project Driven	11	61%	2	40%
Requests / Complaints	8	44%	1	20%

Pedestrian Count Programs / Screen Line Counts	7	39%	3	60%
Part of a Vehicle TMC Program*	4	22%	0	0%

* TMC – Turning Movement Count
Note: this question is multiple choice so percentages may not add to 100

2.2.5 Use of APCs and Pedestrian Traffic Expansion Factors

Table 6 shows that one third of Canadian jurisdictions who collect pedestrian data use an APC. London uses Miovision for short-term counting and Eco-Counters passive infrared pyro counter to collect long-term data. The Miovision cameras are also deployed by Edmonton, Saint John, and Montreal. Vancouver, along with the U.S. jurisdictions of Denver and the University of Vermont also use Eco-Counters. The City of Moncton has an Autoscope video APC to collect pedestrian traffic data for 12 hour durations.

Table 6: Question 7 Response Summary

Do you use automated counting devices to count pedestrians?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Yes	6	33%	3*	60%
No	12	67%	2	40%
If yes, what Detectors do you use?				
Autoscope	1	17%	0	0%
Eco-counter	2	33%	2	40%
Miovision	4	67%	0	0%

* The City of Portland uses pedestrian push button data as an aggregate measure of volume
Note: this question is multiple choice so percentages may not add to 100

Table 7 reveals that three Canadian jurisdictions and one U.S. jurisdiction use factors to expand short term counts. Only Moncton uses expansion factors developed from annual pedestrian traffic data. The expansion factors used by the other jurisdictions are developed from manual counts.

Table 7: Question 8 Response Summary

Do you use temporal adjustment factors to expand short term counts?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Yes	3	17%	1	20%
No	15	83%	4	80%

2.2.6 Other Pedestrian Data Collected

The survey reveals in Table 8 that few jurisdictions collect pedestrian data beyond count data. This is to be expected as most pedestrian counts are conducted as a supplement to vehicle counts and the extra data requirement would be cumbersome for the observers resulting in a loss of count accuracy

Table 8: Question 9 Response Summary

What other pedestrian-related data do you collect on a regular basis?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Age	5	28%	0	0%
Turning Movements	4	22%	1	20%
Origin-Destination	3	17%	1	20%
Gender	2	11%	0	0%
Direction	1	6%	0	0%

Note: this question is multiple choice so percentages may not add to 100

2.2.7 Successes and Challenges with Pedestrian Counting

The growing interest in count data is sited as the greatest success realized in collecting pedestrian volume data for both Canadian and U.S. jurisdictions (50 percent and 80 percent respectively). Table 9 also shows that project evaluation was chosen by one third of the Canadian jurisdictions as a success from collecting pedestrian volume data.

Table 9: Question 10 Response Summary

What are some successes you have found in collecting pedestrian volume data?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Growing Interest in Count Data	9	50%	4	80%
Project Evaluation	6	33%	0	0%
Project Planning	4	22%	0	0%
Volunteer Participation	2	11%	1	20%

Note: this question is multiple choice so percentages may not add to 100

The greatest challenges outlined by both Canadian and U.S. respondents are the lack of equipment and the availability of accurate count data, shown in Table 10.

Table 10: Question 11 Response Summary

What are some challenges you have faced in collecting pedestrian volume data?

	18 CND jurisdictions		5 U.S. jurisdictions	
Responses	Total	Percent	Total	Percent
Lack of Equipment	5	28%	2	40%
Accurate Count Data	4	22%	3	60%
Lack of Persons to Count	3	17%	0	0%
Organizing and Training Personnel	2	11%	1	20%
Weather Conditions	2	11%	0	0%
Low Priority	2	11%	0	0%
Cost	2	11%	1	20%
Insufficient Data	2	11%	1	20%

Note: this question is multiple choice so percentages may not add to 100

2.2.8 Issues with Implementing Pedestrian Counting Programs

The most common issue revealed across all jurisdictions was the lack of standard pedestrian monitoring guidance and analysis. Having staff who can handle pedestrian counting technology was another common issue identified by jurisdictions as well as the lack of such technologies. London, Ontario recognizes the camouflage of counting equipment as a fundamental issue in preventing vandalism. The survey also revealed the following indicators of pedestrian volume that must be accounted for; land-use, pedestrian facility geometry, and adjacent street type. Among others the City of Miami indicated that they have an issue with justifying the cost and subsequently where to acquire funding.

3 RESEARCH METHODOLOGY

This chapter discusses the methodology developed and applied in this research for data collection, Automated Pedestrian Counter (APC) calibration and the analysis of pedestrian traffic characteristics. The chapter presents the following; (1) selection of the counter technology and ultimately the APC used for data collection; (2) methods used in the selection of pedestrian counting sites to deploy APCs; (3) elements that form the data collection system; (4) the procedure used to validate the counters; and (5) the methodology applied to collect and process the pedestrian traffic data. Figure 1 illustrates the thesis methodology as a process.

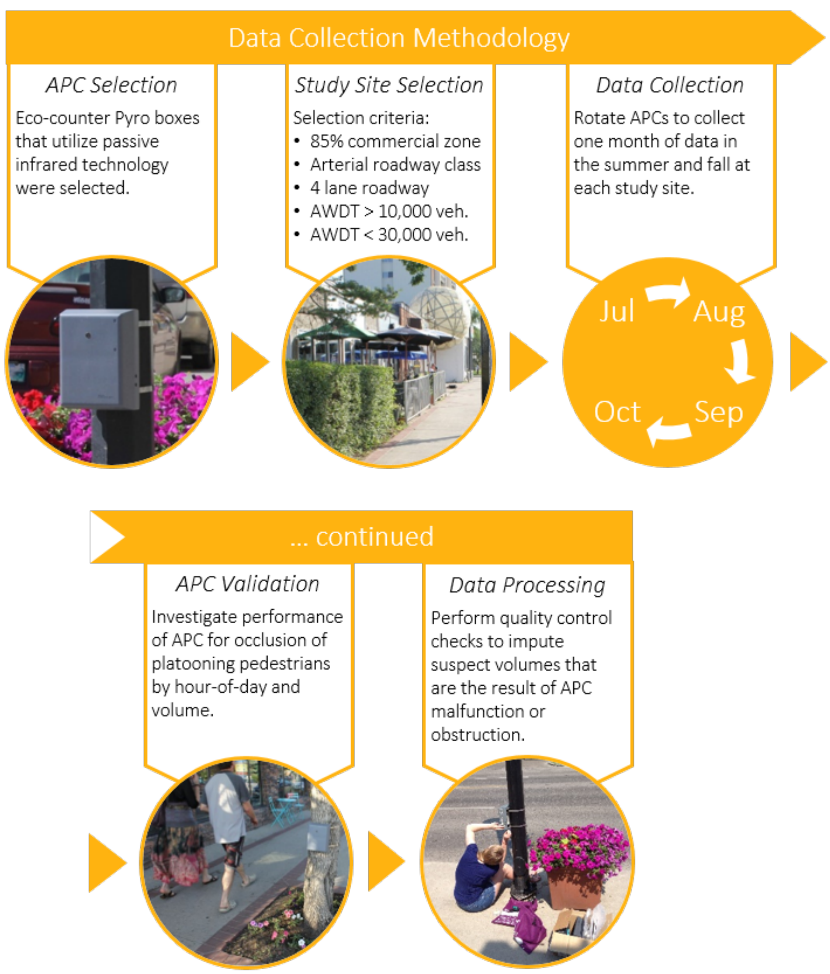

Figure 1: Thesis Methodology Process

3.1 SELECTION OF COUNTER FOR ANALYSIS

The technology of the APC used in this research was chosen after a comprehensive literature review followed by a comparison of leading providers and the subsequent selection of Eco-Counter's *Pyro Box Compact* sensor which uses passive infrared technologies.

3.1.1 Selection of APC Technology

Section 2.1.1 of the literature review contains an in-depth look at the technologies available for use as an APC.

Passive infrared detectors were selected for this research. This equipment can be readily converted to permit directional observation, can be installed at mid-block locations, and performs well in low light conditions. Video-based observation was rejected due to its high cost, poor low light performance, external power supply requirement, overhead installation, and its heavy dependence on computer programming. Piezoelectric counter pads, laser scanners and microwave detectors were also evaluated but not selected, based on cost and performance comparisons.

3.1.2 Selection of APC

Leading providers of these detectors have been identified through a comprehensive literature review, and through discussions with other researchers. The Eco-Counter PYRO sensor was chosen because of its ease of installation, data storage capabilities, increased mobility, wireless connectivity, and longer battery life. Calibration of this counter has been effective in other research (Greene-roesel, Diogenes, Ragland, & Lindau, 2008).

Figure 2: Eco Counter's Pyro Box Compact APC

The technical specifications of the Pyro Box Compact are given in Table 11. Six of these devices were rented from Eco-Counter for 4 months.

Table 11: Eco Counter's Pyro Box Compact Technical Specifications

Dimensions	23 x 10 x 18 cm (9 x 3.9 x 7 inch)
Weight	2.6 kg (5.9 lbs)
Battery Life	10 years
Operating Temperature	-40°C to 50°C (-40°F to 140°F)
Sensitivity	1°C difference between body and ambient temperature
Waterproof	IP 68
Data collection	GSM connection (Passive Remote)

3.2 SELECTION OF SITES FOR DATA COLLECTION

The urban context of this research is in Winnipeg Canada (Figure 3), a city with a population of 704,800 in 2012 as estimated by Statistics Canada (2013). Winnipeg's climate is characterised by long cold winters and short hot summers with average daily temperatures in the summer and fall of 20.2°C (68.4°F) and 4.1°C (39.4°F) respectively (Environment Canada, n.d.).

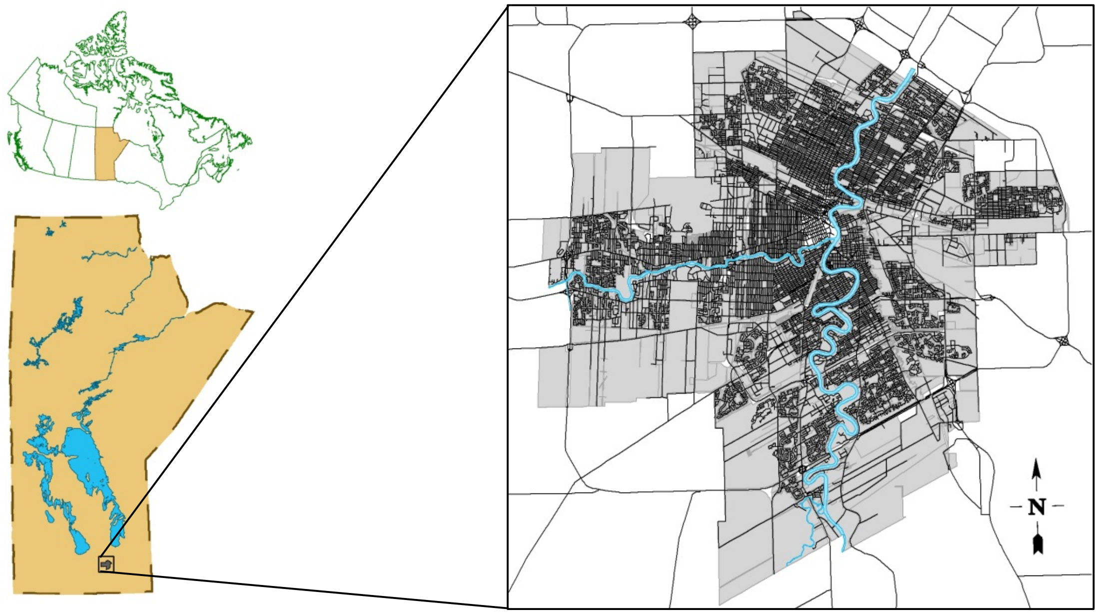

Figure 3: Winnipeg Manitoba, Canada: 2009 Winnipeg Regional Road Network

This research seeks to understand pedestrian traffic in commercial zones and therefore the study site selection criteria reflects this. The study site selection criteria attempts to normalize the pedestrian environment across study sites to enable accurate comparison between them.

Six different city blocks were selected for data collection which resulted in 12 counting locations as both sidewalks on either side of the roadway were counted. There is currently no comprehensive database of sidewalk characteristics available for use in this research so roadway and land-use characteristics were utilized to initially define the walking environment. The three roadway and one land-use characteristic criteria used to classify the sidewalk environments are as follows:

1. Roadways must be classified as a major or minor arterial.
2. Roadways must have 4 lanes (2 lanes each direction).
3. The average weekday daily traffic (AWDT) of roadways must be between 10,000 and 30,000 vehicles per day.

4. The surrounding land-use of the roadway segments must be classified as more than 85 percent commercial zoning districts.

GeoMedia software and a comprehensive GIS database of Winnipeg's regional roadways and land parcel zoning provided by the City of Winnipeg were used to identify roadway segments that meet the aforementioned criteria. Figure 3 shows Winnipeg's 2009 regional road network. The roadway network is composed of many small roadway segments defined by each sequential intersection.

Figure 4 provides an example of how the sites were selected. To start, Winnipeg's arterial roadways (major and minor) with an AWDT (average weekday traffic) between 10,000 and 30,000 vehicles per day and a total of 4 vehicle traffic lanes (2 lanes each direction) were identified (highlighted in green). Figure 4 indicates that the roadway segment of Corydon Ave between Wentworth St and Lilac St has passed the first three criteria outlined above. To determine the forth study site selection criteria, a 50-meter buffer zone was placed around each roadway segment that passed the first three criteria. The proportion of commercial land-use contained within the buffer zone was then divided by the area of all land parcels in the same buffer zone to determine the percent of commercial land-use surrounding the road segment. As seen in Figure 4, the buffer zone (indicated as a black rectangle) around the segment of Corydon Ave west of Lilac St does not contain greater than 85 percent commercial land-use therefore it is not highlighted in orange. The 50 meter buffer distance was used because it is the width of a typical land parcel in Winnipeg and would therefore adequately represent the streetscape of the sidewalk. In Figure 4, the two segments on Corydon Ave between Lilac St and Cockburn St are identified as candidate study sites.

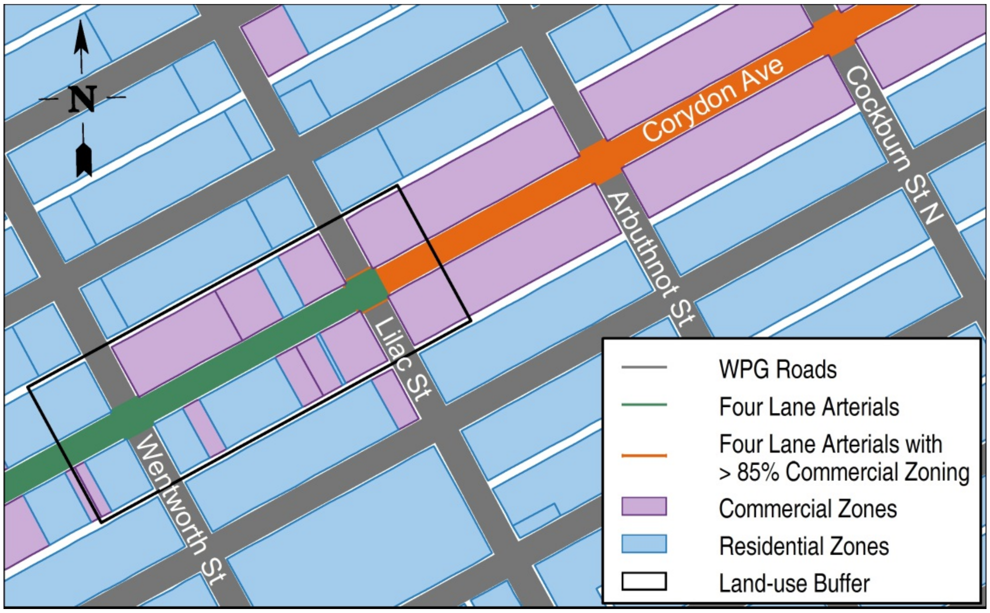

Figure 4: Site selection example

The candidate sites identified above were visually reviewed using Google street view to identify any commercial districts that have been abandoned or recently re-purposed. The ten most relevant roadway segments were then subject to a site visit to ensure that the pedestrian environments behave like commercial districts. Table 12 reveals the roadway characteristics of the six selected sites.

Table 12: Roadway Characteristics of Selected Study Sites

Study Sites	Functional Class	AWDT	Posted Speed [km/hr]	Segment Length [m]	Percent of Commercial Zone
Academy Rd east of Beaverbrook Ave	Minor Arterial	21700	50	138	92%
Corydon Ave east of Arbuthnot St	Major Arterial	14600	50	172	100%
Dakota St north of Meadowood Dr	Minor Arterial	25100	60	247	95%
Osborne St north of Rathgar Ave	Major Arterial	25700	50	65	95%
Roblin Blvd east of Hendon Ave	Major Arterial	16900	50	152	100%
St Anne's Rd north of Worthington Ave	Major Arterial	29800	60	152	89%

The location of the selected sites relative to Winnipeg can be seen in Figure 5. The sites are located in the south west part of the city. Other areas of the city were considered for this research but none of them passed the selection criteria. A more detailed view of each study site is provided in Figure 6.

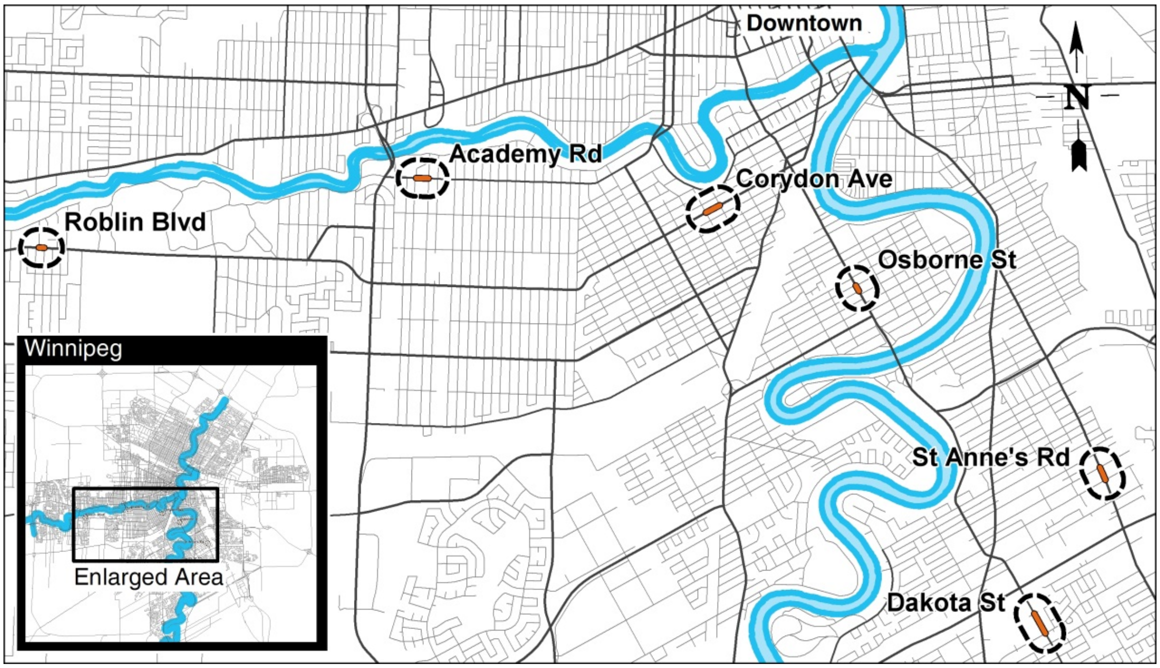

Figure 5: Location of Selected Sites in Winnipeg

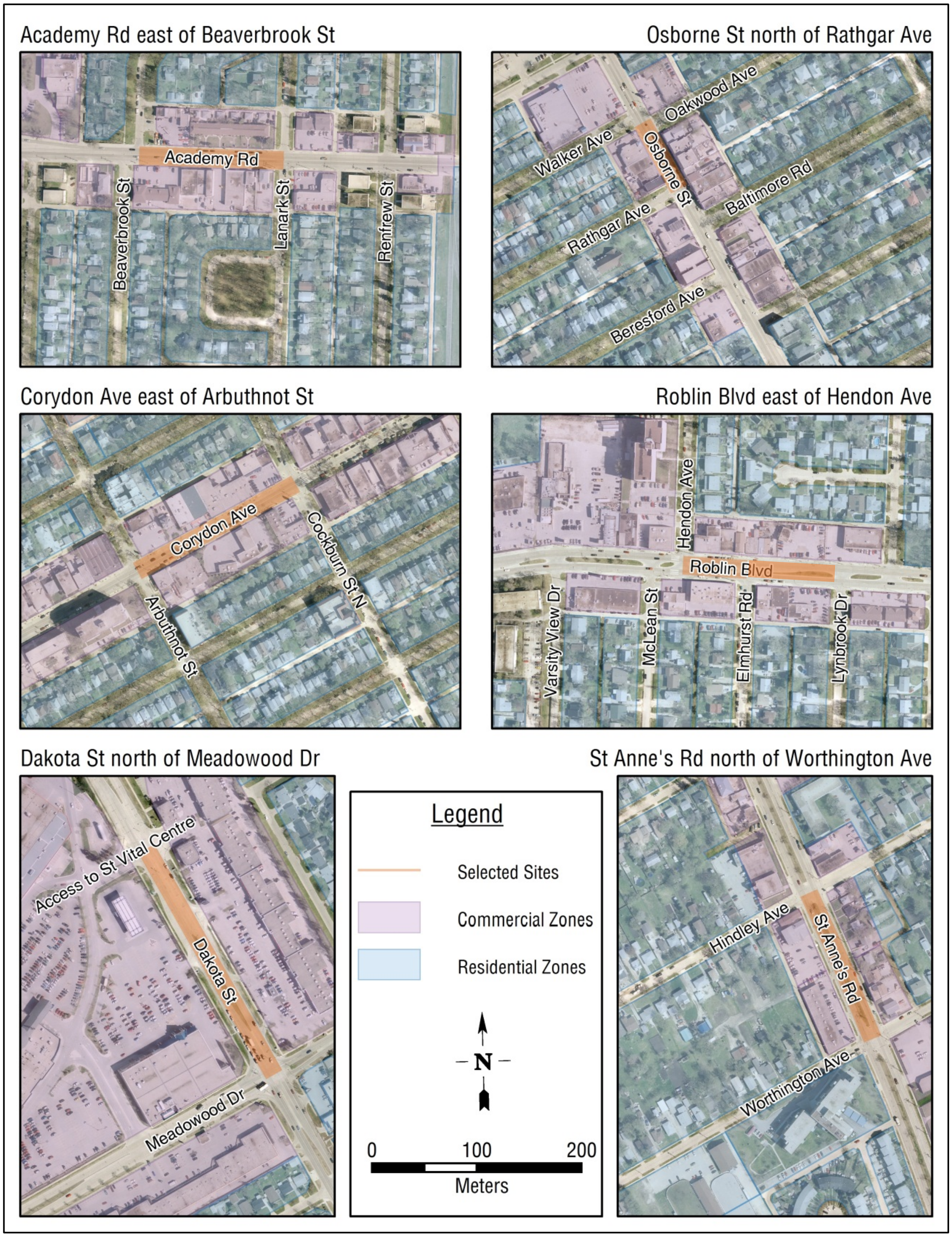

Figure 6: Aerial View of Selected Sites

3.3 DATA COLLECTION SYSTEM

It is essential that the data collection system of this research be reproducible to ensure that its contribution to knowledge is maximized. The data collection system comprises the field equipment setup, field data collection, and weather data collection.

3.3.1 Field Equipment Setup

The APCs were installed perpendicular to the sidewalk at a height between 75 cm and 100 cm above the ground as specified by the manufacturer and directed away from the vehicles on the roadway. The devices were attached by metal Band-it Scru-Seals® to any type of permanent sidewalk fixture like trees, parking poles, or street light standards. Sidewalk fixtures near the roadway curb are preferred to reduce the likelihood that pedestrians will by-pass the counter. It is crucial that the APCs are not directed towards building entrances or areas where pedestrians may loiter because a single pedestrian may be counted multiple times. The APC installed on the south sidewalk of Corydon Ave is an example of a properly installed APC and is shown in Figure 7.

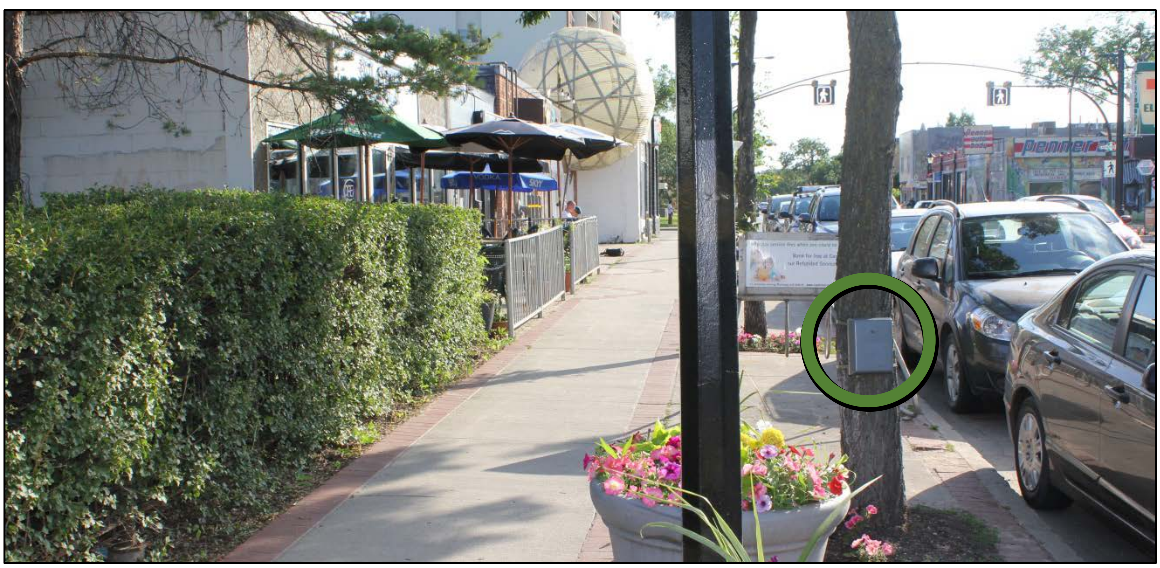

Figure 7: APC installed on the south sidewalk of Corydon Ave

The west sidewalk of Dakota St did not have any such fixtures so the APC was installed onto a permanent city waste bin. Two weeks into data collection the counter was removed by the advertising agency responsible for maintaining the disposal bins. Care should be taken to ensure all agencies that maintain city sidewalks are consulted prior to installation.

After installation, it is advised that APCs are calibrated as soon as possible because it is beneficial to observe each individual site over an entire day in order to adequately remark on the suitability of APC placement. In this research the location of the APC installed on the east sidewalk of Osborne St was found to be frequently disrupted by a shop keeper and people on smoke-breaks. The counter required an adjustment to obtain accurate pedestrian traffic data.

3.3.2 Field Data Collection

This research analyzed pedestrian traffic behaviour at 12 different study sites from six separate Winnipeg roadway segments over the summer (June to August) and fall (September to November) seasons in 2012. This research utilized six APCs to count 12 study sites in each season; as such they were rotated through the following rotation groups.

APC ID	Rotation Group 1	Rotation Group 2
3938	Academy North	Roblin North
3940	Academy South	Roblin South
1997	Corydon North	St Anne’s West
1537	Corydon South	St Anne’s East
1996	Osborne East	Dakota East
0869	Osborne West	Dakota West

The APCs were rotated through the two rotation groups approximately every month over the 4-month data collection period to minimize equipment costs and collect strong data. The monthly (4-week) rotation increased the probability that there was at least one full 24-hour count for each day-of-week in each month, as is required to produce an annual average daily traffic (AADT) by the Guidelines for Traffic Data Programs (AASHTO). The APCs were moved on three dates that corresponded to statutory holidays in Manitoba as holiday traffic data is unique and is not considered in this research. The rotation schedule was as follows:

Start Date	14-Jul	07-Aug	04-Sep	09-Oct
End Date	05-Aug	02-Sep	07-Oct	03-Nov
APC Group	1	2	1	2

The APCs used in this research have a Global System for Mobile (GSM) communication connection which enabled them to transfer data remotely via cellular network. At 03:00 every morning, the data was uploaded to Eco-Counters online software called Eco-Visio and could be accessed at any time. With daily data updates the software was able to alert the user if a count was unusual, based on user threshold inputs like minimum expected daily volume or minimum percent variation of daily volume.

Eco-Counter also provided a personal digital assistant (PDA) to manually retrieve the data from the counters in the event that the GSM connection failed. The PDA uses Bluetooth technology to connect to the APCs which requires the PDA to be in close proximity. When connected, the PDA reveals the real-time performance of the APC as shown in Figure 8. This is helpful when trying to decipher the source of false calls or other disturbances. It should also be noted that Laptops with Bluetooth capabilities can remotely connect with the APCs for real-time viewing of APC performance.

Figure 8: PDA showing real-time APC performance

The data can be viewed daily in the Eco-Visio software; Figure 9 shows one of the figures that can be queried to visually inspect APC performance. At the end of each month's rotation the data from each APC was exported to a comma separated values file (.csv) in fifteen minute intervals by direction.

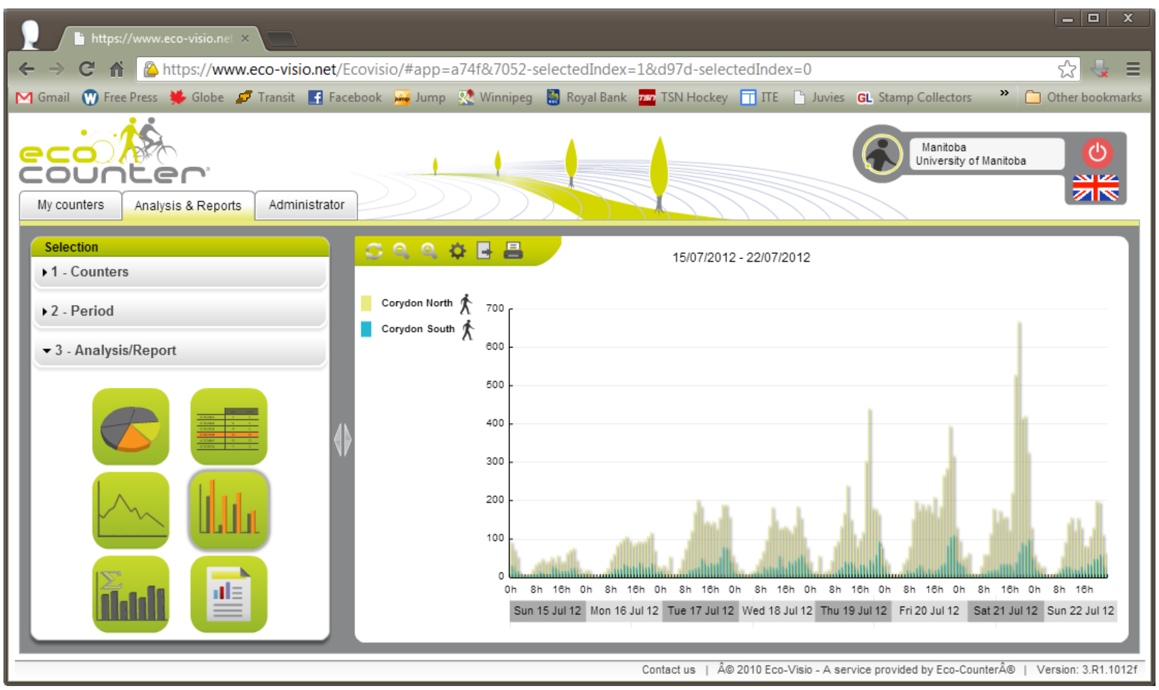

Figure 9: Analysis of APC Data by Hour from Eco-Visio software

3.3.3 Weather Data Collection

The *Traffic Monitoring Guide* indicates that weather can be a significant factor in pedestrian walking behaviour and thus should be recorded as part of a non-motorized traffic monitoring program (FHWA, 2013). This research represents the effects of weather by the number of hourly precipitation events in a day where an hourly precipitation event is an hour where the weather condition as reported by Environment Canada includes the words rain, drizzle, or snow. Winnipeg's hourly weather data was collected monthly from the Environment Canada website (http://www.weatheroffice.gc.ca) at their weather station located at the James Armstrong Richardson International Airport.

3.4 AUTOMATED PEDESTRIAN COUNTER VALIDATION

This research is concerned with pedestrian traffic periodicities (expressed as hourly proportions of daily volume) at each study site rather than pedestrian traffic volume; therefore, no calibration factors are developed to adjust these APC counts to relative volumes (e.g, AADT). However, if APC performance is affected by factors that vary throughout the day, like pedestrian volume, then the periodicities would need to be adjusted. Previous research has concluded that the APCs used in this research consistently undercount pedestrians regardless of the pedestrian volume (Greene-Roesel et al. (2008), Schneider et al. (2009b), and Aultman-Hall (2009)) and that undercounting is "most directly" related to the tendency of pedestrians to walk in platoons (close together) (Greene-roesel, Diogenes, Ragland, & Lindau, 2008). Previous research has quantified the performance of the same APCs used in this research:

> Greene-Roesel et al. (2008) collected manual, video/manual, and APC data on three consecutive days for four-hour periods (1200 to 1600) at three different sites (12 total hours counted). They found that Eco-Counter APCs under count

> pedestrians in a range from 9 to 19 percent. On average the undercounting was 13.2 percent with a SD of 0.14; the stability revealed through the SD indicates that calibration would be successful.
>
> Schneider et al. (2009a) indicate that APC counts used in their study were tested against manual counts from “several different time periods“ and reveal APC undercounting occurred between one and 20 percent. They conclude that there is no evidence that APC undercounting is related to pedestrian volume.
>
> Aultman-Hall et al. (2009) completed one six-hour manual comparison count on a single day and found that the APC undercounted by five percent.

Pedestrian platooning behaviour in Winnipeg may vary from those in the aforementioned studies. Therefore this research tested if the APCs consistently undercount pedestrians in Winnipeg. Manual review of video recordings were used as ground truth by Greene-roesel et al. (2008) but they concluded that “field observers are not necessarily less accurate than those obtained by manual review of video recordings”. Thus manual counts were used as the ground truth pedestrian volumes to validate the findings from this research.

One field observer conducted 4-hour manual counts at the two sidewalk study sites, located on Corydon Ave, over three consecutive days covering the 12-hour period from 08:00 to 16:00. The field observer positioned themselves to ensure a clear view of both APCs on either side of the roadway and counted combined (not directional) pedestrian volumes at each counter in 15-minute intervals. Table 13 indicates the date, time, and count statistics when manual pedestrian data was collected.

Table 13: APC manual validation count periods

Date	Start Time	End Time	Volume (ped)	Period (hrs)	Flow (ped/hr)
North Corydon Ave sidewalk east of Arbuthnot St					
Tuesday, 25-Sep, 2012	08:00	13:00	243	4.5*	54
Wednesday, 26-Sep, 2012	13:00	17:00	332	4	83
Thursday, 27-Sep, 2012	17:00	20:00	320	3	107
South Corydon Ave sidewalk east of Arbuthnot St					
Tuesday, 25-Sep, 2012	08:00	13:00	94	4.5*	21
Wednesday, 26-Sep, 2012	13:00	17:00	105	4	26
Thursday, 27-Sep, 2012	17:00	20:00	109	3	36

* one half-hour period starting at 10:00 was missed

The sidewalks at Corydon Ave were selected for the APC validation process because the North sidewalk (Cor_N) had the highest hourly volumes, while the South sidewalk (Cor_S) provided representation of low-volume APC performance. Hourly intervals, as opposed to fifteen-minute intervals, were used to produce strong results when computing relative error of the APC. The relative error between the manual count and the APC count was calculated by the following equation as is consistent with Greene-Roesel et al. (2008):

$$Relative\ Error\ = \frac{NP_{APC} - NP_{manual}}{NP_{manual}}$$

Where NP_x is the number of pedestrians counted per hour by either the manual counter or APC device as indicated. The relative errors between the APC and manual counting methods are given in Table 14. As expected, the APC systematically undercounted pedestrians when compared to manual counts. The relative hourly errors from the two Corydon Ave sidewalks range from -31 to 11 percent with a mean relative error of -12 percent and a standard deviation of 0.11. These relative errors are within the expected range of the aforementioned research. Both extreme ends of the range of relative errors occurred on the South sidewalk and may be explained by its small pedestrian volumes and thus volatile results. This effect can be seen clearly in the residual plot in Figure 10 (a) which shows high variability with the residuals at lower pedestrian volumes. The period from 10:00 to 11:00 was not counted because the field observer needed a restroom break.

Table 14: Relative error between APC and manual counting methods

	Start	End	Volume		Relative Error	
Date	Time	Time	Cor_N	Cor_S	Cor_N	Cor_S
Tuesday, 25-Sep, 2012	08:00	09:00	24	18	-4%	-6%
Tuesday, 25-Sep, 2012	09:00	10:00	28	26	-21%	-31%
Tuesday, 25-Sep, 2012	10:00	11:00	*Not Counted*			
Tuesday, 25-Sep, 2012	11:00	12:00	60	19	-18%	-16%
Tuesday, 25-Sep, 2012	12:00	13:00	109	29	-25%	-3%
Wednesday, 26-Sep, 2012	13:00	14:00	85	27	-16%	-4%
Wednesday, 26-Sep, 2012	14:00	15:00	91	17	1%	0%
Wednesday, 26-Sep, 2012	15:00	16:00	86	28	-20%	11%
Wednesday, 26-Sep, 2012	16:00	17:00	70	33	0%	-6%
Thursday, 27-Sep, 2012	17:00	18:00	91	22	-16%	-14%
Thursday, 27-Sep, 2012	18:00	19:00	99	39	-30%	-26%
Thursday, 27-Sep, 2012	19:00	20:00	130	48	-21%	-10%
		Total Error (over 12-hr period)			-15%	-9%

Additionally, the field observation identified a possible increase in pedestrian platooning by time-of-day due to a change in pedestrian activity. For example, pedestrians may be more likely to travel in groups when they are headed to a restaurant in the evening as opposed to when they are travelling to work in the morning. The residual plot in Figure 10 (b) reveals a weak correlation ($R^2 = 0.002$) between hourly relative error and time-of-day which indicates that counter performance is not influenced by time-of-day.

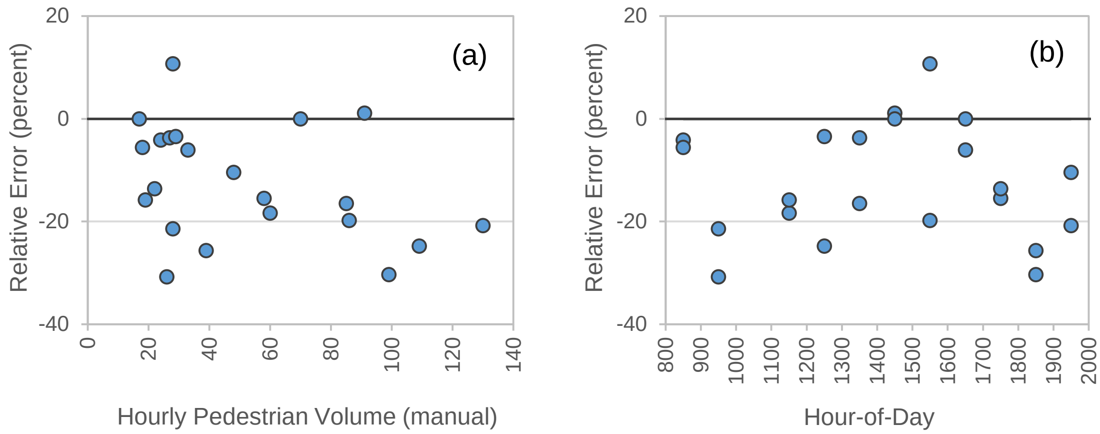

Figure 10: Residual plot: Relative error by
(a) hourly pedestrian volume (manual), and
(b) hour-of-day

Most importantly, the low correlation of both residual plots shown in Figure 10 ($R_a^2 = 0.131, R_b^2 = 0.002$) indicates that neither pedestrian volume nor time-of-day affect counter performance. In other words, the results indicate that the APCs undercount pedestrians but this doesn't affect factors because undercounting is independent of pedestrian volume and hour-of-day. This verifies our ability to use data from the APCs to create expansion factors without having to first develop calibration factors for the APCs.

3.5 DATA PROCESSING

Before analysis, the data must be processed to ensure it truthfully represents the pedestrian activity at each study site. The processing of data includes the collection and organisation of raw data and quality control checks to remove any data anomalies that may misrepresent pedestrian activity.

3.5.1 Raw Data

Raw data from the APCs was downloaded as a comma separated values file (.csv) from on-line software provided by Eco-counter called Eco-visio (www.eco-visio.net) as mentioned in *Section 3.3.2 Field Data Collection*. The data was downloaded from all six counters in a single file at the end of each counter rotation and imported into Excel. The raw data (Table 15) includes the 15-minute time interval when the count was taken, the total combined count and both directional counts for each APC. The columns with location names indicate the total combined count at that location. The other columns indicate the assigned counter number and the direction of pedestrian travel as configured in the counter. For example, values under the *003_IN* column indicate the number of pedestrians heading eastbound ("IN" was configured to indicate pedestrian travel heading towards downtown) on the south sidewalk of Corydon Ave.

Table 15: Example of *Raw Count* database

Date	Corydon South	003_IN	003_OUT	Corydon North	001_IN	001_OUT
…	…	…	…	…	…	…
Tue 17 Jul 2012 12:00	8	2	6	54	22	32
Tue 17 Jul 2012 12:15	3	1	2	57	21	36
Tue 17 Jul 2012 12:30	5	1	4	41	17	24
Tue 17 Jul 2012 12:45	11	4	7	51	19	32
Tue 17 Jul 2012 13:00	10	1	9	50	15	35
Tue 17 Jul 2012 13:15	11	8	3	44	21	23
…	…	…	…	…	…	…

The raw fifteen-minute binned data was summed into hourly bins to form the *hourly count* database (Table 16). The directional information was used to help discern equipment malfunctions and is not kept in the hourly count database.

Table 16: Example of the *Hourly Count* database

Date information				Hourly ped volume	
Date	Day-of-Week		Hour	Corydon North	Corydon South
…	…	…	…	…	…
2012-07-17	wkday	Tue	12	203	27
2012-07-17	wkday	Tue	13	187	49
2012-07-17	wkday	Tue	14	143	35
2012-07-17	wkday	Tue	15	148	28
2012-07-17	wkday	Tue	16	139	38
2012-07-17	wkday	Tue	17	146	33
…	…	…	…	…	…

3.5.2 Data Quality Control

The quality control process involves the review of raw data to ensure it accurately represents the pedestrian activity of its specific location. The *Traffic Monitoring Guide* (FHWA, 2013, pp. 3-6) indicates that quality control procedures should be formalized to ensure truth-in-data. Data that was affected by an equipment malfunction or blockages was removed from further analysis. All other atypical data was retained because this research seeks to define typical pedestrian traffic by testing the influence of factors on pedestrian traffic.

Every hourly volume at a study site was compared to the corresponding mean hourly volume for that specific hour-of-day, day-of-week, season, and study site (also referred to as the seasonal average hour-of-week traffic volume). Hourly volumes that were greater than or less than 20 percent different were flagged and subjected to a manual review that consisted of:

- consulting the raw data in 15-minute bins to see if there was a consistent change in volume over the hour or by direction. An abrupt change may indicate a counter malfunction or obstruction.
- checking if there was any inclement weather during the count period in question.
- Identifying events specific to commercial business on the sidewalk whose data is in question. For example, Roblyn St north would experience high volumes every Tuesday and Thursday evening from a local training gym and Osborne St east would experience peaks in the evening that coincided with the concert schedule of a near-by venue.

Atypical data that was the result of inclement weather or local events was not rejected. If atypical data was found to be the product of obstruction or APC data transfer error it was rejected and replaced with the corresponding mean hourly volumes. This method of replacing rejected data with its mean is consistent with recent research (Schneider (2009a)) and permits the calculation of hourly proportions. Only two percent of all data collected was rejected during this process (408 of 15,834 hourly volumes).

3.5.3 Hourly Proportion of Daily Pedestrian Traffic

Once the hourly pedestrian traffic volumes were verified through the quality control procedure, they were converted into an hourly proportion of daily pedestrian traffic to facilitate the comparison of pedestrian traffic periodicities across the study sites. This was achieved by dividing each hourly volume by the corresponding daily volume for each specific study site. The resulting hourly proportions were supplemented with weather data to form the *Hourly Proportion* database shown in Table 17. The summation of the 24 hourly proportions at a study site for any day will be 100 percent.

Table 17: Example of the *Hourly Proportion* database

Date information				Weather		Hourly proportion	
Date	Day-of-Week		Hour	Temp.	Condition	Corydon North	Corydon South
…	…	…	…	…	…	…	…
2012-07-17	wkday	Tue	12	12 °C	Mostly Cloudy	8.12	4.31
2012-07-17	wkday	Tue	13	13 °C	Mostly Cloudy	7.48	7.81
2012-07-17	wkday	Tue	14	14 °C	Mostly Cloudy	5.72	5.58
2012-07-17	wkday	Tue	15	15 °C	Mostly Cloudy	5.92	4.47
2012-07-17	wkday	Tue	16	16 °C	Mostly Cloudy	5.56	6.06
2012-07-17	wkday	Tue	17	17 °C	Mostly Cloudy	5.84	5.26
2012-07-17	wkday	Tue	18	18 °C	Mostly Cloudy	5.16	5.90
…	…	…	…	…	…	…	…

4 DATA ANALYSIS

This chapter presents the results of the analysis of the effect of temporal and spatial factors on hourly pedestrian traffic. Temporal factors influence pedestrian travel at a study site level and include day-of-week, number of hourly precipitation events per day, and seasonality (summer versus fall). Spatial factors include adjacent sidewalk behavior on either side of the roadway and pedestrian traffic in commercial zones. Adjacent sidewalks refer to sidewalks that run parallel to each other on either side of the same roadway.

Hourly pedestrian traffic periodicities for the temporal factors were represented by a set of 24 mean hourly proportions of daily pedestrian traffic. The mean hourly proportions of a temporal factor for each of the 18 daytime hours between 06:00 and 24:00 were statistically tested for significant differences using either the analysis of variance (ANOVA) test for comparing more than two factors or Student's T-test for comparing two factors.

Once the influence of temporal factors were normalized the resulting mean hourly proportions for each site were tested against each other to determine the actual influence of spatial factors on pedestrian traffic.

Figure 11 illustrates the analysis process which involves testing the temporal factors to determine days that represent typical pedestrian traffic for further analysis and testing the resulting mean hourly proportions from each site to determine hours with significant differences between spatial influencing factors that affect pedestrian traffic.

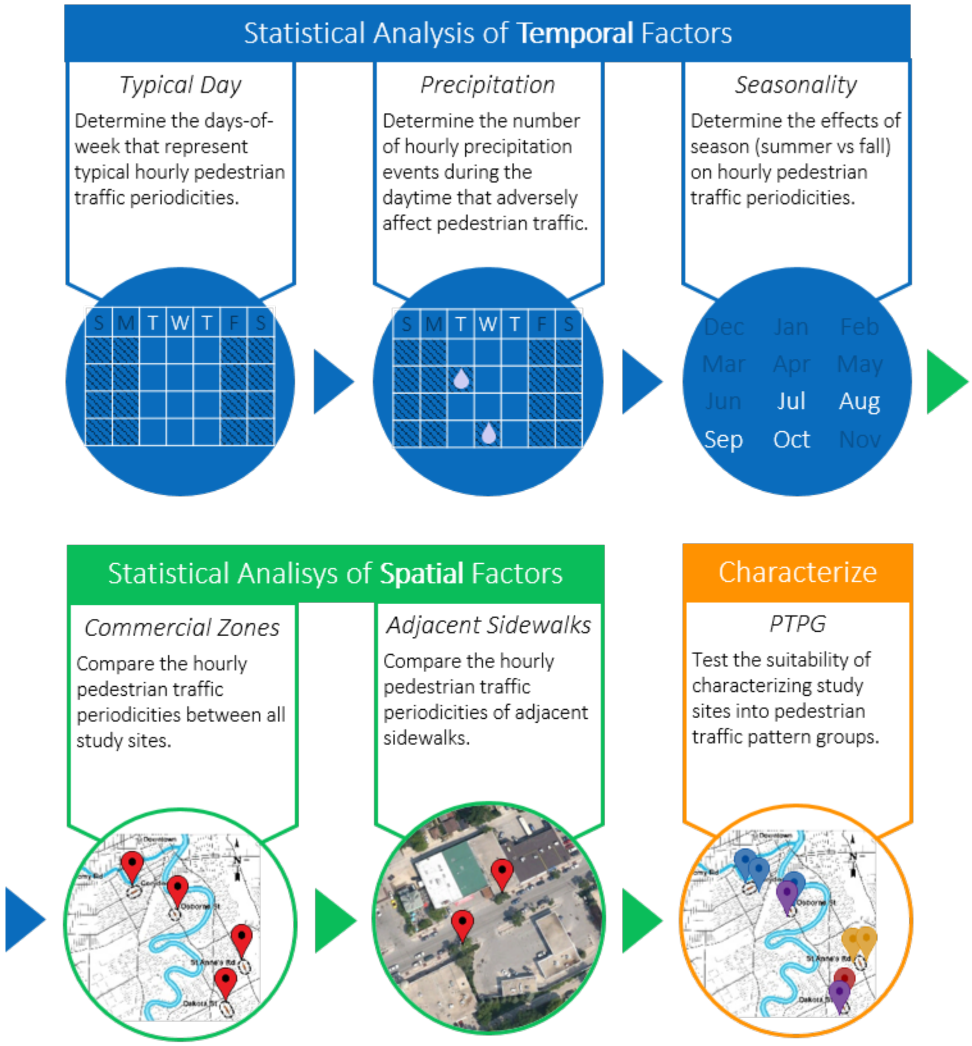

Figure 11: Thesis Analysis Process Schematic

4.1 TEMPORAL FACTORS

The mean hourly proportions of daily pedestrian traffic volumes at each study site should represent typical or average volumes to normalize (or minimize) variability to enable accurate comparison between spatially different study sites. Specifically, temporal factors define what days of the week represent typical hourly pedestrian traffic periodicities, what precipitation conditions have minimal effect on pedestrian traffic, and whether or not seasons affect pedestrian traffic differently. The north sidewalk on Corydon Ave (APC ID: Cor_N) is used to illustrate how typical pedestrian traffic was determined for all study sites. The hourly pedestrian traffic proportions from Cor_N are shown in Figure 12 and grouped by season into summer and fall where *n* indicates the respective sample sizes. This figure gives an indication of the high variability that is characteristic of pedestrian traffic.

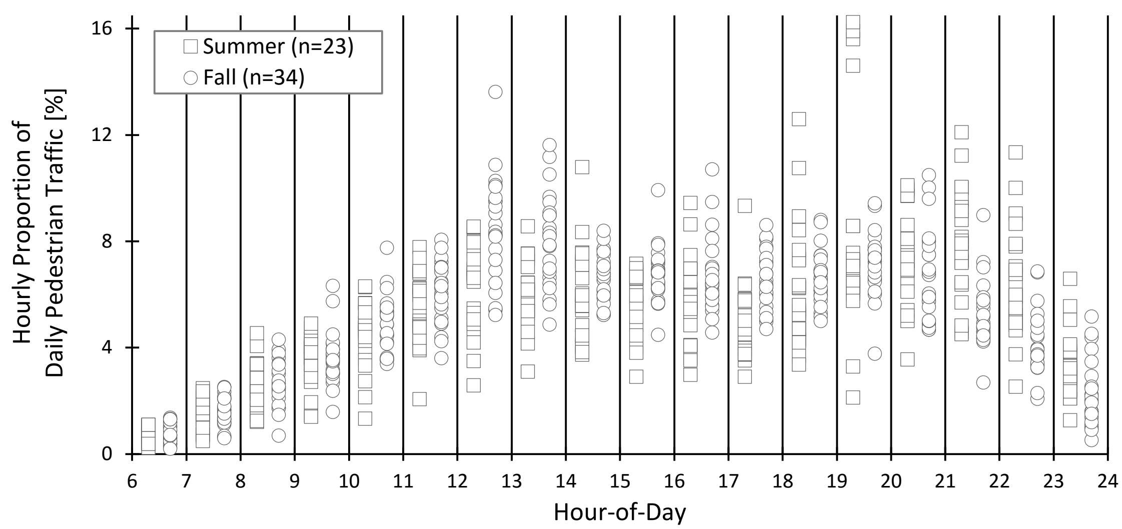

Figure 12: Hourly Proportions of Daily Pedestrian Traffic at Cor_N
Note: *n* indicates the number of days sampled from 57 days of data.

4.1.1 Typical Day Condition

Limiting short-duration counts to typical days reduces the variability of traffic volumes. For each study site, this improves the accuracy of annual traffic volume factoring, spatial comparisons between different study sites, and temporal comparisons between different time periods at the same study site. In general, short-duration *vehicle* traffic counts are completed between Tuesday and Thursday because these days have been found to represent a typical day of vehicular traffic. The literature review indicated that pedestrian traffic also varies by day-of-week but no studies have been completed in Winnipeg to determine what days-of-week represent typical pedestrian traffic. This research tested the following five typical day conditions for the summer and fall seasons combined:

D1. Monday – Sunday (assumes no effect from day-of-week)

D2. Monday – Friday (excludes weekend days)

D3. Monday – Thursday (excludes weekends and 1 weekday at end of week)

D4. Monday – Wednesday (excludes weekends and 2 weekdays at end of week)

D5. Tuesday – Thursday (common practice for vehicular data collection)

The typical day conditions were selected based on a visual inspection of the average hourly proportion distributions for all days-of-the-week at each study site. The hourly proportion distribution for each day-of-the-week at Cor_N for summer and fall combined are shown in Figure 13.

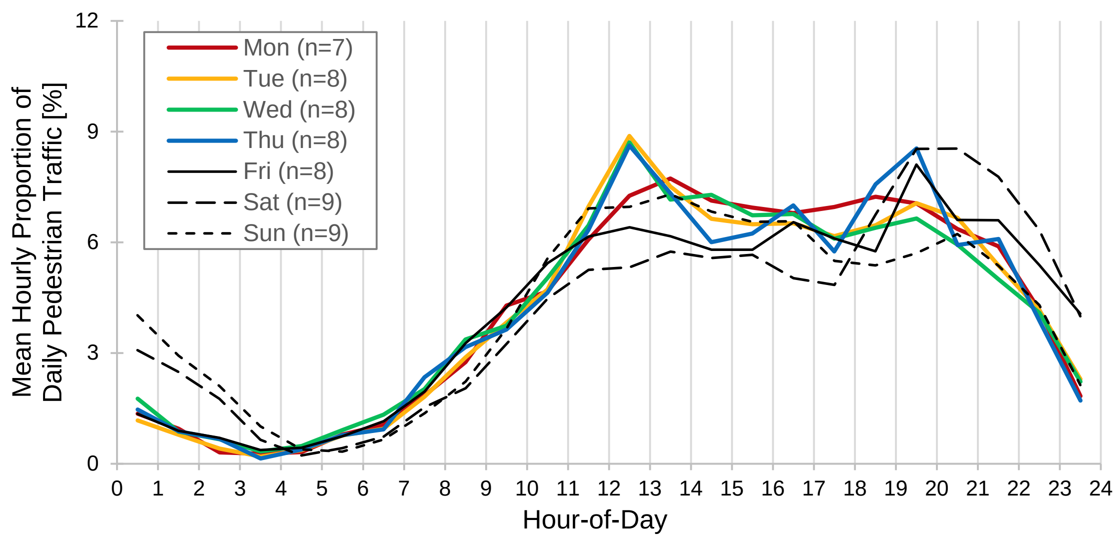

Figure 13: Mean Hourly Proportion of Pedestrian Traffic at Cor_N by Day-of-Week

Note: *n* indicates the number of days sampled from 57 days of data.

Figure 13 illustrates that pedestrian traffic on Thursdays follows a similar early evening peak (19:00) as Friday which indicates typical days of vehicle traffic (Tue-Thu) may not represent typical days of pedestrian traffic.

Figure 14 provides a detailed view of the data that comprises the mean hourly proportion at 12:00 for each day-of-week. Monday exhibits the least variance of data (tightest data distribution) around its mean while Thursday has the largest variance around its mean. Tuesday, Wednesday, and Thursday have the least variance between their mean hourly proportions (shown as blue diamonds). These two sources of variance can be described as the variance within groups (e.g., the variance within Tuesday) and the variance between groups where the groups are the days-of-week (e.g., the variance between Tuesday and Wednesday). To discern which typical day condition best represents typical pedestrian traffic the ANOVA (analysis of variance) test was used to quantify these two sources of variance and test for statistically significant differences between their means. The ANOVA test was completed at every site for the typical day conditions and each hour in an 18-hour period between 06:00 and 24:00 inclusive. The six-hour time period occurring over night between 00:00 and 06:00 was not used in this analysis because the pedestrian volumes approach zero.

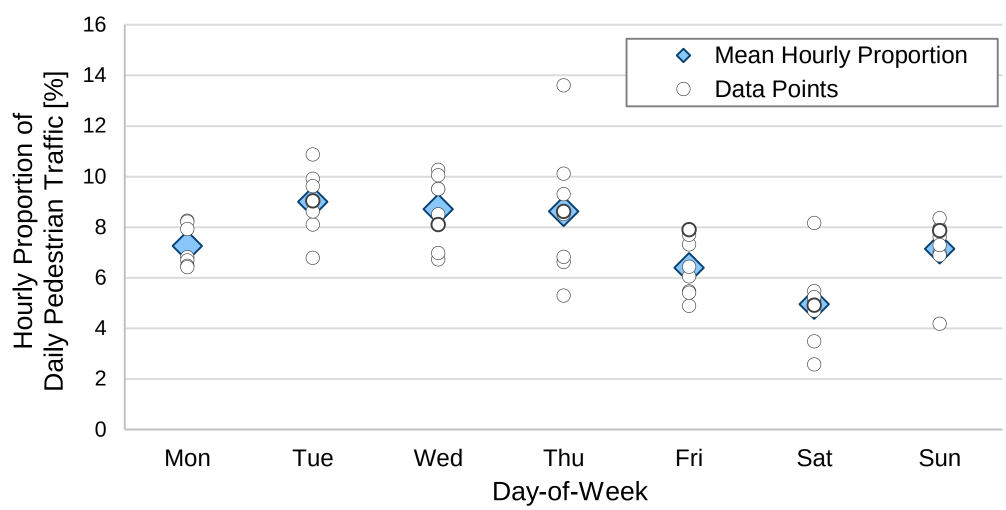

Figure 14: Hourly & Mean Hourly Proportion of Pedestrian Traffic at 12:00 on Cor_N

The ANOVA test is used to reject the null hypothesis (H_o) that any difference between multiple group means is due to chance. This is achieved by comparing a measure of the variance *within* the groups to a measure of the variance *between* groups. The variance within groups is represented by the mean square of the sum of squares also known as the mean square within groups (MS_W) calculated as follows:

$$MS_W = \frac{SS_W}{df_W} = \frac{\sum_j \sum_i \left(x_{ij} - \bar{x}_j\right)^2}{(n-k)}$$

Where;

SS_W = sum of squares within day-of-week groups

x_{ij} = the hourly proportion of data point i in day-of-week group j

$\bar{x}_j$ = the mean hourly proportion of day-of-week group j

df_W = degrees of freedom within day-of-week groups

n = total number of data points in all day-of-week groups

k = number of day-of-week groups

The hourly proportion data and resulting SS_W for Cor_N at 12:00 is provided in Table 18. The MS_W is found by dividing the SS_W by the df_W as follows, MS_W = 112.8 / 48 = 2.4.

Table 18: Hourly Proportion Data and SS_W for Cor_N at 12:00

Day-of-week group (j)	Hourly Proportion Data Points (i) 1	2	3	4	5	6	7	8	Mean ($\bar{x}$)	Sum of Squares (SS)
Mon	6.8	6.7	6.5	8.3	8.2	6.4	7.9		7.3	4.2
Tue	8.1	9.9	6.8	8.6	9.1	10.9	9.6	9.1	9.0	10.6
Wed	8.5	6.7	7.0	9.5	10.3	9.5	10.1	8.1	8.7	12.8
Thu	8.5	5.3	6.6	13.6	10.1	9.3	6.8	8.6	8.6	45.9
Fri	5.5	4.9	7.3	5.4	7.7	6.1	6.4	7.9	6.4	9.1
Sat	4.7	3.5	5.1	2.6	5.5	5.2	8.2	4.9	5.0	18.6
Sun	4.2	7.6	7.0	8.0	6.9	8.4	7.3	7.9	7.1	11.7
									SS_W	**112.8**

The variance between groups is represented by the mean square of the sum of squares of the group mean also known as the mean square between groups (MS_B) as follows:

$$MS_B = \frac{SS_B}{df_B} = \frac{\sum_j n_j(\bar{x}_j - \bar{x})^2}{(k-1)}$$

Where;

SS_B = sum of squares between day-of-week groups

$\bar{x}_j$ = the mean hourly proportion of day-of-week group j

$\bar{x}$ = the mean hourly proportion for the entire sample

df_B = degrees of freedom

k = number of day-of-week groups

The hourly proportion data and the resulting SS_B for typical day condition D1 at Cor_N at 12:00 is provided in Table 19. The MS_B is found by dividing the SS_B by the df_B as follows, MS_B = 102.6 / 6 = 17.1.

Table 19: Hourly Proportion Data and SS_B for Cor_N at 12:00

Day-of-week group (j)	Hourly Proportion Data (i) 1	2	3	4	5	6	7	8	Count	Mean ($\bar{x}$)	Sum of Squares (SS)
Mon	6.8	6.7	6.5	8.3	8.2	6.4	7.9		7	7.3	0.0
Tue	8.1	9.9	6.8	8.6	9.1	10.9	9.6	9.1	8	9.0	2.4
Wed	8.5	6.7	7.0	9.5	10.3	9.5	10.1	8.1	8	8.7	1.6
Thu	8.5	5.3	6.6	13.6	10.1	9.3	6.8	8.6	8	8.6	1.4
Fri	5.5	4.9	7.3	5.4	7.7	6.1	6.4	7.9	8	6.4	1.1
Sat	4.7	3.5	5.1	2.6	5.5	5.2	8.2	4.9	8	5.0	6.2
Sun	4.2	7.6	7.0	8.0	6.9	8.4	7.3	7.9	8	7.1	0.1
							Total Sample Mean	7.4		**SS_B**	**102.6**

MS_W is a measure of variability due to error and MS_B is a measure of MS_W plus group effects so if the MS_B is equal to the MS_W then there is no measurable group effects. Thus, any difference between the group means around the total mean can be considered error and the H_o holds true that any difference between multiple group means is due to chance. The F-test was used to determine the probability that rejecting the H_o was valid. For ANOVA testing, the F-value is the ratio of the MS_B over the MS_W (e.g., the F-value for Cor_N at 12:00 is 17.1 / 2.4 = 7.3). The F-value, as well as the degree of freedom for both variances (df_W and df_B) was used to find the corresponding probability value (p-value) from the F distribution table. In this example the p-value is 0.00001, which is less than our critical p-value of 0.1 (10%), so the H_o can be rejected. Therefore, at Cor_N the variance between the mean hourly proportions for the days-of-week in typical day condition D1 at 12:00 are not due to chance and there is 90% confidence that they are significantly different.

The p-values that result from the ANOVA test for Cor_N are presented in Table 20, where p-values that represent a significantly different mean hourly proportion (i.e., p-value < 0.1) are highlighted in red. The number of hours where H_o is rejected (i.e., significantly different mean hourly proportions) are used as a measure of variability of the five typical day conditions. Typical day condition D1 exhibits the most variability with 10 of the 16 mean hourly proportions being significantly different. Both condition D3 and D5 do not have any significantly different mean hourly proportions. The mean hourly proportions for 12:00 are significantly different for three of five typical day conditions.

Table 20: P-Value Results from ANOVA Testing at Cor_N

Typical Day Condition	Hour-of-Day 6	7	8	9	10	11	12	13	14	
D1	0.05	0.04	0.00	0.09	0.30	0.17	0.00	0.15	0.02	---
D2	0.44	0.58	0.55	0.48	0.54	0.51	0.01	0.53	0.06	---
D3	0.36	0.32	0.37	0.45	0.89	0.44	0.21	0.95	0.18	---
D4	0.38	0.56	0.19	0.38	0.79	0.34	0.02	0.84	0.58	---
D5	0.21	0.30	0.50	0.89	0.78	0.40	0.91	0.94	0.16	---

Typical Day Condition	Hour-of-Day (continued) 15	16	17	18	19	20	21	22	23	**Number of Rejected H_o**
D1	0.15	0.38	0.12	0.18	0.19	0.02	0.07	0.08	0.00	**10**
D2	0.28	0.96	0.48	0.17	0.46	0.84	0.57	0.47	0.00	**3**
D3	0.64	0.94	0.27	0.37	0.19	0.75	0.69	0.98	0.51	**0**
D4	0.64	0.83	0.18	0.40	0.70	0.69	0.70	0.99	0.55	**1**
D5	0.61	0.86	0.76	0.28	0.16	0.51	0.53	0.93	0.35	**0**

Significantly different means do not necessarily indicate that the compared means have more variability. They indicate that the means of the data groups are not sampled from the same population of data. Therefore, using typical day conditions that are composed of significantly different mean hourly proportions will introduce error into the base data that may be further amplified through the factoring process. The typical day condition with the least amount of significantly different mean hourly proportions will result in factored pedestrian traffic statistics with the least variability. The mean hourly proportions were tested for significant differences for every typical day condition, at each site, and hour between 06:00 and 24:00. The results for each individual site can be found in Appendix A and are summarized in Table 21.

Table 21: Measure of Typical Day Condition Variability

Typical Day Condition	# of Significantly Different Mean Hourly Proportions
D1	80
D2	28
D3	14
D4	17
D5	8

Table 21 indicates that condition D1 has the largest amount of significantly different mean hourly proportions of all the typical day conditions with 80 of the 216 (12 study sites * 18 hours = 216) mean hourly proportions tested (37 percent). Conditions D5 has the least significantly different mean hourly proportions, with only eight (4 percent).

Typical day condition D5 (Tue-Thu) is carried forward throughout the research for the following reasons:

- it has the lowest amount of significantly different mean hourly proportions;
- counting from Tuesday to Thursday is consistent with existing vehicular practice so current counting procedures can remain unchanged; and
- effect of statutory holidays (mostly occurring on Monday and Friday) is minimized (jurisdictions are less likely to lose a day of data collection and pedestrian traffic variability incurred when expanding short-duration counts is less likely).

This method of analysis is a fusion of quantitative and qualitative methods to determine the influence of factors on hourly pedestrian traffic. The ANOVA test is a rigorous statistical tool used in this research to quantify the number of significantly different mean hourly proportions for the entire set of commercial zone study sites. However, the results of the test are interpreted qualitatively to determine the influence of each factor tested.

Cor_N is now composed of 24 data points that represent typical days of pedestrian traffic (Tuesday to Thursday).

4.1.2 Precipitation Conditions

Weather has been found to have an adverse effect on pedestrian traffic volume (Aultman-Hall, Lane, & Lambert, 2009). This research defines weather by the amount of hourly precipitation events in a given day using hourly weather data from Environment Canada. The Environment Canada weather data provide the hourly weather condition in text format, however, it does not provide the actual amount of hourly precipitation. A precipitation event is defined as any weather condition with the key words rain, drizzle, or snow. The following precipitation conditions are tested:

P1. days that have *at least one* hourly precipitation event during daytime hours

P2. days that have *two or more* hourly precipitation events during daytime hours

P3. days that have *three or more* hourly precipitation events during daytime hours

P4. days that have *four or more* hourly precipitation events during daytime hours

The conditions are defined by an hourly threshold that results in an entire day being classified as an atypical day (i.e., wet). The hourly events cannot be removed individually because the hourly proportions are calculated from each of the 24 hourly volumes that make up a day (removing one hour from a day would skew the hourly proportions for the other 23 hours from that day). Therefore, the entire day must be rejected or maintained when testing the mean hourly proportions for each condition. Only daylight hours between 06:00 and 24:00 are tested because overnight hours between 00:00 and 06:00 have pedestrian volumes approaching zero. The precipitation conditions are tested under typical day condition D5 (Tuesday to Thursday) to highlight the effect of precipitation by minimizing the effect of atypical days.

In total, there were 10 weekdays with precipitation events at Cor_N for the summer (4 weekdays) and fall (6 weekdays) seasons. Four of these days had only one hour of precipitation, two days had five or more, and four days had between 2 and 4 hours of precipitation. One day had precipitation events during all daytime hours (18 hours between 06:00 and 24:00). Figure 15 provides a side-by-side comparison of the hourly proportions for dry days and wet days with one or more hours of precipitation events (P1). Most of the hourly proportions for dry and wet conditions have similar levels of variability. However, some hours (e.g., 09:00, 17:00, and 19:00) indicate that wet conditions have a more pronounced variability.

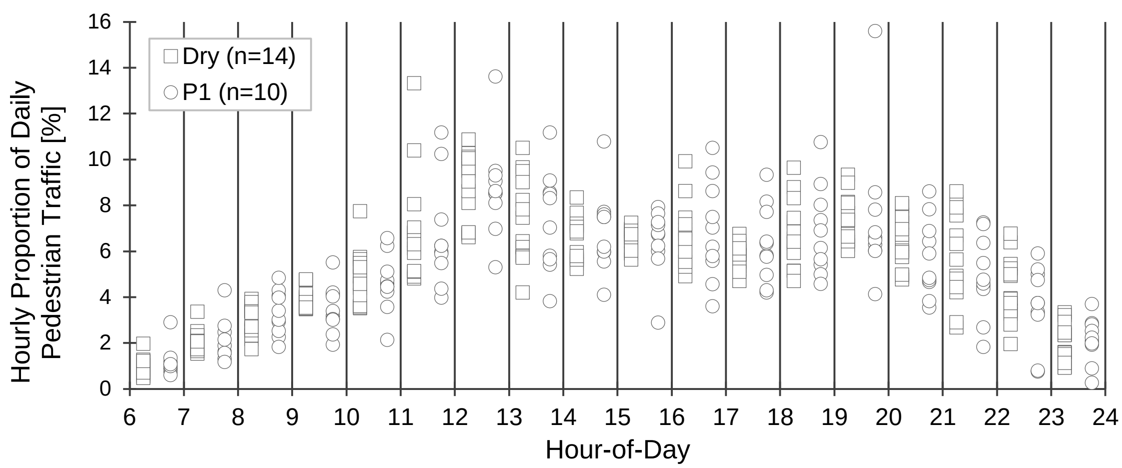

Figure 15: Dry vs Wet (P1) Hourly Proportions of Daily Pedestrian Traffic at Cor_N
Note: *n* indicates the number of days sampled from 24 typical days of data.

Student's T Test (T-Test) was used to determine if the mean hourly proportions for wet and dry conditions are significantly different. T-tests are similar to the ANOVA testing completed to determine the typical day condition, except they only test the null hypothesis (H_0) between two group means (wet versus dry) rather than multiple group means. The null hypothesis for this analysis is that the mean hourly proportion for wet conditions is the same for dry conditions. The T-test evaluates the null hypothesis (H_0) by comparing the t-score between two data groups with the critical t-score chosen based on the desired confidence level. The t-score is the ratio of the difference between the two group means over the variability of the difference determined by the following equation:

$$T = \frac{\bar{x} - \bar{y}}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where;

T = the t-score

$\bar{x}$ = the mean hourly proportion of sample 1

$\bar{y}$ = the mean hourly proportion of sample 2

S_p = the pooled standard deviation for both samples

n_1, n_2 = the number of data points for the indicated sample

The pooled standard deviation can be calculated as follows:

$$S_p = \sqrt{\frac{(n_1 - 1){S_1}^2 + (n_2 - 1){S_2}^2}{n_1 + n_2 - 2}}$$

The resulting t-score can be compared to the critical t-score (t-crit) to discern the probability that rejecting the H_o is valid. T-crit is selected from the t-distribution table by searching for the degrees of freedom (*df* = $n_1 + n_2 - 2$) and desired confidence ($\alpha = 0.1$ for 90 percent confidence). If the t-score is greater than t-crit then H_o is rejected at a 90 percent confidence. Similarly, if the p-value is less than 0.1 then then H_o is rejected at a 90 percent confidence. Table 22 shows the p-value results from completing the t-test for all precipitation conditions at Cor_N.

Table 22: P-Value Results from Precipitation Condition T-Test at Cor_N

Precipitation Condition	Hour-of-Day 6	7	8	9	10	11	12	13	14	
P1	0.42	0.89	0.35	0.24	0.54	0.80	0.96	0.98	0.50	---
P2	0.43	0.78	0.32	0.35	0.34	0.54	0.78	0.87	0.83	---
P3	0.45	0.64	0.47	0.53	0.61	0.59	0.83	0.64	0.93	---
P4	0.53	0.42	0.66	0.89	0.69	0.36	0.93	0.44	0.61	---

Precipitation Condition	Hour-of-Day (continued) 15	16	17	18	19	20	21	22	23	**Number of Rejected H_o**
P1	0.86	0.77	0.36	0.87	0.97	0.20	0.22	0.31	0.77	**0**
P2	0.04	0.44	0.23	0.86	0.37	0.16	0.10	0.06	0.73	**3**
P3	0.08	0.24	0.49	0.99	0.46	0.03	0.14	0.08	0.64	**3**
P4	0.04	0.11	0.80	0.70	0.52	0.08	0.18	0.03	0.67	**3**

In contrast to the typical day analysis, larger numbers of rejected H_o identify a larger difference between dry and wet conditions. The reason for this is that the conditions were developed to identify the greatest difference between dry and wet precipitation conditions. For Cor_N (Table 22), precipitation condition P1 does not produce any hours with a significant difference. This could be because one hourly precipitation event over the course of a day does not have a significant effect on pedestrian traffic. The remaining precipitation conditions (P2, P3, and P4) have three significantly different hours each.

The number of significantly different mean hourly proportions for each site and precipitation condition is provided in Table 23. Similar to the results from Cor_N, precipitation conditions P2, P3, and P4 produce the largest amount of significantly different mean hourly proportions. Condition P4 is preferred because it retains the largest number of dry days for further analysis. A precipitation condition for 5 or more events was not tested due to the increased volatility of a sample size of 2 wet days. The typical precipitation condition test results for each study site are provided in Appendix B.

Table 23: Measure of Precipitation Condition Variability

Typical Day Condition	Count of Dry Days	Count of Wet Days	# of Significantly Different Mean Hourly Proportions
P1	31	17	37
P2	35	13	48
P3	36	12	46
P4	37	11	46

Precipitation condition P4 (days that have four or more hourly precipitation events) is carried forward throughout the research for the following reasons:

- it retains the largest amount of days for further analysis; and
- it exhibits the second largest number of significantly different mean hourly proportions.

Cor_N is now composed of 21 data points that represent typical days (Tuesday to Thursday) and dry days (days with less than 4 hourly precipitation events).

4.1.3 Seasonality

Pedestrian hour-of-day periodicities may change by season due to a number of reasons such as a decrease in temperature, the start of school, or a change in seasonal activities such as tourism. If the hour-of-day periodicities change significantly, pedestrian expansion factors may need to be developed for multiple seasons or counts may have to be taken in specific seasons. This analysis determines if the mean hourly proportions at a site are significantly different between the summer and fall seasons. Figure 16 shows all the data points that make up the summer and fall hourly proportions for the Cor_N site. Compared to Figure 12 (page 58), the hourly proportions form tighter groups and approximately follow a bimodal distribution with the data peaking in the morning and later in the evening. This can be attributed to the removal of atypical days by applying the typical day condition (D5; Tuesday to Thursday) and the precipitation condition (P4; less than 4 hourly precipitation events a day).

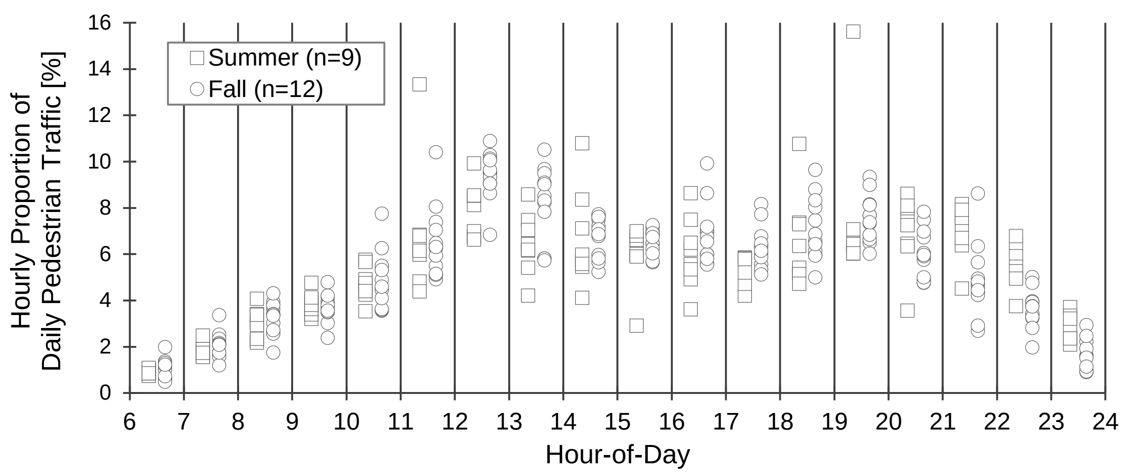

Figure 16: Hourly Proportions of Typical Daily Pedestrian Traffic at Cor_N

Note: *n* indicates the number of days sampled from 21 typical dry days.

The mean hourly proportions for the summer and fall seasons at Cor_N are provided in Figure 17. The summer and fall mean hourly proportions for each hour were compared using Student's T-test as outlined in *Section 4.1.2 Precipitation Conditions*. The hours where the mean hourly proportion between the two seasons is significantly different are shaded yellow. These discrepancies between summer and fall may be caused by the increase in late evening pedestrian traffic during the summer months. The lunch-period proportions indicate a decrease in pedestrian traffic in the summer. While the actual volume over the lunch-period may not have decreased, the mean hourly proportion is dependent on the other hours-of-day so an increase in evening volume would result in a relative decrease in the mean hourly proportion over the lunch-period and all other hours.

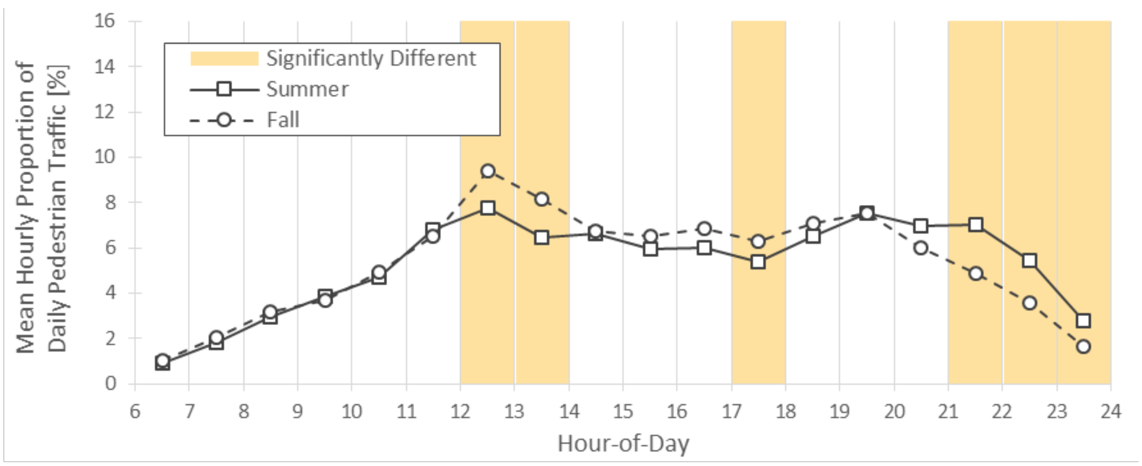

Figure 17: Hourly Pedestrian Traffic Periodicities at Cor_N by Season

Table 24 reveals the P-value results from the T-test analysis of seasonality for all stations (Appendix C contains more detailed information of the analysis at each study site). The results indicate that seasonality, summer versus fall, have an effect on pedestrian traffic with 39 percent (85 of 216) of all mean hourly proportions tested being significantly different. The hours of 10:00, 13:00, 14:00, and 17:00 have the least amount of significantly different hours at two hours each.

Table 24: P-Value Results from Seasonality T-Test

Study Site	Hour-of-Day 6	7	8	9	10	11	12	13	14	
Corydon North	0.31	0.26	0.43	0.47	0.69	0.80	0.00	0.02	0.88	---
Corydon South	0.03	0.00	0.02	0.11	0.83	0.29	0.03	0.42	0.91	---
Academy North	0.07	0.39	0.00	0.78	0.75	0.06	0.02	0.22	0.18	---
Academy South	0.45	0.82	0.14	0.54	0.01	0.20	0.09	0.01	0.93	---
Osborne East	0.64	0.82	0.47	0.32	0.34	0.13	0.56	0.71	0.11	---
Osborne West	0.03	0.00	0.02	0.00	0.33	0.06	0.04	0.47	0.60	---
St Anne's East	0.97	0.10	0.00	0.70	0.93	0.77	0.26	0.61	0.03	---
St Anne's West	0.48	0.02	0.97	0.01	0.24	0.90	0.01	0.66	0.63	---
Roblin North	0.03	0.50	0.00	0.03	0.29	0.27	0.40	0.43	0.48	---
Roblin South	0.78	0.01	0.49	0.15	0.00	0.60	0.10	0.20	0.81	---
Dakota East	0.00	0.81	0.48	0.98	0.25	0.03	0.00	0.18	0.03	---
Dakota West	0.00	0.00	0.00	0.56	0.43	0.43	0.97	0.69	0.27	---
Total	**6**	**5**	**6**	**3**	**2**	**3**	**8**	**2**	**2**	**---**

Study Site	Hour-of-Day 15	16	17	18	19	20	21	22	23	**Total**
Corydon North	0.27	0.23	0.02	0.45	0.98	0.12	0.00	0.00	0.00	**6**
Corydon South	0.02	0.03	0.37	0.02	0.75	0.16	0.00	0.00	0.02	**10**
Academy North	0.79	0.16	0.72	0.01	0.04	0.00	0.05	0.24	0.95	**8**
Academy South	0.00	0.35	0.12	0.30	0.22	0.83	0.00	0.01	0.10	**6**
Osborne East	0.14	0.66	0.25	0.45	0.97	0.08	0.08	0.02	0.57	**3**
Osborne West	0.20	0.05	0.70	0.00	0.00	0.01	0.32	0.74	0.82	**10**
St Anne's East	0.05	0.50	0.88	0.71	0.64	0.00	0.01	0.36	0.47	**5**
St Anne's West	0.00	0.93	0.44	0.21	0.65	0.00	0.02	0.02	0.00	**8**
Roblin North	0.81	0.46	0.58	0.80	0.24	0.94	0.29	0.32	0.00	**4**
Roblin South	0.71	0.04	0.47	0.73	0.10	0.02	0.01	0.02	0.41	**7**
Dakota East	0.00	0.02	0.93	0.90	0.07	0.00	0.00	0.09	0.05	**11**
Dakota West	0.76	0.02	0.00	0.00	0.25	0.04	0.46	0.52	0.91	**7**
Total	**5**	**5**	**2**	**4**	**3**	**8**	**9**	**7**	**5**	**85**

The summer and fall pedestrian traffic data at each site are not combined for the analysis of spatial influencing factors due to the following:

- Thirty-nine percent of all mean hourly proportions tested are significantly different between the summer and fall seasons.

4.2 SPATIAL FACTORS

This section evaluates hourly pedestrian traffic periodicities for significant differences between spatial influencing factors. Testing of the spatial influencing factors for adjacent sidewalks on either side of the roadway with in commercial zones as defined by this research. Testing of commercial zones is achieved through the cluster analysis of all study sites by season. The study sites counted for this research comprise six adjacent sidewalk pairs as indicated by the roadway and the cardinal location of the sidewalk (i.e., the Corydon South and Corydon North study sites are adjacent to each other). The mean hourly proportions tested represent the typical pedestrian traffic at each study site by controlling for day-of-week, precipitation, and season as detailed in previous sections.

4.2.1 Commercial Zone Behaviour

The commercial zone site selection criteria may not have been detailed enough to capture a consistent hourly pedestrian traffic periodicity. It is evident through a visual inspection of the resulting mean hourly proportions at each site and season (shown in Figure 18) that this research has captured multiple hourly pedestrian traffic periodicities that are indicative of different pedestrian traffic characteristics. An ANOVA test was completed to verify that the 36 hourly pedestrian traffic periodicities (18 hours * 2 seasons = 36) are significantly different. As expected, the ANOVA test found that all hours are significantly different with 99 percent confidence.

Naming convention - the first three letters indicate the roadway, the first single character indicates the side of the roadway where the sidewalk resides (**n**orth, **s**outh, **e**ast, and **w**est), and the second character represents the season (**s**ummer or **f**all).

Figure 18: Hourly Pedestrian Traffic Periodicities for Each Study Site and Season

4.2.2 Adjacent Sidewalk Behaviour

The study sites were selected within commercial zones in Winnipeg. The pedestrian sidewalk environment is defined at a roadway level by three roadway and one land-use criteria (described in Section 3.2). These roadway criteria were chosen to provide a detailed characterization of the pedestrian environment with information available to most jurisdictions. However, the criteria results in adjacent sidewalks being classified identically which may not be the case in commercial zones where the individual destinations on each block (restaurants, retailers, etc.) draw different trips on adjacent sidewalks. The differences between pedestrian traffic on adjacent sidewalks is tested using a T-test.

The T-test results between Cor_N and Cor_S for the summer is presented in Figure 19. Six mean hourly proportions are significantly different between the two adjacent sidewalks on Corydon. Additionally, pedestrian traffic peaks at different hours-of-day with two hours during lunch-time and two hours in the late-evening being significantly different.

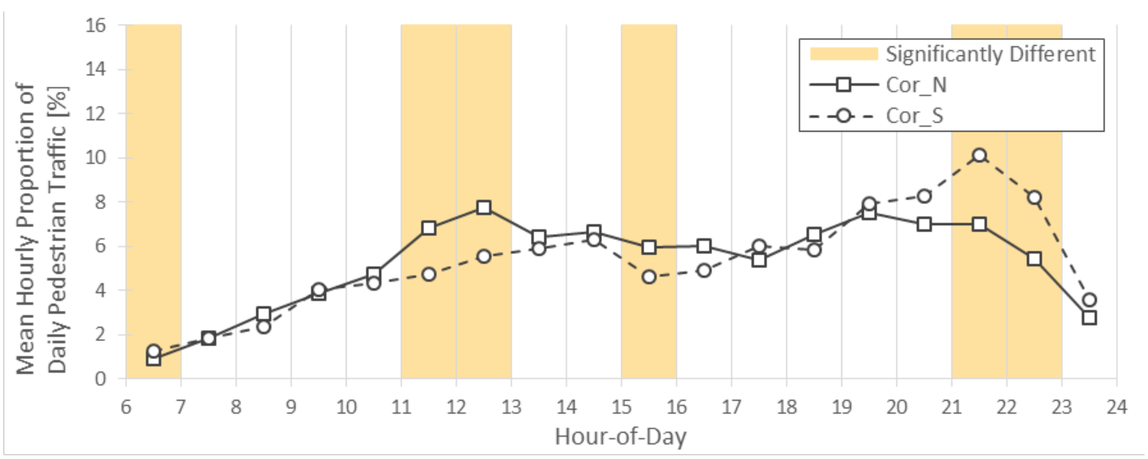

Figure 19: Hourly Pedestrian Traffic Periodicities at Adjacent Sidewalks in summer (Cor_N vs Cor_S)

The T-test results between Cor_N and Cor_S are presented in Figure 20 for the fall season. Apart from the magnitude being slightly different, the hourly pedestrian traffic periodicities follow the same pattern of a lunch-hour peak, a slight after-work peak at 16:00, and an evening entertainment peak at 19:00. These results indicate that pedestrian traffic may stabilize in the fall once people return to a usual routine.

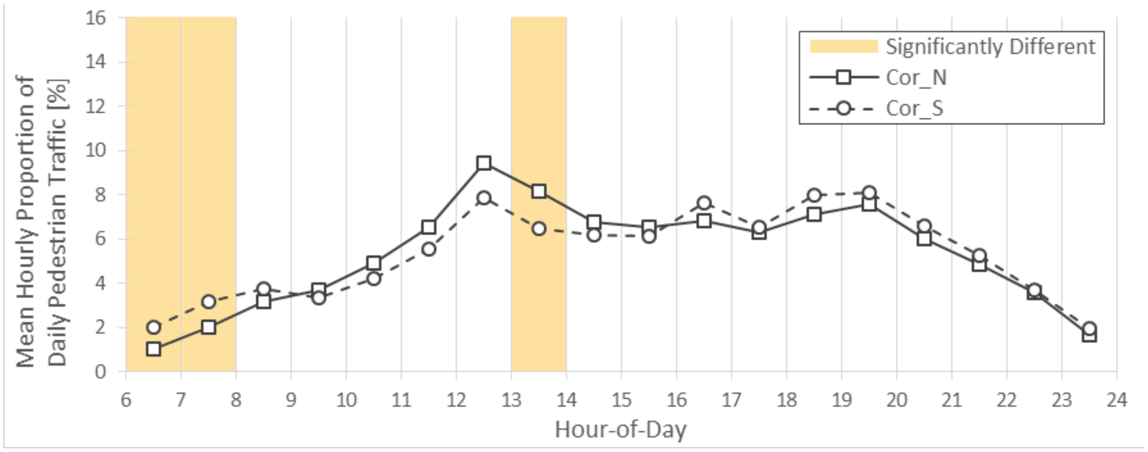

Figure 20: Hourly Pedestrian Traffic Periodicities at Adjacent Sidewalks in fall (Cor_N vs Cor_S)

Table 25 presents the p-value results from the t-test for each adjacent sidewalk pair and season. While adjacent sidewalks on Corydon had fewer significantly different hours in the fall the other study site pairs don’t support or disprove this finding as evident by the seasonal totals of 46 significantly different hours in the summer and 47 in the fall. St Anne’s exhibits the opposite correlation with three significantly different hours in the summer and eight in the fall which indicates that the summer traffic between the two adjacent sidewalks is more similar. The hours of 14:00 and 16:00 exhibit the least amount of significantly different hours. Forty-three percent (93 of 216) of all mean hourly proportions tested are significantly different. Corydon Ave in the fall and St Anne’s St in the summer exhibit the least amount of significantly different mean hourly proportions between their adjacent sidewalks. These sites may be candidates to combine into a single hourly pedestrian traffic periodicity for the roadway.

Table 25: P-Value Results from the T-Test of adjacent sidewalks

Study Site Roadway	Season	Hour-of-Day 6	7	8	9	10	11	12	13	14	
Corydon	Summer	0.06	0.89	0.21	0.59	0.45	0.08	0.01	0.52	0.72	---
Corydon	Fall	0.01	0.00	0.24	0.34	0.21	0.19	0.10	0.01	0.33	---
Academy	Summer	0.93	0.25	0.03	0.92	0.18	0.27	0.23	0.00	0.68	---
Academy	Fall	0.04	0.03	0.15	0.33	0.22	0.03	0.00	0.28	0.33	---
Osborne	Summer	0.88	0.24	0.00	0.00	0.08	0.00	0.00	0.03	0.06	---
Osborne	Fall	0.00	0.01	0.32	0.00	0.00	0.12	0.03	0.00	0.63	---
St Anne's	Summer	0.76	0.00	0.02	0.79	0.38	0.53	0.52	0.89	0.75	---
St Anne's	Fall	0.35	0.00	0.00	0.09	0.18	0.52	0.01	0.49	0.08	---
Roblin	Summer	0.03	0.30	0.09	0.00	0.05	0.05	0.78	0.32	0.56	---
Roblin	Fall	0.36	0.84	0.00	0.00	0.00	0.85	0.48	0.01	0.21	---
Dakota	Summer	0.01	0.73	0.14	0.12	0.04	0.43	0.04	0.01	0.58	---
Dakota	Fall	0.00	0.01	0.00	0.06	0.19	0.30	0.19	0.44	0.58	---
	Total	**7**	**6**	**7**	**6**	**5**	**4**	**6**	**6**	**2**	**---**
	Summer	3	1	4	2	3	3	3	3	1	---
	Fall	4	5	3	4	2	1	3	3	1	---

Study Site Roadway	Season	Hour-of-Day continued 15	16	17	18	19	20	21	22	23	Total
Corydon	Summer	0.05	0.10	0.18	0.43	0.77	0.28	0.00	0.04	0.19	**6**
Corydon	Fall	0.39	0.49	0.69	0.28	0.21	0.46	0.53	0.90	0.32	**3**
Academy	Summer	0.07	0.05	0.26	0.37	0.67	0.10	0.01	0.01	0.15	**7**
Academy	Fall	0.30	0.81	0.48	0.22	0.03	0.17	0.02	0.21	0.79	**6**
Osborne	Summer	0.00	0.74	0.58	0.01	0.01	0.01	0.00	0.00	0.41	**13**
Osborne	Fall	0.00	0.13	0.09	0.02	0.03	0.02	0.12	0.34	0.91	**11**
St Anne's	Summer	0.37	0.90	0.16	0.91	0.66	0.11	0.75	0.75	0.08	**3**
St Anne's	Fall	0.01	0.51	0.00	0.15	0.94	0.62	0.87	0.55	0.02	**8**
Roblin	Summer	0.37	0.25	0.03	0.00	0.18	0.06	0.19	0.94	0.23	**8**
Roblin	Fall	0.54	0.13	0.03	0.05	0.05	0.05	0.01	0.05	0.01	**11**
Dakota	Summer	0.14	0.32	0.05	0.09	0.07	0.36	0.00	0.63	0.02	**9**
Dakota	Fall	0.19	0.65	0.01	0.00	0.07	0.09	0.65	0.85	0.99	**8**
	Total	**5**	**1**	**6**	**6**	**6**	**6**	**6**	**4**	**4**	**93**
	Summer	3	1	2	3	2	3	4	3	2	**46**
	Fall	2	0	4	3	4	3	2	1	2	**47**

Sidewalks on adjacent sides of the roadway are kept separate for the analysis of pedestrian characteristics in commercial zones for the following reason:

- Forty-three percent of all mean hourly proportions tested are significantly different between adjacent sidewalks.

4.3 CHARACTERIZATION OF HOURLY PEDESTRIAN TRAFFIC

While the study sites in this research do not represent a single homogenous hourly pedestrian traffic periodicity it may be possible to characterize them into smaller pedestrian traffic pattern groups (PTPG) that share similar pedestrian traffic characteristics. For example, Corydon south and Osborne east both have a late evening peak in the summer season that is the result of local restaurants and bars on each block. Commercial zones are comprise establishments of a variety of sizes that include offices, restaurants, retail outlets, entertainment venues, bars, and grocers, each of which may affect pedestrian traffic in different ways.

In traffic monitoring programs, traffic pattern groups (TPGs) are used to group sites with similar traffic characteristics to facilitate the expansion of short-duration counts into annual average daily traffic volumes by applying adjustment factors created from continuous count sites in the same TPG. The FHWA (2013) indicates that traffic pattern groups for non-motorized traffic are commonly grouped by trip purpose and typically include:

- Commuter – pedestrian traffic peaks in the morning and evening due to travel to and from the office or school,

- Recreation – represents recreational trip purposes and may peak once daily or be consistently distributed throughout the daytime, and

- Mixed – may have various traits exhibited by commuter or recreational trips.

Sidewalks in commercial zones, characterized by higher pedestrian traffic and busy arterial roadways, are not typically the desired facility for recreational pedestrian trips. In Figure 18, it can be seen that none of the study sites show a single gradual peak of pedestrian traffic. Instead the hourly pedestrian traffic periodicities are a product of the surrounding commercial real-estate and its ability to attract pedestrian traffic. As such, recreation PTPGs will not be explored further in this research. Instead, commuter and multiple commercial PTPGs are statistically tested.

The Traffic Monitoring Guide indicates that two of the most useful approaches to creating traffic pattern groups are clustering and through the visual examination of graphs illustrating the traffic periodicities at sites (FHWA, 2013, pp. 3-8). This research develops PTPGs through a combination of both of the previously mentioned approaches. Visual examination is used to select similar traffic patterns that are then tested using the ANOVA test to determine if the traffic patterns form a reasonable PTPG. This process is repeated for all probable pattern groups in an iterative manner. This research identifies the following five PTPGs to test for significance:

- *Commuter sites* have a high proportion of offices or a school nearby
- *Restaurant sites* have a distinct noon peak period
- *Entertainment sites* includes study sites that have establishments that draw pedestrian traffic in the evenings like bars, entertainment venues, and restaurants
- *Small business sites* consists of study sites that have small retail shops, cafes, and salons
- *Services sector sites* have medical offices, post offices, and other business type services

Specific study sites are identified by the first three letters of the roadway, followed by a character indicating the side of the roadway (**n**orth, **s**outh, **e**ast, or **w**est) the sidewalk resides on, and then by the season they represent (**s**ummer or **f**all). The west sidewalk on Dakota St for the summer season would be Dak_W_S.

4.3.1.1 Restaurant PTPG

The restaurant pattern group is composed of study sites that have a defined lunch-period peak at 12:00 followed by consistent pedestrian traffic volumes until 19:00 when they gradually decline. Three hourly pedestrian traffic periodicities from Corydon Ave make up the restaurant PTPG shown in Figure 21. The south sidewalk at Corydon Ave during the summer is not included because it exhibits a large evening peak at 21:00 and does not have a pronounced lunch-period peak. There is a slight increase of pedestrian traffic at 16:00 that could be produced by commuters returning from work.

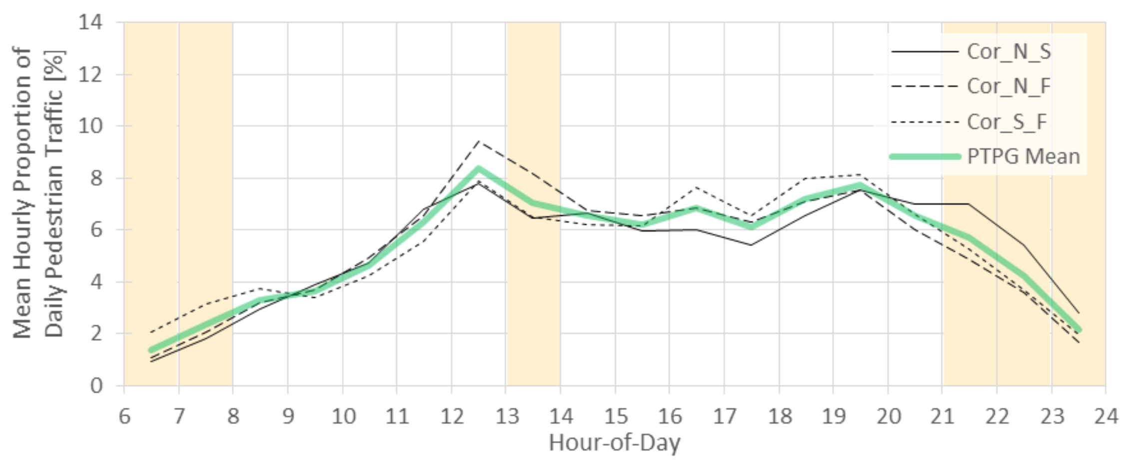

Figure 21: Restaurant PTPG, Hourly Pedestrian Traffic Periodicities

The mean hourly proportions for each study site and the restaurant PTPG are provided in Table 26 along with results (p-values) from an ANOVA test of the group. The study time period comprises 96 percent of the total daily pedestrian traffic volume with the 12:00 peak being the largest at 8.4 percent. Six of the 18 hours tested are statistically different.

Table 26: Restaurant PTPG, Mean Hourly Proportions of Daily Pedestrian Traffic [%] and ANOVA Test Results

	Hour-of-Day																	
Study Site	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Cor_N_S	0.9	1.8	2.9	3.9	4.7	6.8	7.8	6.4	6.6	6.0	6.0	5.4	6.5	7.5	7.0	7.0	5.4	2.8
Cor_N_F	1.1	2.0	3.2	3.7	4.9	6.5	9.4	8.2	6.8	6.5	6.8	6.3	7.1	7.6	6.0	4.9	3.6	1.7
Cor_S_F	2.0	3.2	3.7	3.4	4.2	5.6	7.9	6.5	6.2	6.1	7.6	6.5	8.0	8.1	6.6	5.3	3.7	2.0
TPG Mean	1.3	2.3	3.3	3.6	4.6	6.3	8.4	7.0	6.5	6.2	6.8	6.1	7.2	7.7	6.5	5.7	4.2	2.1

ANOVA Test Results for the PTPG

p-value	0.0	0.0	0.2	0.3	0.4	0.4	0.1	0.0	0.7	0.5	0.4	0.1	0.3	0.7	0.5	0.0	0.0	0.0

4.3.1.2 Entertainment PTPG

The entertainment district includes study sites that have establishments that draw pedestrian traffic in the evenings like bars, entertainment venues, and restaurants. These sites do not have an a.m. or lunch-period peak but instead pedestrian traffic increases gradually until a p.m. peak sometime between 17:00 and 22:00. The pedestrian environment on St Anne's St is more characteristic of the restaurant PTPG but the lack of an a.m. or lunch-period peak has resulted in its classification as an evening entertainment study site. The west sidewalk at Dakota in the summer exhibits a small a.m. peak similar to the commuter PTPG but the late evening peak at this site is large enough that it fit better in the entertainment PTPG. These study site assignments illustrate the difficulty in assigning pedestrian counting sites to PTPGs.

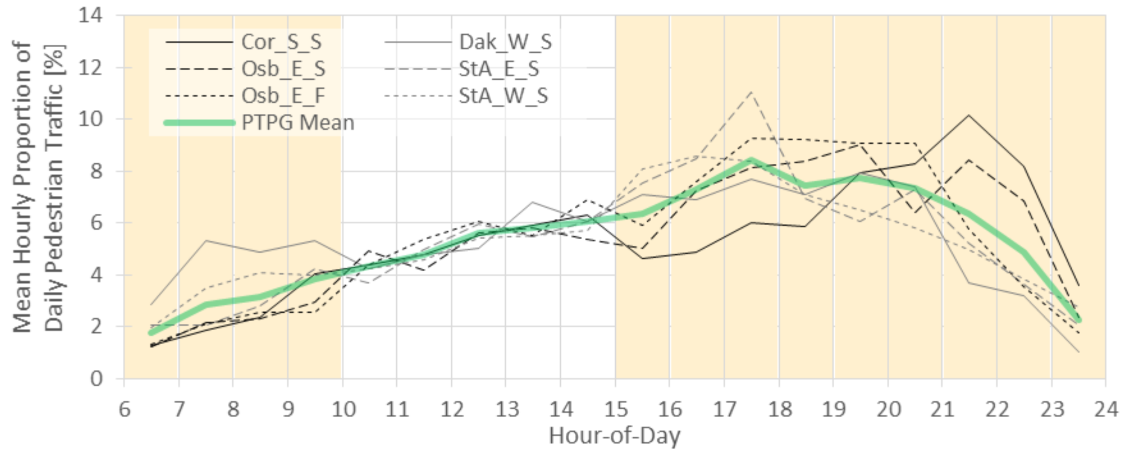

Figure 22: Entertainment PTPG, Hourly Pedestrian Traffic Periodicities

The mean hourly proportions for each study site and the entertainment PTPG are provided in Table 27Table 26 along with results (p-values) from an ANOVA test of the group. The PTPG mean peaks at 17:00 with 8.4 percent of the daily pedestrian traffic and doesn't drop below 7 percent between 16:00 and 21:00. The ANOVA test results find that 13 hours are significantly different for the entertainment PTPG. The five mean hourly proportions that are not significantly different occur in one time period between 10:00 and 15:00.

Table 27: Entertainment PTPG, Mean Hourly Proportions of Daily Pedestrian Traffic [%] and ANOVA Test Results

	Hour-of-Day																	
Study Site	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Cor_S_S	1.3	1.9	2.3	4.1	4.4	4.8	5.5	5.9	6.3	4.6	4.9	6.0	5.9	7.9	8.3	10.1	8.2	3.6
Dak_W_S	2.8	5.3	4.9	5.3	4.3	4.8	5.0	6.8	6.1	7.1	6.9	7.7	7.1	8.0	7.4	3.7	3.2	1.0
Osb_E_S	1.2	2.2	2.3	2.9	4.9	4.2	5.6	5.8	5.4	5.0	7.2	8.1	8.4	9.0	6.4	8.4	6.9	2.4
StA_E_S	2.1	2.0	2.8	4.2	3.7	5.0	5.9	5.4	6.1	7.5	8.5	11.1	7.0	6.1	7.3	5.2	3.6	2.1
Osb_E_F	1.3	2.1	2.6	2.5	4.4	5.4	6.1	5.5	6.9	5.9	7.6	9.3	9.2	9.1	9.1	5.8	3.5	1.8
StA_W_S	1.9	3.5	4.1	4.0	4.3	4.6	5.4	5.5	5.7	8.1	8.6	8.4	7.1	6.5	5.8	5.0	3.8	2.8
TPG Mean	1.8	2.8	3.2	3.9	4.3	4.8	5.6	5.8	6.1	6.4	7.3	8.4	7.4	7.8	7.4	6.4	4.9	2.3
ANOVA Test Results for the PTPG																		
p-value	0.0	0.0	0.0	0.0	0.6	0.7	0.8	0.5	0.7	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

4.3.1.3 Small Business PTPG

The small business PTPG consists of study sites that have small retail shops, cafes, and other commercial businesses that draw pedestrian traffic during business hours between 10:00 and 19:00. Both seasons at the Osborne St west and Academy Rd south sidewalks meet this criteria. In Figure 23, the PTPG mean gradually increases to a slight peak periods at 12:00 and another slight peak at 16:00 before gradually declining again. Both these study sites remain relatively unchanged between the summer and fall months.

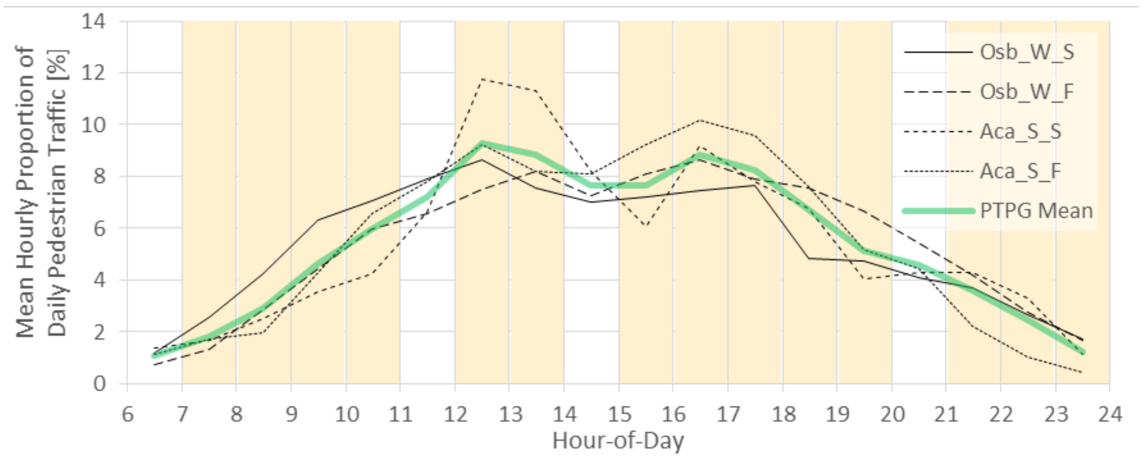

Figure 23: Small Business PTPG, Hourly Pedestrian Traffic Periodicities

The mean hourly proportions for the small business PTPG and each of its study sites are provided in Table 28 along with results (p-values) from an ANOVA test of the group. All but four mean hourly proportions are significantly different. The peak at 12:00 and 16:00 represent 9.2 and 10.2 percent of daily pedestrian traffic respectively. Combined, the period represents 98 percent of all pedestrian traffic for this PTPG.

Table 28: Small Business PTPG, Mean Hourly Proportions of Daily Pedestrian Traffic [%] and ANOVA Test Results

	Hour-of-Day																	
Study Site	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Osb_W_S	1.2	2.6	4.2	6.3	7.1	7.9	8.6	7.6	7.0	7.2	7.5	7.7	4.8	4.8	4.1	3.7	2.7	1.7
Osb_W_F	0.7	1.3	2.8	4.5	6.0	6.6	7.5	8.2	7.2	8.1	8.6	7.9	7.6	6.6	5.5	4.2	2.8	1.7
Aca_S_S	1.4	1.7	2.5	3.5	4.2	6.6	11.8	11.3	8.2	6.1	9.2	7.8	6.8	4.0	4.3	4.3	3.3	1.1
Aca_S_F	1.1	1.7	2.0	4.3	6.6	7.8	9.2	8.2	8.1	9.2	10.2	9.6	7.6	5.2	4.4	2.2	1.1	0.4
TPG Mean	1.1	1.8	2.9	4.6	6.0	7.2	9.3	8.8	7.6	7.6	8.9	8.2	6.7	5.2	4.6	3.6	2.4	1.2
ANOVA Test Results for the PTPG																		
p-value	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0

4.3.1.4 Commuter PTPG

Study sites that have a high proportion of offices or a school nearby are candidates for the commuter PTPG. These sites will typically have an a.m. peak between 7:00 and 9:00 and a p.m. peak between 15:00 and 18:00. Figure 24 reveals the hourly pedestrian traffic periodicities from study sites that show these characteristics. Both sides of St Anne's and the east sidewalk at Dakota for the fall season are classified as a commuter pedestrian traffic pattern. St Anne's has an elementary school located a block south of the study site which explains the lunch-time peak and the early p.m. peak at 15:00. The east sidewalk shows a second peak in the p.m. period at 17:00 which is more indicative of pedestrians returning from work. Dakota east is located along a large strip mall of mixed commercial and a major bus route which draws commuter trips for those working or schooling outside of the neighborhood. Dakota west is not included because the influence of a major grocer results in a large p.m. peak from 17:00 to 19:00 that overpowers the mean hourly proportion of other hours-of-day.

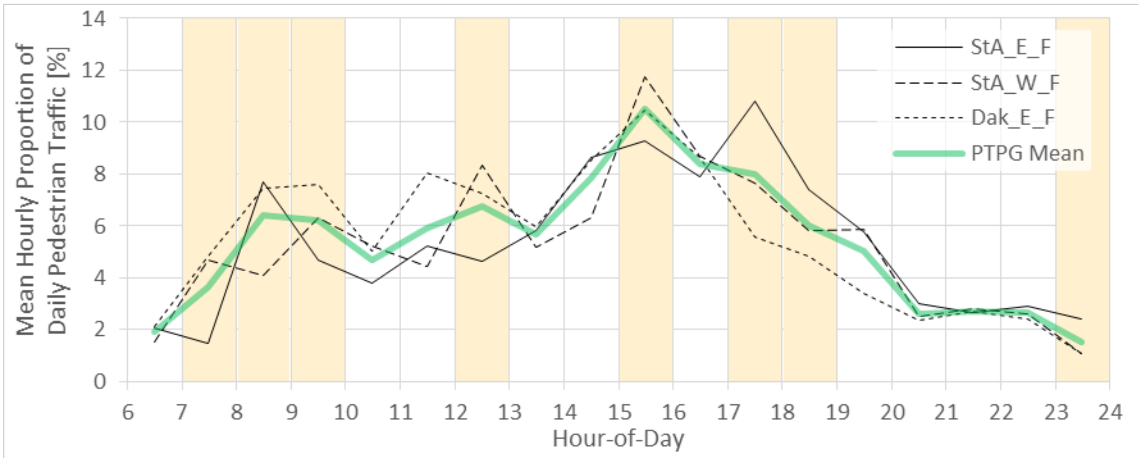

Figure 24: Commuter PTPG, Hourly Pedestrian Traffic Periodicities

The hourly pedestrian traffic periodicity is characterized by three peak periods that occur in the a.m. peak at 8:00, the lunch peak at 12:00, and the p.m. peak at 15:00. The mean hourly proportions for each study site and the commuter PTPG are provided in Table 29 along with results (p-values) from an ANOVA test of the commuter PTPG. The ANOVA test results confirm that the commuter pedestrian traffic in commercial zones do not form a strong PTPG.

Table 29: Commuter PTPG, Mean Hourly Proportions of Daily Pedestrian Traffic [%] and ANOVA Test Results

	Hour-of-Day																	
Study Site	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
StA_E_F	2.1	1.5	7.7	4.7	3.8	5.2	4.7	5.8	8.7	9.3	7.9	10.8	7.4	5.8	3.0	2.7	2.9	2.4
StA_W_F	1.5	4.7	4.1	6.3	5.2	4.4	8.4	5.2	6.3	11.8	8.7	7.6	5.8	5.9	2.5	2.8	2.6	1.1
Dak_E_F	2.1	4.8	7.4	7.6	5.0	8.1	7.3	6.0	8.6	10.5	8.7	5.6	4.8	3.4	2.4	2.7	2.4	1.1
TPG Mean	1.9	3.7	6.4	6.2	4.7	5.9	6.8	5.7	7.8	10.5	8.4	8.0	6.0	5.0	2.6	2.7	2.6	1.5
ANOVA Test Results for the PTPG																		
p-value	0.5	0.0	0.0	0.1	0.3	0.1	0.0	0.8	0.2	0.1	0.7	0.0	0.1	0.1	0.8	1.0	0.7	0.0

4.3.1.5 Services Sector PTPG

The services sector PTPG represents study sites that have medical offices, post offices, and other similar service providers. Only Roblin Blvd south exhibits these traits in the summer and fall. The study site has a sharp peak at 10:00 followed by a less pronounced peak at 14:00 as shown in Figure 25. The discrepancy between the two seasons at 21:00 is the result of a local gym class running by the counter in the summer. This peak would be expected to level out with the inclusion of more study sites in the PTPG.

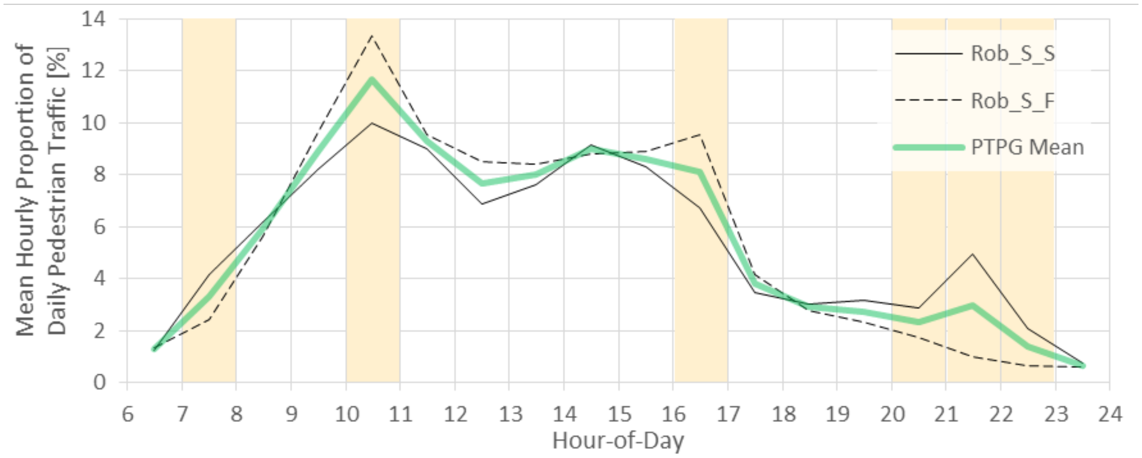

Figure 25: Services Sector PTPG Hourly Pedestrian Traffic Periodicities

The mean hourly proportions for the services sector PTPG and each of its study sites are provided in Table 30 Table 27Table 26along with results (p-values) from a T-Test of the group. A T-test is used rather than an ANOVA test because there are only two study sites being compared. The peak at 10:00 is 11.7 percent of the daily traffic and the peak at 14:00 is 9.0 percent of daily traffic. Six hours were found to have significantly different mean hourly proportions. 99 percent of daily traffic for this PTPG occurs during the 18-hour study period.

Table 30: Services Sector PTPG, Mean Hourly Proportions of Daily Pedestrian Traffic [%] and T-Test Results

	Hour-of-Day																	
Study Site	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Rob_S_S	1.2	4.1	6.2	8.2	10.0	9.0	6.9	7.6	9.2	8.3	6.7	3.4	3.0	3.2	2.9	4.9	2.1	0.7
Rob_S_F	1.3	2.4	5.7	9.6	13.4	9.5	8.5	8.4	8.8	8.9	9.5	4.2	2.8	2.3	1.7	1.0	0.7	0.6
TPG Mean	1.3	3.3	5.9	8.9	11.7	9.3	7.7	8.0	9.0	8.6	8.1	3.8	2.9	2.7	2.3	3.0	1.4	0.7

Student's T-Test Results for the PTPG

p-value	0.8	0.0	0.5	0.2	0.0	0.6	0.2	0.3	0.8	0.7	0.0	0.5	0.7	0.1	0.1	0.0	0.1	0.4

5 CONCLUSION

This chapter discusses the research findings and identifies future research opportunities. The purpose of this research is to characterize hourly pedestrian traffic periodicities in commercial zones. The hourly pedestrian traffic periodicities are a representation of the pedestrian traffic at each study site and are composed of a set of 18 mean hourly proportions of daily pedestrian traffic between 06:00 and 24:00. The influence of temporal factors (day-of-week, precipitation events, and seasonality) at each study site are determined followed by the influence of spatial factors (commercial zones and adjacent sidewalks) between study sites. Finally, the hourly pedestrian traffic periodicities are characterized into pedestrian traffic pattern groups (PTPGs) that provide an indication of pedestrian traffic behaviour in commercial zones. The research is conducted in Winnipeg, Manitoba and is limited to the summer and fall seasons.

5.1 SUMMARY OF FINDINGS

- After installation, it is advised that APCs are calibrated as soon as possible because it is beneficial to observe each individual site over an entire day in order to adequately remark on the suitability of APC placement.

- One field observer conducted 4-hour manual (approx.) counts at the two sidewalk study sites, located on Corydon Ave, over three consecutive days covering the 12-hour period from 08:00 to 16:00. The APCs were found to undercount pedestrians by 15 percent on the north sidewalk and 9 percent on the south sidewalk.

- Further, the error residuals for APC performance by pedestrian volume and time-of-day showed low correlation ($R^2 = 0.131, R^2 = 0.002$ respectively). These results indicate that the APCs perform consistently regardless of pedestrian volume or time-of-day. Therefore, pedestrian data from the APCs can be used to create expansion factors without having to first develop calibration factors.

5.1.1 Influence of Day-of-Week

This research completed an ANOVA test on five typical day conditions to determine which days-of-week represent typical pedestrian traffic. The typical day conditions tested include Monday to Sunday, Monday to Friday, Monday to Thursday, Monday to Wednesday and Tuesday to Thursday. The research found:

- Tuesday to Thursday had the least amount of significantly different mean hourly proportions when the test results for all study sites were added together. Four percent of the 216 hours tested were found to be significantly different.

- Monday to Sunday had the largest amount of significantly different mean hourly proportions when the test results for all study sites were added together. Thirty-seven percent of the 216 hours tested were found to be significantly different.

5.1.2 Influence of Precipitation

Student's T Test was used to test if the mean hourly proportions for wet and dry days were significantly different. Wet days were defined by the minimum number of hourly precipitation events that occurred in the daytime between 06:00 and 24:00. The minimum thresholds tested include at least one hourly event, at least two hourly events, at least three hourly events, and at least four hourly events. The analysis found:

- Days having at least one hourly precipitation event had the least influence on pedestrian traffic. Seventeen percent of the mean hourly proportions were significantly different.

- Days having at least two hourly precipitation events had the largest influence on pedestrian traffic. Twenty-two percent of the mean hourly proportions were significantly different. However, days having at least four hourly precipitation events had only slightly less significantly different mean hourly proportions at 21 percent but maintained two additional days' worth of data.

5.1.3 Influence of Seasonality

The hourly pedestrian traffic periodicities for the summer and fall seasons at each study site were tested for significant differences using a T-test. The comparison found:

- Thirty-nine percent of the mean hourly proportions tested (85 of 216) were significantly different. This indicates that hourly pedestrian traffic periodicities in commercial zones are influenced by the summer and fall seasons.

5.1.4 Commercial Zone Behaviour

An ANOVA test was used to test the hourly pedestrian traffic periodicities from the study sites to evaluate the study site selection criteria. The criteria were chosen to identify study sites that would share similar hourly pedestrian traffic periodicities. The ANOVA test found:

- All the mean hourly proportions tested (18 total) were significantly different for the commercial zone study sites. This finding indicates that the study site selection criteria was not detailed enough to capture a consistent hourly pedestrian traffic periodicity for commercial zones. Defining study sites with more detailed information may result in a homogenous hourly pedestrian traffic periodicity that can form a pedestrian traffic pattern group.

5.1.5 Adjacent Sidewalk Behaviour

The hourly pedestrian traffic periodicities between adjacent sidewalks for the same season were compared using a T-test to identify significantly different mean hourly proportions. The T-test found:

- Forty-three percent of the mean hourly proportions tested (93 of 216) were significantly different between adjacent sidewalks. This result indicates that the hourly pedestrian traffic periodicities in commercial zones are influenced differently by adjacent sidewalks on either side of a roadway. The influence is most likely related to the different commercial businesses that front onto adjacent sidewalks.

5.1.6 Characterization of Pedestrian Traffic

The study sites were grouped into probable pedestrian traffic pattern groups (PTPG) based on a visual review of the hourly pedestrian traffic periodicities verified by an ANOVA test. The 18 mean hourly proportions from the PTPGs were then investigated for significant differences using ANOVA tests and T-tests. The investigation found:

- The restaurant PTPG comprises three study sites that includes both seasons at Corydon Ave north and the fall season on the south sidewalk. Six of the 18 mean hourly proportions tested were found to be significantly different. However, only one of these occurs between 08:00 and 21:00 which indicates that this PTPG has potential to be used to expand short-duration counts.

- The entertainment PTPG comprises six study sites that includes Corydon Ave south in the summer, Dakota St west in the summer, Osborne east for both seasons, and both sidewalks on St Anne's in the summer. The ANOVA test found 13 significantly different mean hourly proportions. However, the five hours that are not significantly different occur consecutively which may support the expansion of short-duration counts taken during this period.

- The small business PTPG comprises four study sites that includes both seasons from Osborne St west and Academy Rd south. All but four dispersed mean hourly proportions were found to be statistically different. This PTPG is too volatile to support the expansion of short-duration counts.

- The commercial PTPG comprises St Anne's Rd east and west and Dakota St east in the fall. Results of the ANOVA test reveal eight significantly different mean hourly proportions. The commercial PTPG is not a homogenous representation of hourly pedestrian traffic periodicities.

- The services sector PTPG comprises both seasons at Roblin Blvd south. This study site was previously examined in the seasonality investigation were six mean hourly proportions were significantly different. The PTPG looks relatively promising but it's hard to draw conclusions on only two hourly pedestrian traffic periodicities from the same study site.

- Six study sites did not fit into the aforementioned PTPGs. These sites are Academy Rd north for both seasons, Roblin Blvd north for both seasons, Dakota St east in the summer, and Dakota St west in the fall.

5.2 CONTRIBUTION TO PEDESTRIAN TRAFFIC MONITORING PRACTICE

For a majority of jurisdictions, current pedestrian traffic monitoring practice comprises short-duration counts collected for inconsistent durations, as well as at different times of the day. This research focused on hourly pedestrian traffic periodicities in commercial zones to characterize the variability in pedestrian traffic associated with temporal and spatial factors. Results from the temporal factor analysis indicate when to conduct short-duration counts to minimize pedestrian traffic variability. Results from the spatial factor analysis indicate where to conduct counts to facilitate expansion of the short-duration counts. The results of this research make the following contributions to pedestrian traffic monitoring practice:

- Results from the temporal factor analysis indicate that short-duration counts be conducted on Tuesday, Wednesday, or Thursday to minimize expansion error (results by study site provided in Appendix A).

- Results from analysis of precipitation conditions indicate that there should be no more than three hourly precipitation events between 06:00 and 24:00 on the day that is counted (results by study site provided in Appendix B).

- Results from the analysis of seasonality for all the commercial zone study sites combined found that summer and fall seasons affected pedestrian traffic differently. Therefore, data collected in the summer and fall should not be combined when analyzing hourly pedestrian traffic data collected in the two seasons. However, results indicate that for some individual study sites, combining data from the two seasons would be reasonable (results by study site provided in Appendix C). These study sites are Corydon Ave north, Osborne St east and west, and Roblin Blvd south.

- The spatial factor analysis of all study sites proved that the study site selection criteria was not detailed enough to capture a homogeneous representation of hourly pedestrian traffic in commercial zones. Thus, the study site selection criteria from this research should not be used to create a single pedestrian traffic pattern group.

- Results from the analysis of adjacent sidewalks for all commercial zone study sites indicate that adjacent sidewalks do not represent the same hourly pedestrian traffic periodicity. Therefore, pedestrian traffic data should be collected on both sides of a roadway. However, this does not apply to all study sites individually (results by study site provided in Appendix D). These study sites are Corydon Ave in the fall and St Anne’s in the summer.

- Finally, PTPGs were developed to identify subsets of commercial zone study sites that represent a more homogenous hourly pedestrian traffic periodicity. Visual clustering and an intimate knowledge of the study sites was used to characterize five potential PTPGs. However, given weaknesses in the data, it was not possible to comment on the strength of the PTPGs for expanding short-duration counts. Additionally, the level of effort required to characterize each study site to this detail (i.e., the individual commercial use of buildings along each sidewalk) does not support the characterization of an entire pedestrian network in this manner. Therefore, the PTPGs developed for this research are not recommended for expansion of short-duration counts into daily pedestrian traffic volumes.

5.3 RECOMMENDATIONS FOR FUTURE RESEARCH

- Traffic monitoring programs provide traffic data for entire networks by leveraging continuous count data to expand short-duration count data. Expansion of short-duration counts is possible through the use of traffic pattern groups that represent homogenous traffic periodicities. Future research is needed to develop a practical method that characterizes network wide pedestrian traffic, to identify unique pedestrian traffic periodicities. It is suggested that research targets high pedestrian traffic areas to reduce the variability associated with low volumes.

- Automated pedestrian counting technologies are rapidly evolving and it is becoming common for jurisdictions to own automated pedestrian counters (APC). With the proliferation of APCs, it is foreseeable that a greater number of short-duration counts will be conducted for longer periods spanning more than 24 hours in length. For this reason, future research should investigate the influence of temporal and spatial factors on daily pedestrian traffic periodicities.

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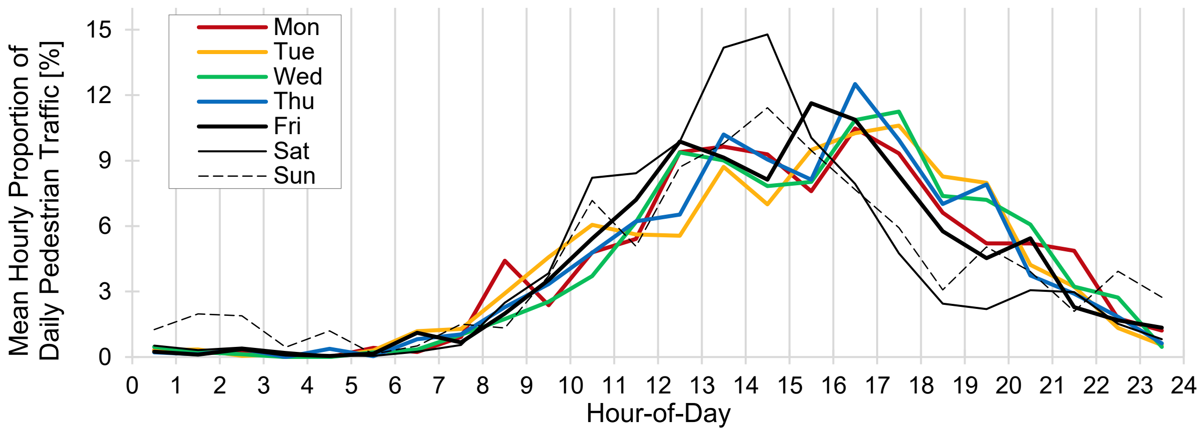
APPENDIX A: RESULTS FROM ANAYISIS OF TYPICAL DAY CONDITION

Typical Day Condition at Academy North

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

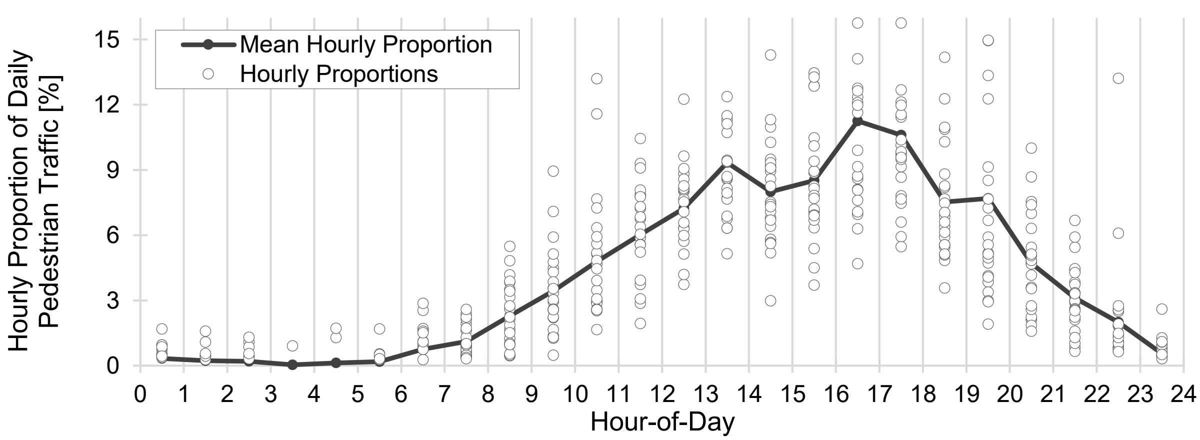
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.16	0.37	0.09	0.47	0.04	0.70	0.08	0.39	0.00	0.43	0.14	0.05	0.00	0.11	0.39	0.22	0.37	0.00	**7**
D2	0.11	0.51	0.02	0.21	0.53	0.79	0.05	0.94	0.56	0.29	0.76	0.75	0.54	0.54	0.58	0.14	0.84	0.14	**2**
D3	0.09	0.81	0.02	0.09	0.51	0.93	0.09	0.89	0.35	0.67	0.64	0.88	0.72	0.75	0.19	0.26	0.77	0.21	**4**
D4	0.02	0.60	0.02	0.07	0.31	0.89	0.08	0.88	0.38	0.55	0.94	0.80	0.61	0.42	0.33	0.31	0.62	0.08	**5**
D5	**0.18**	**0.76**	**0.34**	**0.14**	**0.33**	**0.88**	**0.13**	**0.80**	**0.26**	**0.53**	**0.55**	**0.89**	**0.66**	**0.96**	**0.10**	**0.91**	**0.63**	**0.89**	**1**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

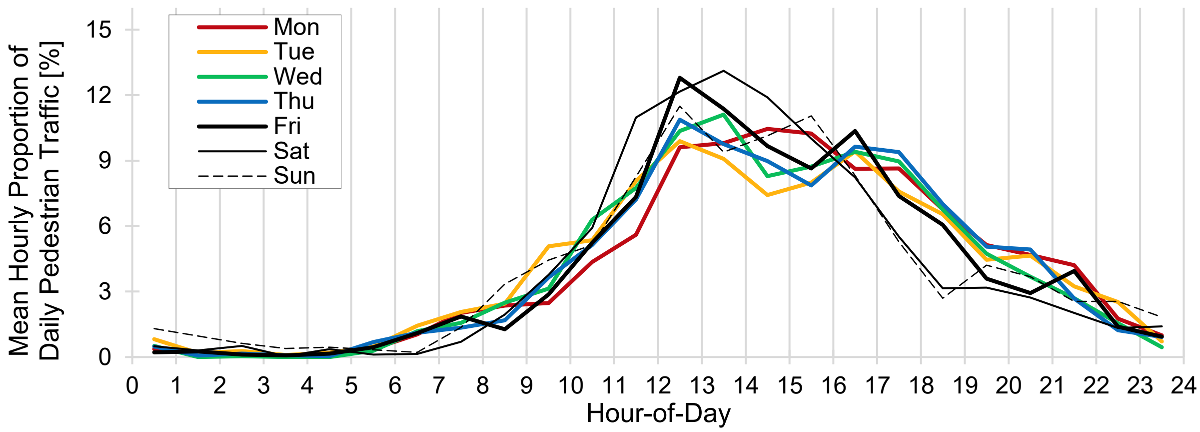
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Academy South

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

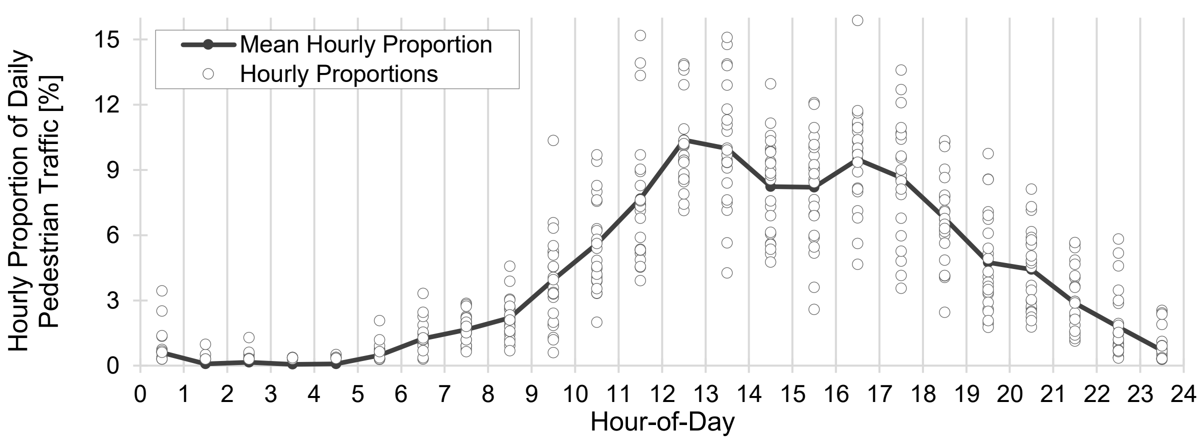
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.00	0.01	0.03	0.33	0.79	0.19	0.29	0.01	0.04	0.39	0.84	0.00	0.00	0.38	0.38	0.34	0.13	0.49	**7**
D2	0.87	0.21	0.02	0.05	0.57	0.51	0.19	0.37	0.16	0.54	0.69	0.30	0.92	0.65	0.23	0.36	0.37	0.77	**2**
D3	0.71	0.12	0.18	0.07	0.35	0.42	0.79	0.48	0.08	0.36	0.86	0.49	0.98	0.93	0.61	0.31	0.33	0.63	**2**
D4	0.41	0.22	0.96	0.05	0.18	0.20	0.81	0.29	0.03	0.30	0.66	0.46	0.97	0.86	0.49	0.30	0.45	0.49	**2**
D5	**0.67**	**0.13**	**0.14**	**0.18**	**0.50**	**0.86**	**0.75**	**0.35**	**0.37**	**0.78**	**0.98**	**0.37**	**0.91**	**0.88**	**0.38**	**0.77**	**0.24**	**0.54**	**0**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

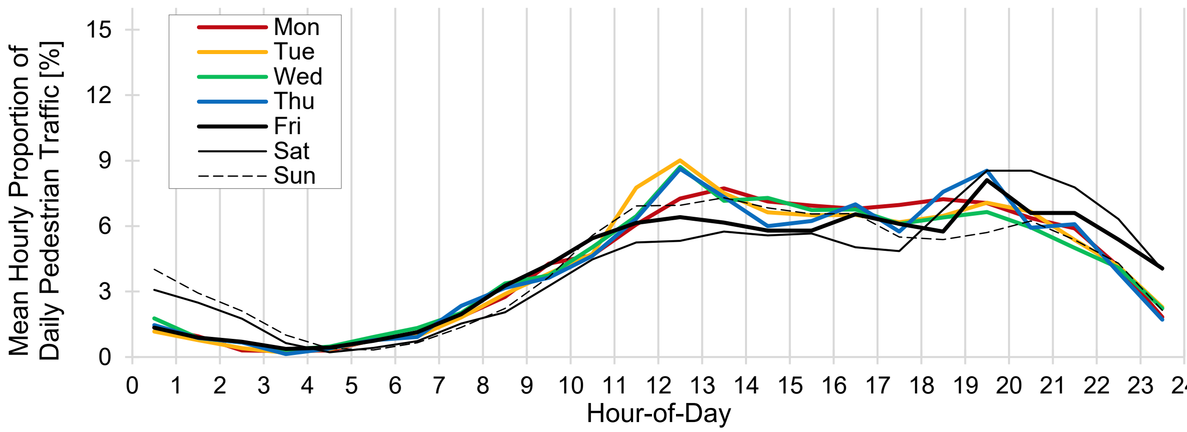
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Corydon North

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

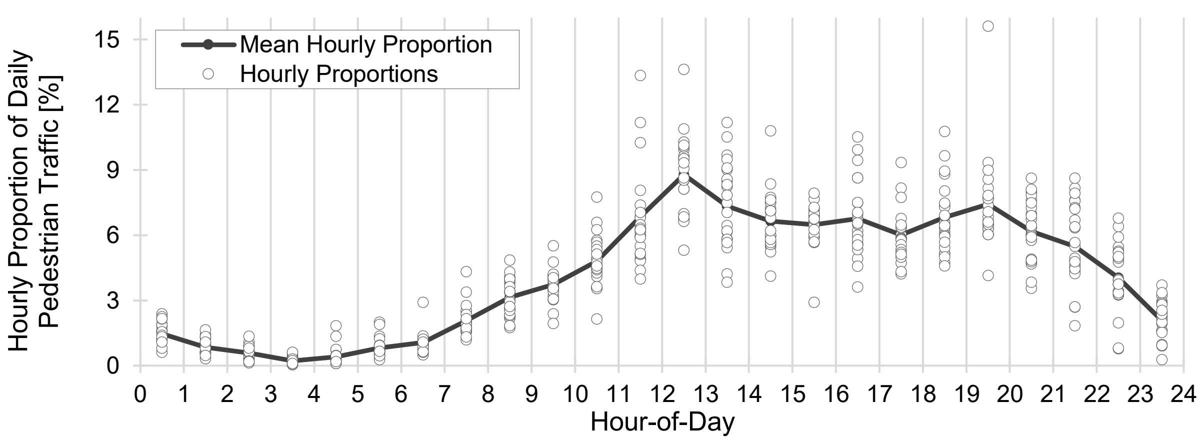
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.05	0.04	0.00	0.09	0.30	0.17	0.00	0.15	0.02	0.15	0.38	0.12	0.18	0.19	0.02	0.07	0.08	0.00	**10**
D2	0.44	0.58	0.55	0.48	0.54	0.51	0.01	0.53	0.06	0.28	0.96	0.48	0.17	0.46	0.84	0.57	0.47	0.00	**3**
D3	0.36	0.32	0.37	0.45	0.89	0.44	0.21	0.95	0.18	0.64	0.94	0.27	0.37	0.19	0.75	0.69	0.98	0.51	**0**
D4	0.38	0.56	0.19	0.38	0.79	0.34	0.02	0.84	0.58	0.64	0.83	0.18	0.40	0.70	0.69	0.70	0.99	0.55	**1**
D5	**0.21**	**0.30**	**0.50**	**0.89**	**0.78**	**0.40**	**0.91**	**0.94**	**0.16**	**0.61**	**0.86**	**0.76**	**0.28**	**0.16**	**0.51**	**0.53**	**0.93**	**0.35**	**0**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

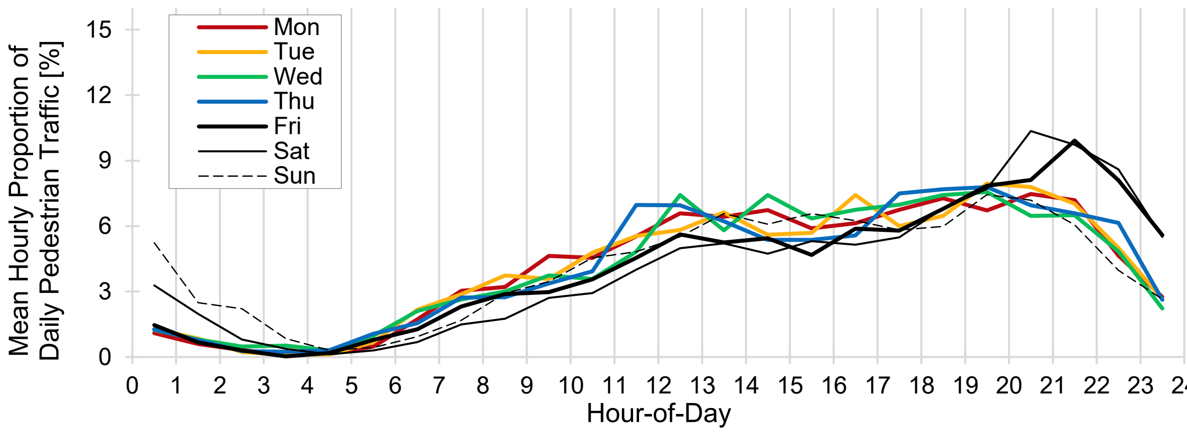
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Corydon South

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

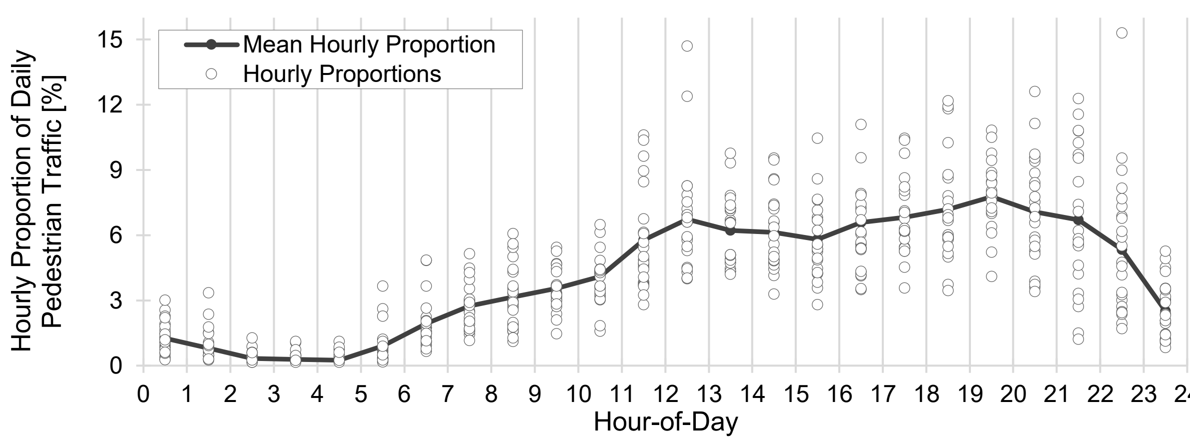
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.00	0.02	0.09	0.03	0.00	0.03	0.12	0.32	0.03	0.45	0.71	0.18	0.81	0.88	0.03	0.18	0.07	0.00	**10**
D2	0.34	0.77	0.68	0.13	0.08	0.15	0.43	0.69	0.06	0.46	0.60	0.40	0.90	0.76	0.72	0.33	0.27	0.00	**3**
D3	0.62	0.91	0.58	0.25	0.15	0.26	0.55	0.76	0.06	0.70	0.56	0.46	0.81	0.44	0.73	0.97	0.75	0.92	**1**
D4	0.72	0.80	0.64	0.29	0.07	0.67	0.36	0.54	0.10	0.72	0.72	0.58	0.71	0.36	0.59	0.92	0.95	0.78	**2**
D5	**0.50**	**0.92**	**0.39**	**0.76**	**0.14**	**0.17**	**0.43**	**0.61**	**0.03**	**0.54**	**0.45**	**0.25**	**0.59**	**0.89**	**0.60**	**0.95**	**0.69**	**0.81**	**1**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

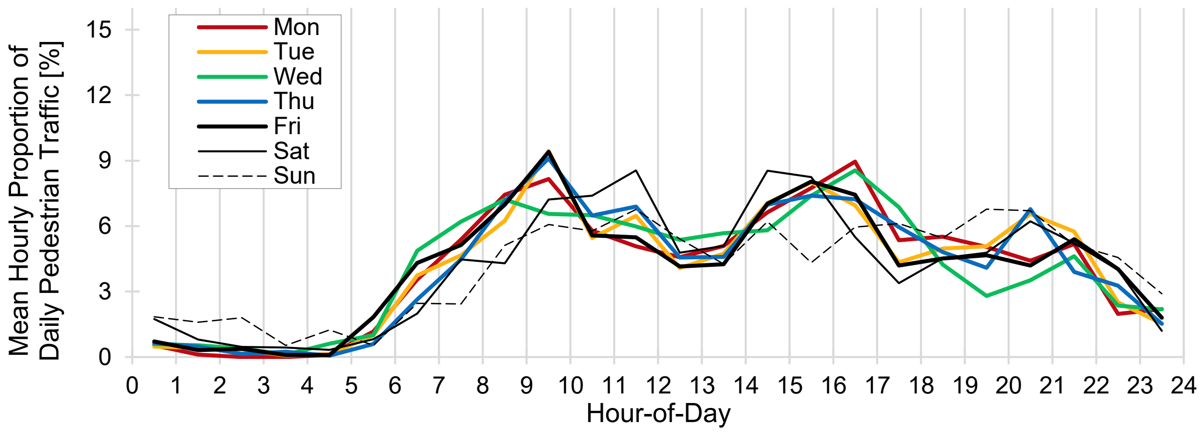
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Dakota East

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

ANOVA Test Results: p-value

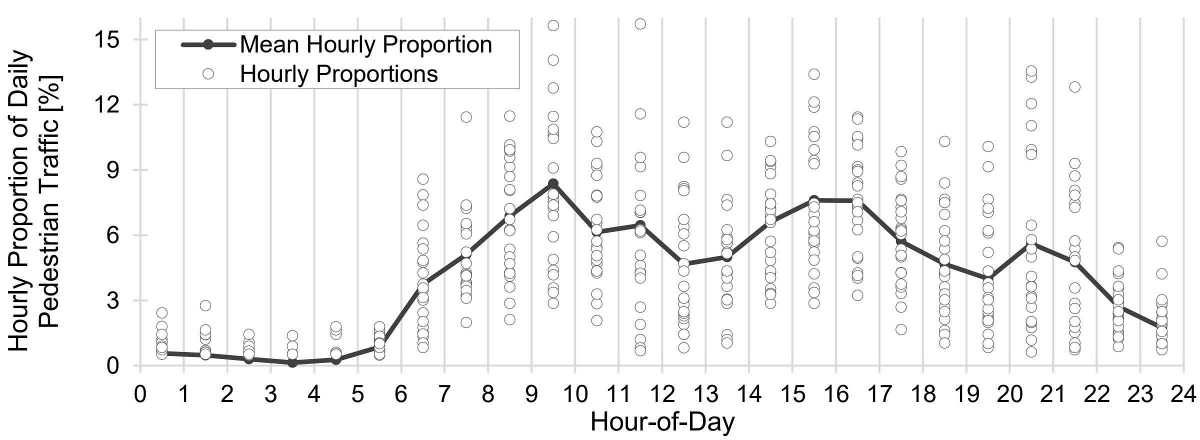
Typical Day Condition	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.08	0.02	0.11	0.46	0.63	0.68	0.95	0.89	0.70	0.18	0.39	0.06	0.96	0.13	0.41	0.95	0.14	0.37	**3**
D2	0.39	0.39	0.92	0.58	0.79	0.92	0.91	0.79	0.86	0.99	0.61	0.14	0.87	0.34	0.27	0.75	0.26	0.78	**0**
D3	0.30	0.27	0.81	0.45	0.72	0.86	0.82	0.81	0.77	0.98	0.43	0.19	0.81	0.27	0.25	0.71	0.32	0.63	**0**
D4	0.55	0.36	0.67	0.28	0.50	0.77	0.71	0.73	0.66	0.93	0.35	0.14	0.60	0.10	0.24	0.79	0.78	0.61	**0**
D5	**0.13**	**0.17**	**0.73**	**0.28**	**0.62**	**0.91**	**0.67**	**0.64**	**0.58**	**0.91**	**0.38**	**0.09**	**0.83**	**0.26**	**0.22**	**0.52**	**0.31**	**0.56**	**1**

(Columns 6–23: Hour-of-Day)

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

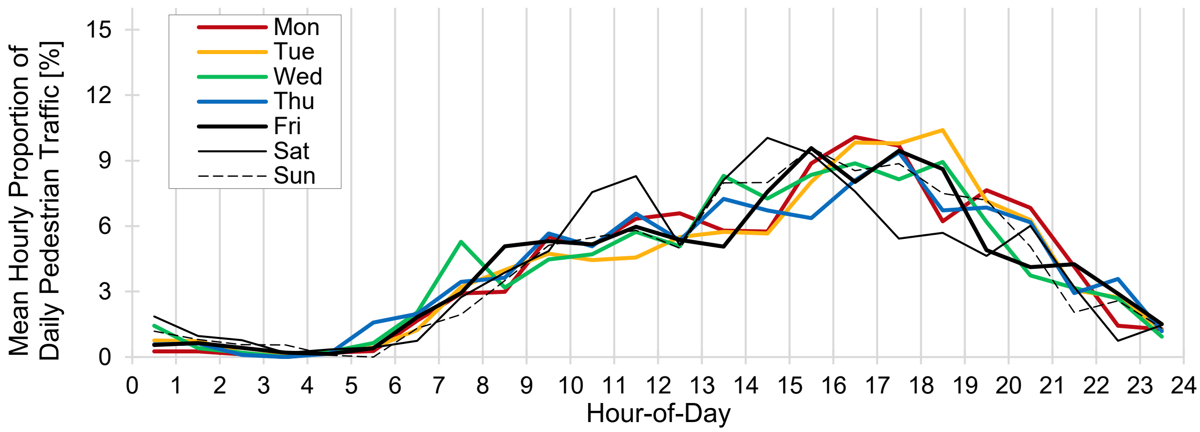
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



<u>**Typical Day Condition at Dakota West**</u>

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

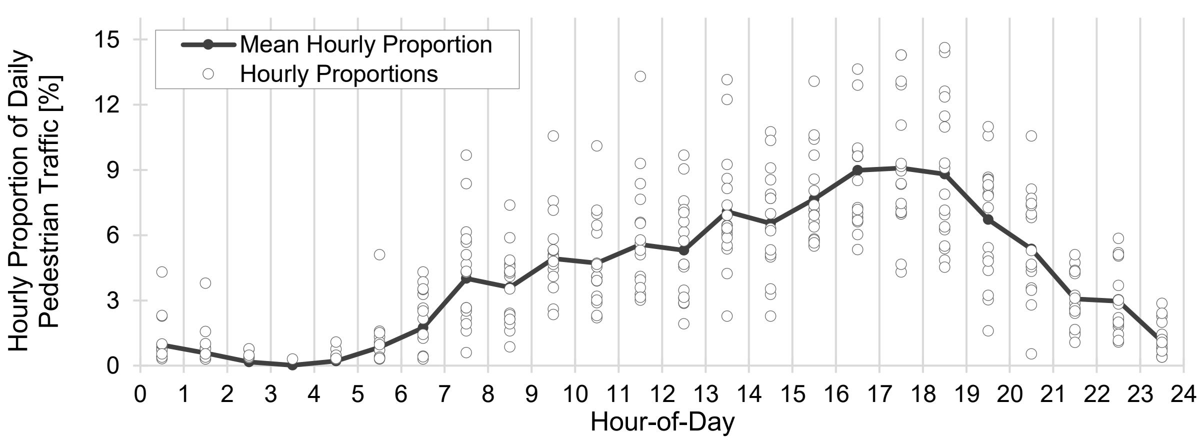
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.79	0.29	0.85	0.99	0.32	0.52	0.97	0.30	0.22	0.40	0.84	0.31	0.37	0.44	0.32	0.13	0.02	0.95	**1**
D2	0.92	0.46	0.64	0.90	0.97	0.81	0.87	0.19	0.67	0.34	0.74	0.91	0.38	0.59	0.21	0.42	0.29	0.85	**0**
D3	0.84	0.40	0.77	0.78	0.94	0.66	0.78	0.29	0.72	0.51	0.69	0.80	0.14	0.88	0.26	0.62	0.21	0.92	**0**
D4	0.69	0.33	0.62	0.69	0.81	0.47	0.58	0.16	0.61	0.91	0.81	0.62	0.17	0.68	0.09	0.45	0.26	0.80	**1**
D5	**0.65**	**0.36**	**0.74**	**0.70**	**0.89**	**0.57**	**0.96**	**0.26**	**0.54**	**0.29**	**0.65**	**0.66**	**0.20**	**0.85**	**0.22**	**0.96**	**0.59**	**0.83**	**0**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

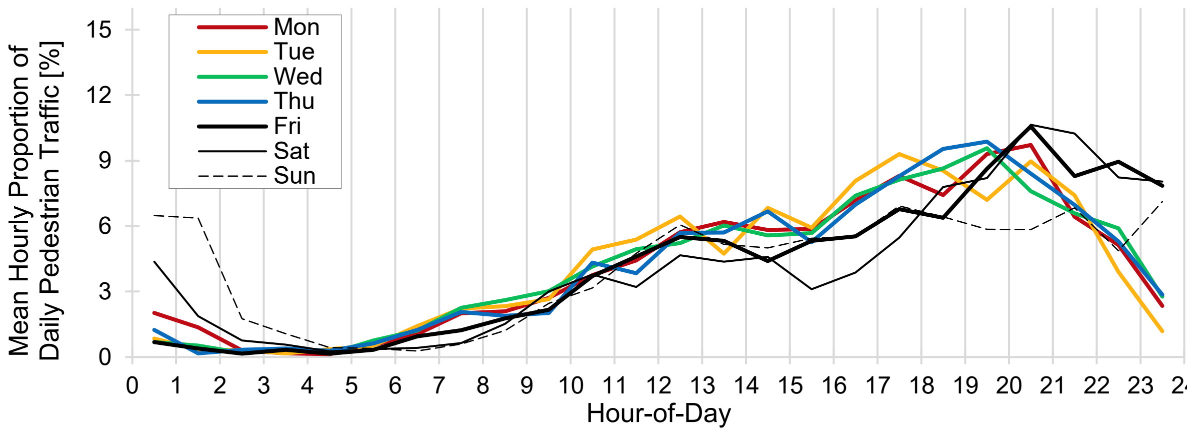
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Osborne East

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

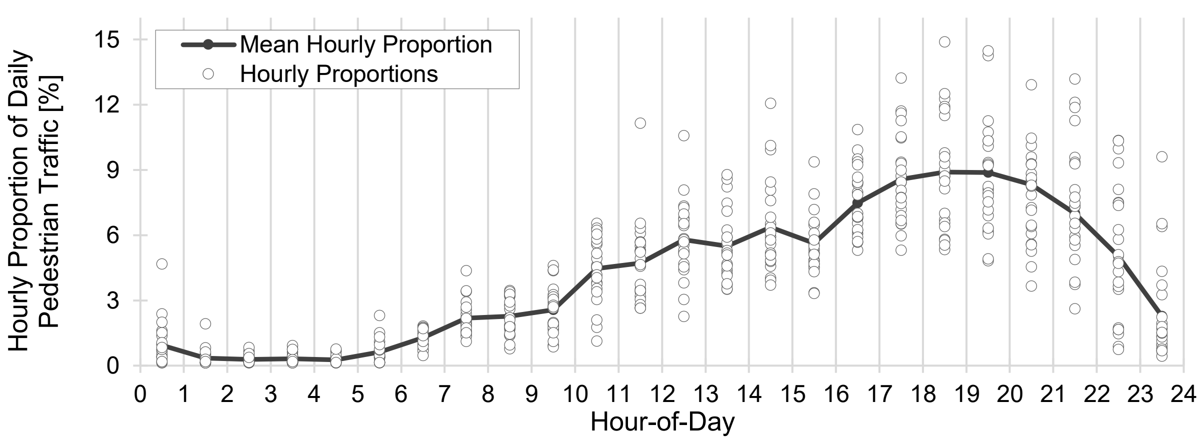
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.00	0.00	0.00	0.32	0.52	0.20	0.84	0.51	0.14	0.02	0.00	0.00	0.36	0.12	0.28	0.74	0.24	0.03	**7**
D2	0.15	0.04	0.19	0.29	0.63	0.50	0.79	0.52	0.07	0.87	0.02	0.13	0.11	0.37	0.60	0.80	0.06	0.00	**5**
D3	0.35	0.90	0.32	0.31	0.65	0.41	0.55	0.34	0.50	0.82	0.54	0.61	0.44	0.24	0.76	0.95	0.70	0.41	**0**
D4	0.25	0.76	0.45	0.73	0.44	0.67	0.23	0.21	0.22	0.95	0.55	0.45	0.44	0.11	0.64	0.81	0.53	0.36	**0**
D5	**0.58**	**0.88**	**0.20**	**0.16**	**0.57**	**0.24**	**0.37**	**0.24**	**0.44**	**0.68**	**0.38**	**0.48**	**0.71**	**0.17**	**0.76**	**0.90**	**0.46**	**0.28**	**0**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

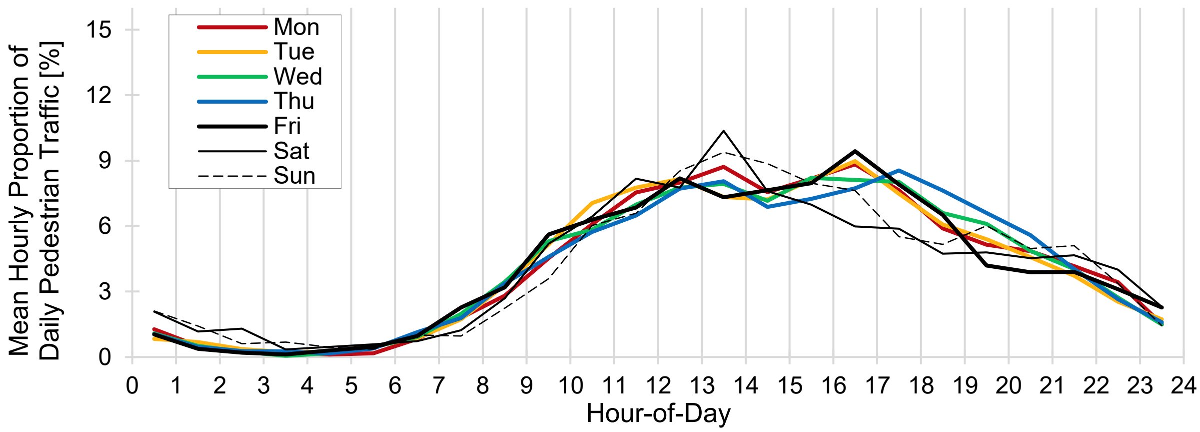
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Osborne West

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

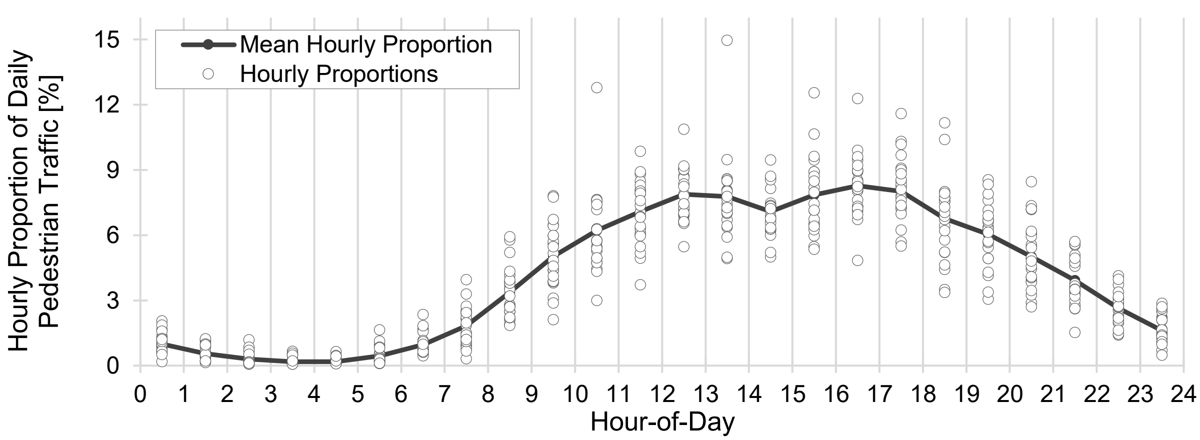
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.90	0.12	0.57	0.23	0.76	0.18	0.94	0.02	0.36	0.53	0.00	0.01	0.04	0.01	0.15	0.44	0.06	0.04	**7**
D2	0.78	0.79	0.84	0.63	0.54	0.44	0.87	0.54	0.77	0.78	0.06	0.69	0.39	0.00	0.17	0.95	0.27	0.24	**2**
D3	0.56	0.95	0.71	0.63	0.45	0.30	0.86	0.57	0.82	0.64	0.17	0.51	0.19	0.12	0.52	0.90	0.24	0.90	**0**
D4	0.92	0.83	0.48	0.48	0.44	0.53	0.81	0.12	0.83	0.99	0.28	0.72	0.61	0.25	0.84	0.69	0.20	0.74	**0**
D5	**0.46**	**0.85**	**0.97**	**0.60**	**0.32**	**0.21**	**0.73**	**0.75**	**0.82**	**0.49**	**0.19**	**0.39**	**0.24**	**0.25**	**0.40**	**0.84**	**0.88**	**0.80**	**0**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

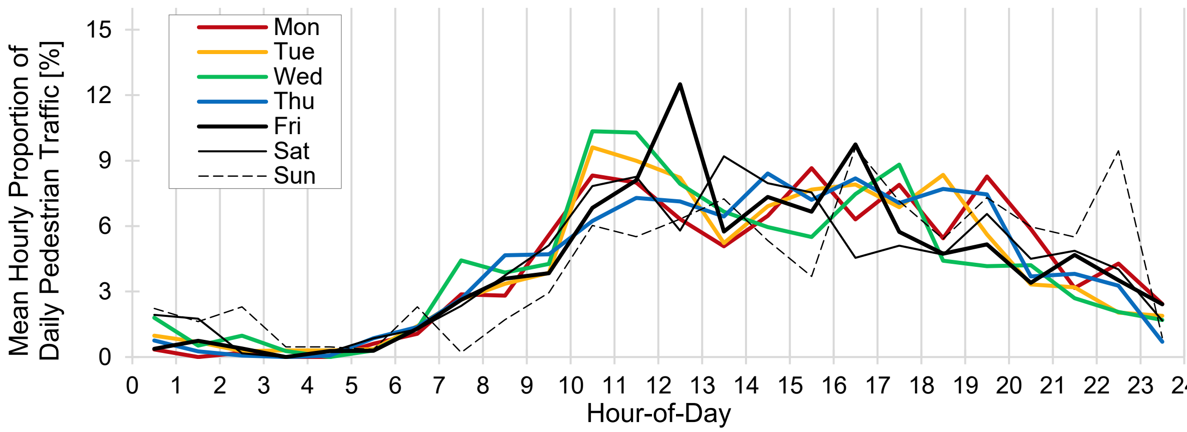
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Roblin North

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

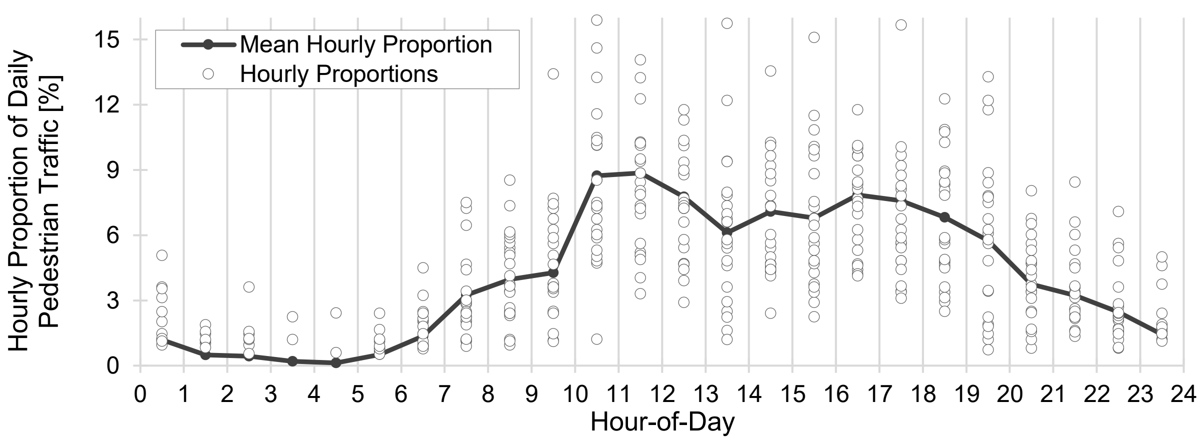
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.83	0.13	0.54	0.87	0.23	0.41	0.02	0.41	0.79	0.30	0.15	0.52	0.04	0.45	0.40	0.52	0.00	0.31	**3**
D2	0.99	0.59	0.55	0.91	0.18	0.64	0.01	0.81	0.81	0.69	0.51	0.61	0.03	0.34	0.27	0.47	0.26	0.25	**2**
D3	0.95	0.50	0.42	0.88	0.16	0.44	0.70	0.72	0.69	0.61	0.68	0.77	0.06	0.30	0.21	0.72	0.06	0.29	**2**
D4	0.88	0.46	0.63	0.72	0.65	0.60	0.35	0.61	0.88	0.40	0.42	0.64	0.07	0.24	0.20	0.79	0.02	0.77	**2**
D5	**0.99**	**0.39**	**0.46**	**0.86**	**0.11**	**0.37**	**0.81**	**0.67**	**0.49**	**0.47**	**0.90**	**0.63**	**0.02**	**0.22**	**0.71**	**0.55**	**0.29**	**0.32**	**1**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

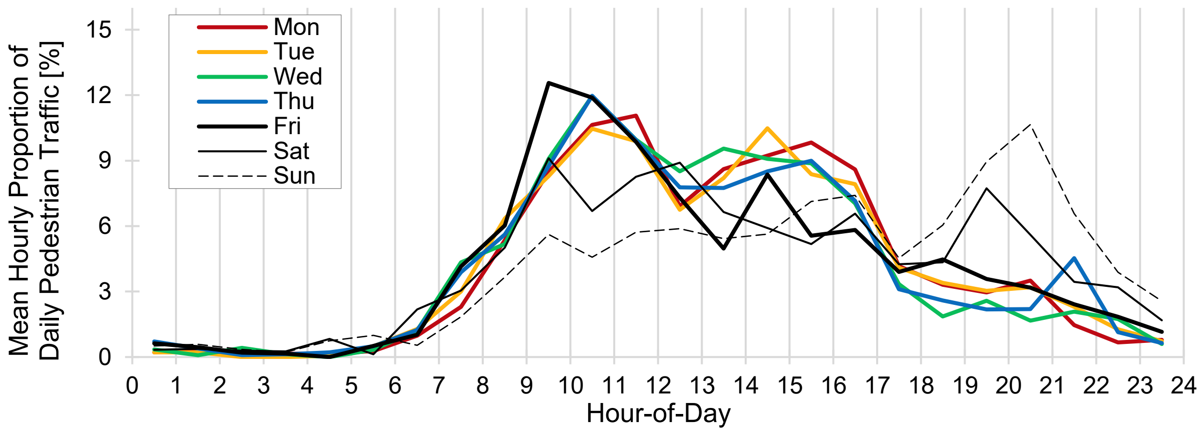
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at Roblin South

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

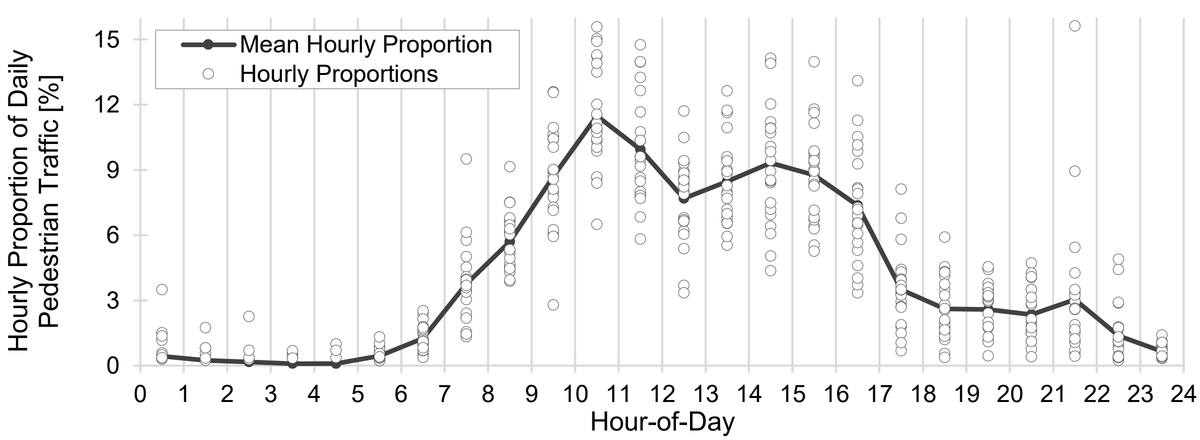
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.00	0.07	0.19	0.02	0.00	0.03	0.56	0.00	0.01	0.01	0.74	0.93	0.00	0.00	0.00	0.02	0.01	0.01	**14**
D2	0.78	0.19	0.68	0.05	0.57	0.86	0.55	0.00	0.59	0.03	0.30	0.78	0.02	0.28	0.07	0.32	0.44	0.49	**5**
D3	0.77	0.15	0.50	0.93	0.47	0.78	0.34	0.35	0.61	0.78	0.67	0.61	0.13	0.56	0.04	0.26	0.51	0.85	**1**
D4	0.61	0.16	0.38	0.82	0.44	0.63	0.19	0.49	0.61	0.61	0.50	0.67	0.10	0.68	0.03	0.38	0.39	0.72	**2**
D5	**0.98**	**0.39**	**0.28**	**0.82**	**0.42**	**1.00**	**0.28**	**0.19**	**0.40**	**0.86**	**0.79**	**0.56**	**0.13**	**0.44**	**0.06**	**0.32**	**0.68**	**0.77**	**1**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

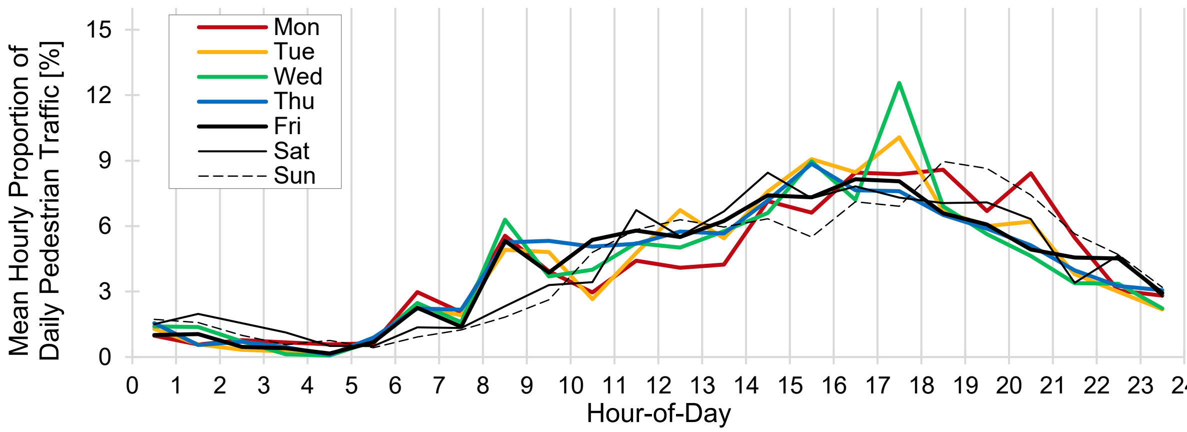
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



<u>**Typical Day Condition at St Anne's East**</u>

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

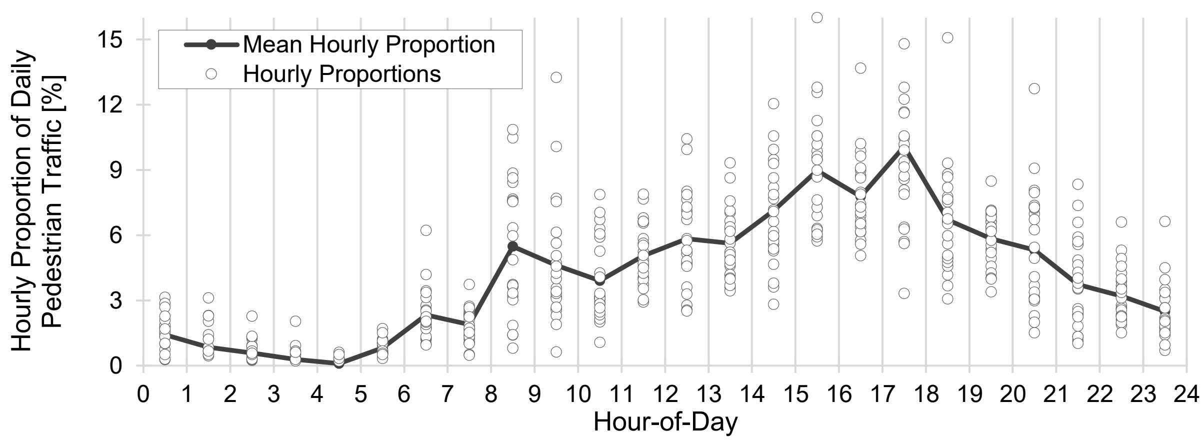
ANOVA Test Results: p-value

Typical Day Condition	Hour-of-Day: 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.01	0.17	0.02	0.24	0.02	0.60	0.42	0.48	0.73	0.01	0.89	0.03	0.40	0.20	0.09	0.23	0.17	0.88	**6**
D2	0.70	0.29	0.93	0.59	0.01	0.69	0.33	0.29	0.95	0.21	0.67	0.07	0.61	0.88	0.09	0.47	0.32	0.66	**3**
D3	0.66	0.51	0.81	0.57	0.03	0.63	0.10	0.32	0.89	0.29	0.46	0.08	0.50	0.68	0.10	0.33	0.95	0.49	**3**
D4	0.63	0.57	0.66	0.54	0.15	0.50	0.06	0.19	0.76	0.24	0.36	0.20	0.49	0.55	0.07	0.11	0.86	0.54	**2**
D5	**0.90**	**0.38**	**0.65**	**0.50**	**0.02**	**0.78**	**0.29**	**0.92**	**0.75**	**0.99**	**0.41**	**0.07**	**0.95**	**0.86**	**0.54**	**0.85**	**0.86**	**0.33**	**2**

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

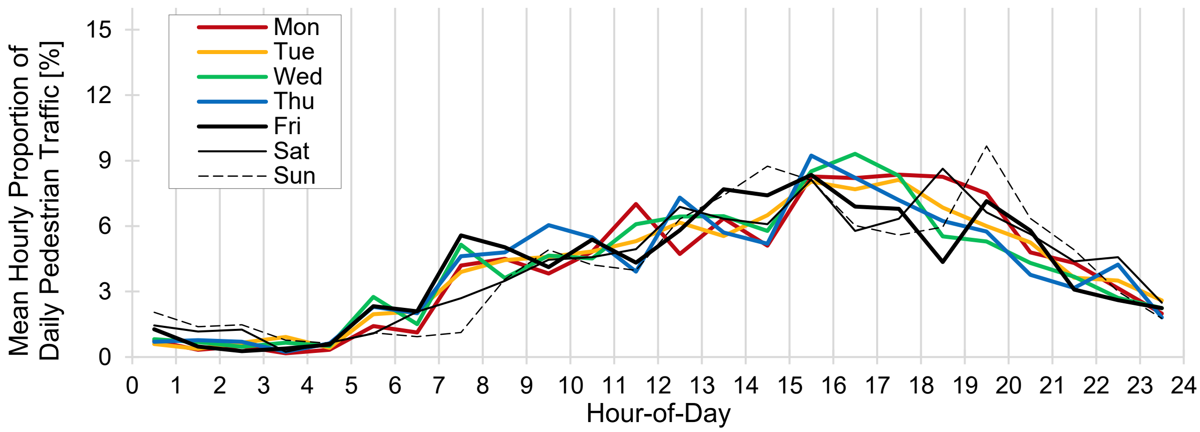
Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)



Typical Day Condition at St Anne's West

INITIAL DATA SET

Mean Hourly Proportion of Daily Pedestrian Traffic by Day-of-Week



STATISTICAL COMPARISON

ANOVA Test Results: p-value

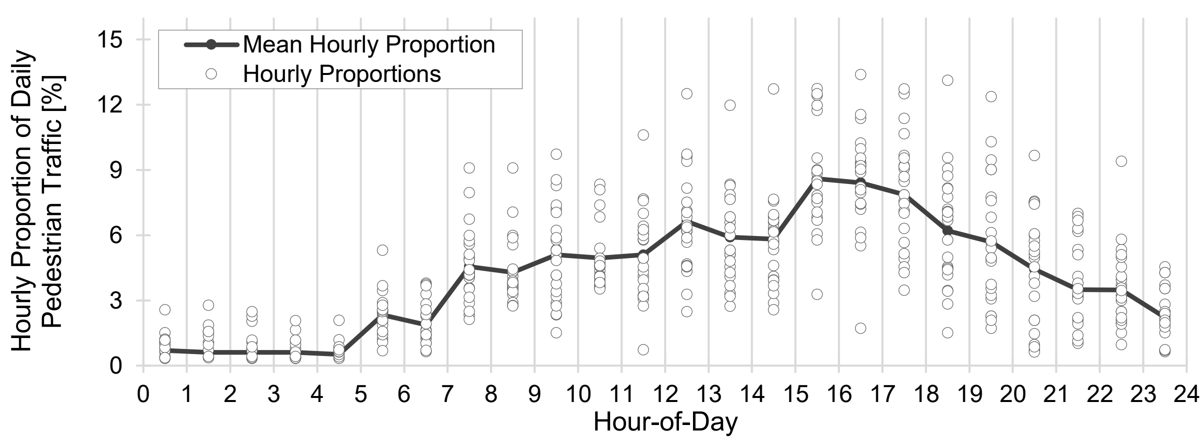
Typical Day Condition	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
D1	0.25	0.00	0.19	0.42	0.78	0.04	0.65	0.62	0.07	0.98	0.06	0.49	0.04	0.19	0.57	0.66	0.38	0.84	**5**
D2	0.33	0.29	0.42	0.23	0.71	0.01	0.35	0.45	0.22	0.93	0.30	0.79	0.12	0.58	0.49	0.86	0.37	0.80	**1**
D3	0.24	0.46	0.45	0.23	0.67	0.03	0.25	0.83	0.55	0.78	0.49	0.83	0.36	0.50	0.68	0.83	0.40	0.68	**1**
D4	0.13	0.37	0.45	0.65	0.88	0.28	0.23	0.59	0.49	0.93	0.10	0.99	0.27	0.31	0.75	0.84	0.53	0.71	**0**
D5	**0.49**	**0.34**	**0.28**	**0.33**	**0.40**	**0.10**	**0.62**	**0.67**	**0.50**	**0.61**	**0.38**	**0.66**	**0.62**	**0.89**	**0.52**	**0.87**	**0.24**	**0.50**	**1**

(Column header: Hour-of-Day)

D1 *= Mon - Sat;* ***D2*** *= Mon - Fri;* ***D3*** *= Mon - Thu;* ***D4*** *= Mon - Wed;* ***D5*** *= Tue - Thu*

RESULTS

Hourly Pedestrian Traffic Periodicity for Typical Day Condition D5 (Tuesday to Thursday)

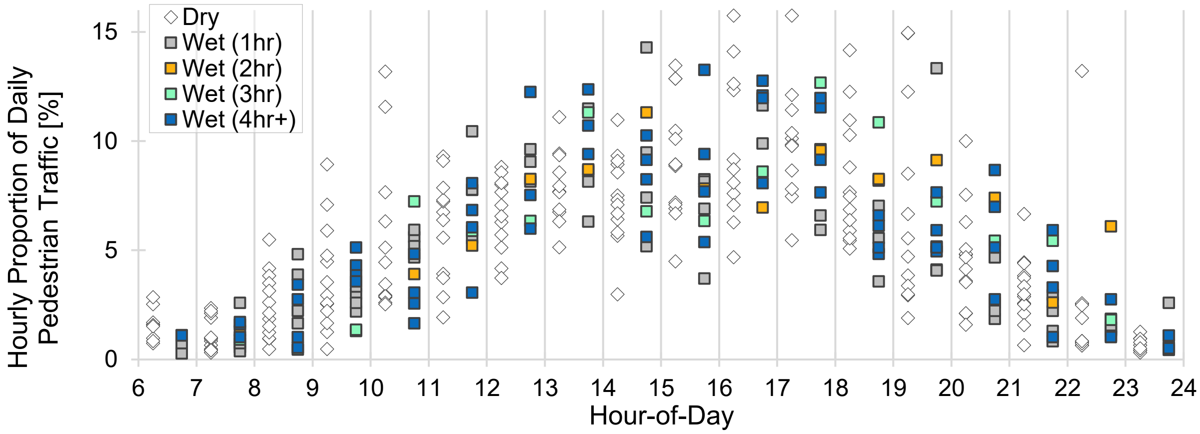


APPENDIX B: RESULTS FROM ANALYSIS OF PRECIPITATION CONDIITON

Typical Precipitation Condition at Academy North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

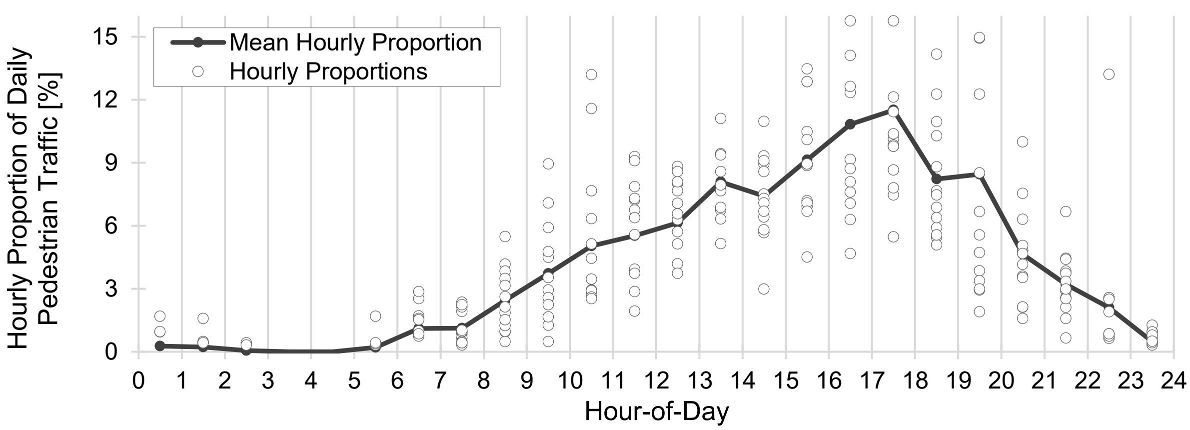
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.02	0.88	0.57	0.41	0.63	0.30	0.16	0.12	0.19	0.21	0.59	0.29	0.15	0.43	0.90	0.75	0.84	0.62	**1**
P2	0.01	0.86	0.06	0.58	0.80	0.78	0.30	0.46	0.64	0.90	0.96	0.68	0.62	0.38	0.14	0.42	0.93	0.49	**2**
P3	0.12	0.75	0.17	0.94	0.36	0.79	0.33	0.63	0.45	0.79	0.71	0.40	0.10	0.35	0.15	0.88	0.95	0.35	**0**
P4	0.23	0.98	0.38	0.76	0.51	0.47	0.31	0.93	0.57	0.36	0.40	0.49	0.47	0.45	0.32	0.44	0.91	0.53	**0**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

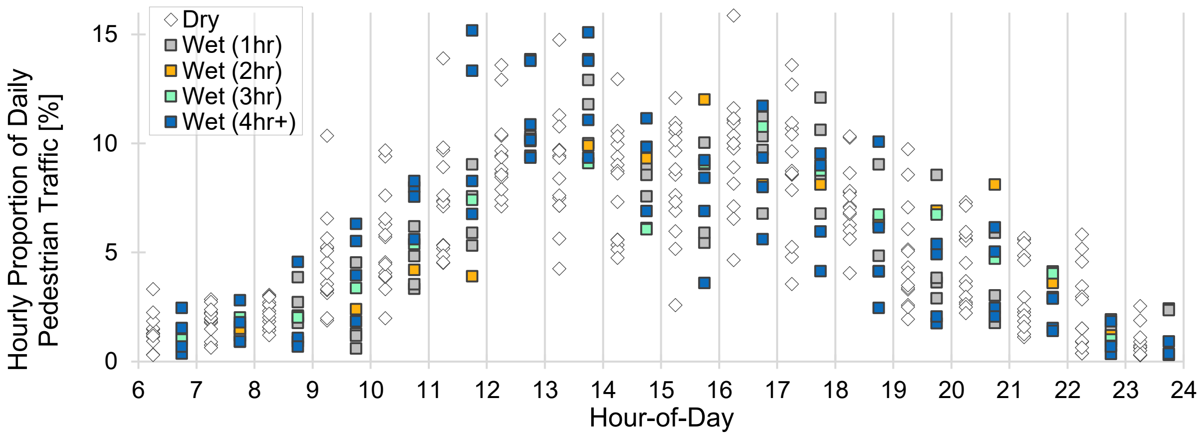
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Academy South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

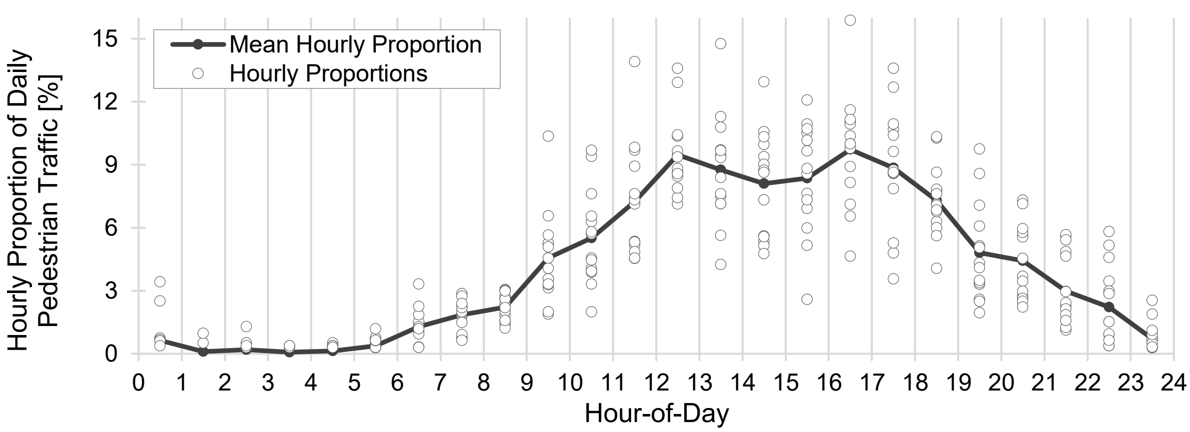
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.71	0.13	0.92	0.10	0.84	0.43	0.03	0.01	0.73	0.71	0.58	0.65	0.13	0.89	0.97	0.70	0.06	0.91	**3**
P2	0.71	0.34	0.67	0.51	0.74	0.53	0.67	0.06	0.77	0.23	0.25	0.57	0.01	0.62	0.48	0.30	0.05	0.89	**3**
P3	0.58	0.20	0.74	0.57	0.69	0.54	0.61	0.03	0.42	0.27	0.13	0.53	0.00	0.92	0.50	0.14	0.07	0.94	**3**
P4	0.70	0.40	0.86	0.92	0.85	0.51	0.55	0.03	0.63	0.33	0.19	0.38	0.00	0.95	0.81	0.25	0.02	0.94	**3**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

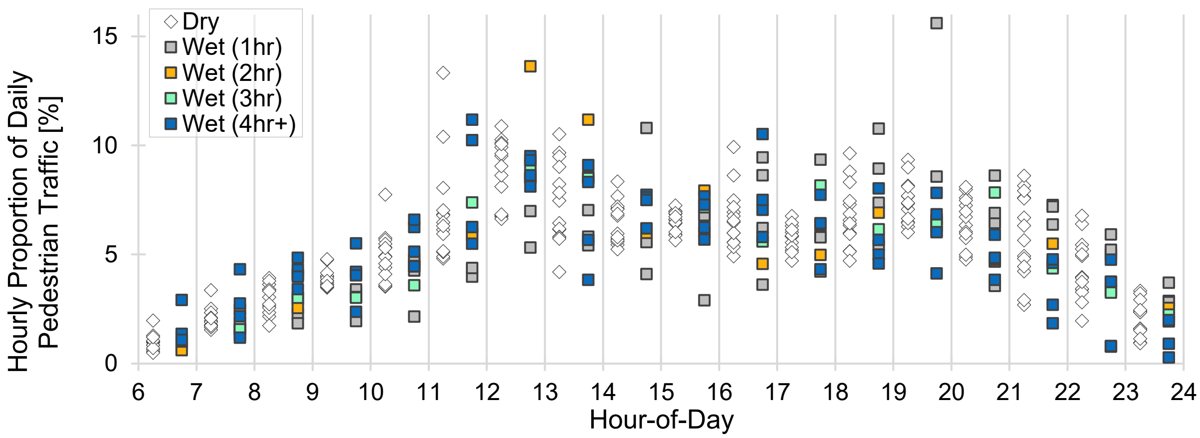
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Corydon North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

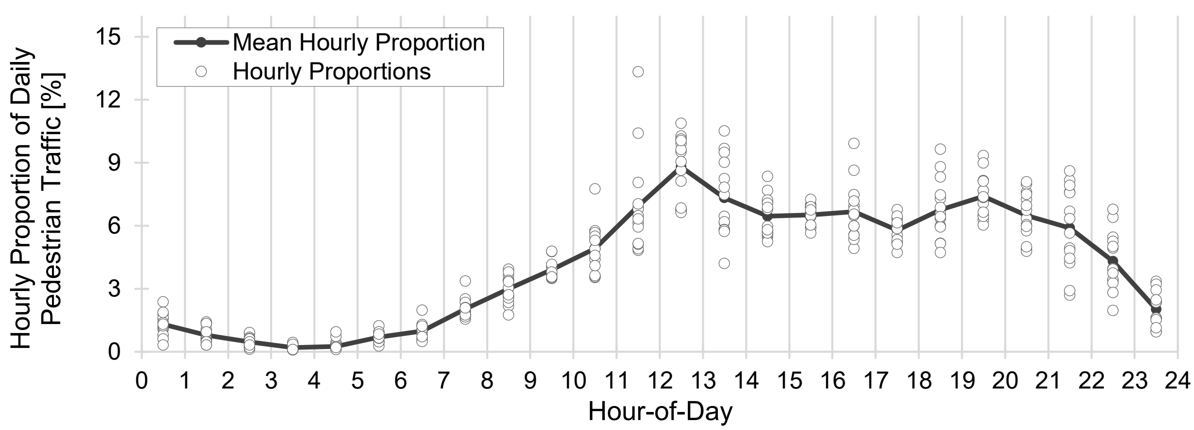
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.42	0.89	0.35	0.24	0.54	0.80	0.96	0.98	0.50	0.86	0.77	0.36	0.87	0.97	0.20	0.22	0.31	0.77	**0**
P2	0.43	0.78	0.32	0.35	0.34	0.54	0.78	0.87	0.83	0.04	0.44	0.23	0.86	0.37	0.16	0.10	0.06	0.73	**3**
P3	0.45	0.64	0.47	0.53	0.61	0.59	0.83	0.64	0.93	0.08	0.24	0.49	0.99	0.46	0.03	0.14	0.08	0.64	**3**
P4	0.53	0.42	0.66	0.89	0.69	0.36	0.93	0.44	0.61	0.04	0.11	0.80	0.70	0.52	0.08	0.18	0.03	0.67	**3**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

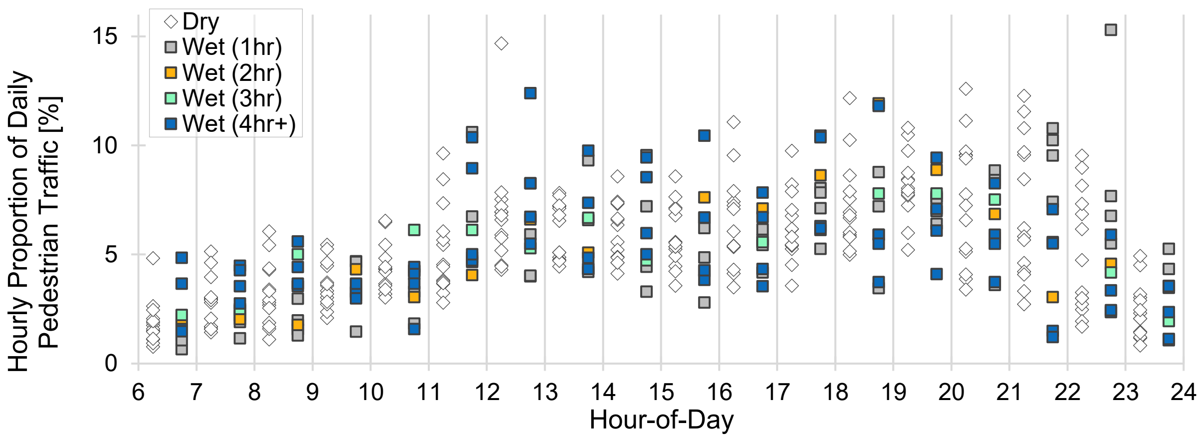
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Corydon South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

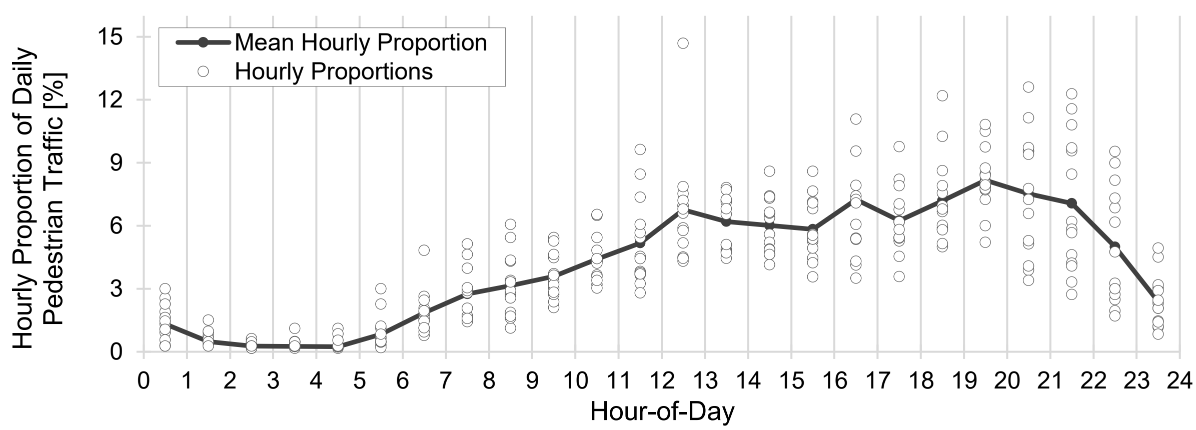
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.68	0.96	0.96	0.84	0.14	0.14	0.95	0.94	0.73	0.94	0.14	0.06	0.99	0.14	0.28	0.53	0.55	0.65	**1**
P2	0.09	0.46	0.55	0.31	0.10	0.03	0.32	0.49	1.00	0.05	0.59	0.01	0.22	0.06	0.41	0.07	0.46	0.39	**6**
P3	0.09	0.37	0.99	0.26	0.01	0.03	0.61	0.38	0.70	0.07	0.74	0.00	0.23	0.04	0.34	0.08	0.68	0.48	**7**
P4	0.04	0.33	0.90	0.32	0.10	0.01	0.38	0.75	0.56	0.10	0.73	0.00	0.80	0.05	0.42	0.09	0.58	0.47	**7**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

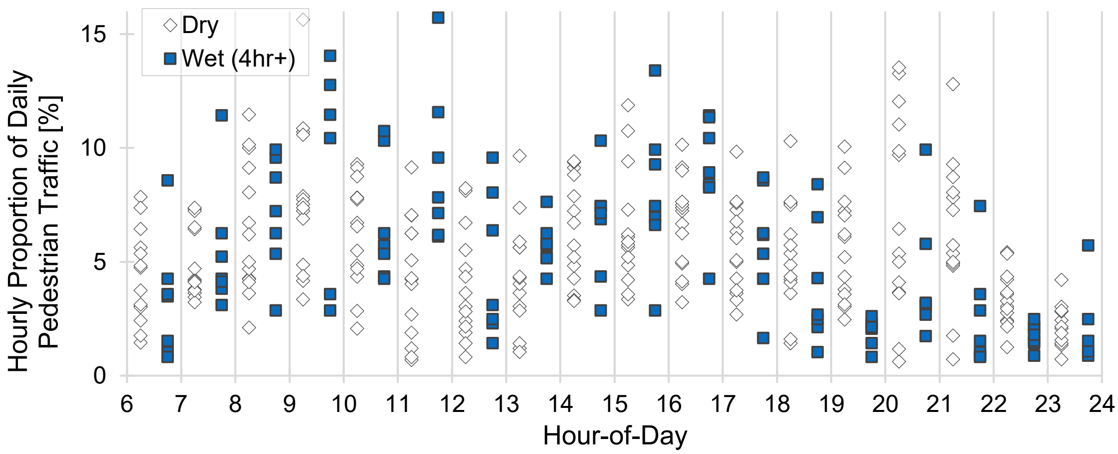
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Dakota East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

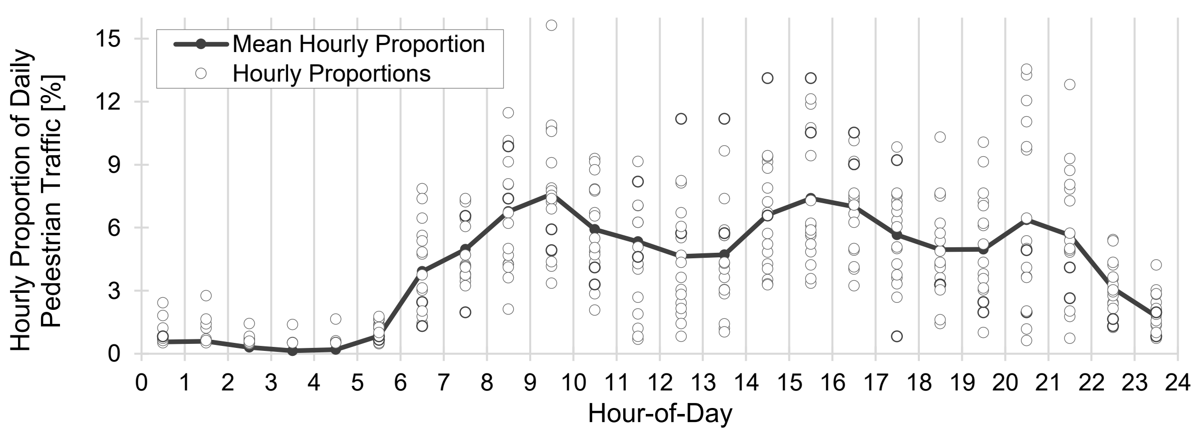
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.56	0.61	0.77	0.14	0.47	0.04	0.93	0.21	0.99	0.65	0.06	0.87	0.40	0.00	0.17	0.03	0.00	0.89	**5**
P2	0.56	0.61	0.77	0.14	0.47	0.04	0.93	0.21	0.99	0.65	0.06	0.87	0.40	0.00	0.17	0.03	0.00	0.89	**5**
P3	0.56	0.61	0.77	0.14	0.47	0.04	0.93	0.21	0.99	0.65	0.06	0.87	0.40	0.00	0.17	0.03	0.00	0.89	**5**
P4	0.56	0.61	0.77	0.14	0.47	0.04	0.93	0.21	0.99	0.65	0.06	0.87	0.40	0.00	0.17	0.03	0.00	0.89	**5**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

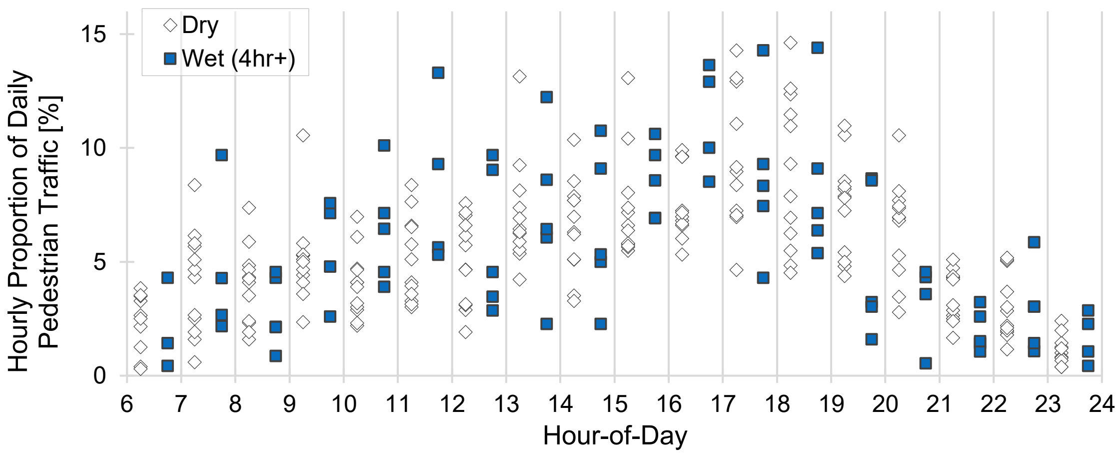
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Dakota West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

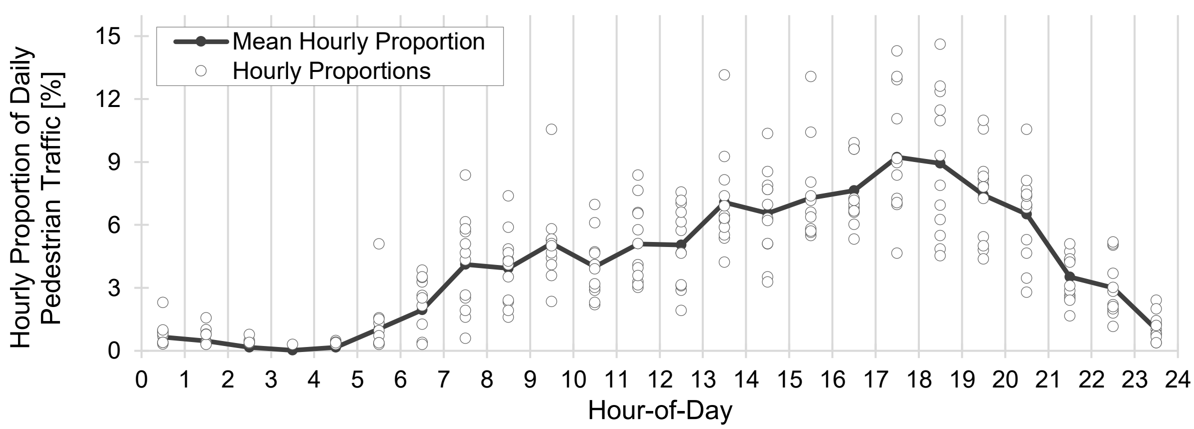
	Hour-of-Day 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
P1	0.41	0.81	0.22	0.58	0.02	0.51	0.50	0.97	0.96	0.29	0.00	0.77	0.81	0.09	0.00	0.01	0.89	0.53	**5**
P2	0.41	0.81	0.22	0.58	0.02	0.51	0.50	0.97	0.96	0.29	0.00	0.77	0.81	0.09	0.00	0.01	0.89	0.53	**5**
P3	0.41	0.81	0.22	0.58	0.02	0.51	0.50	0.97	0.96	0.29	0.00	0.77	0.81	0.09	0.00	0.01	0.89	0.53	**5**
P4	0.41	0.81	0.22	0.58	0.02	0.51	0.50	0.97	0.96	0.29	0.00	0.77	0.81	0.09	0.00	0.01	0.89	0.53	**5**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

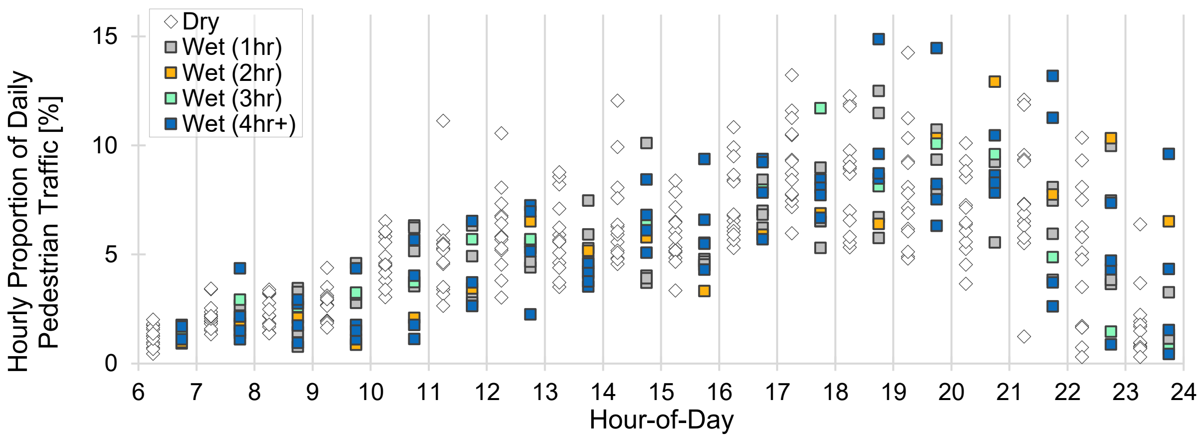
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Osborne East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

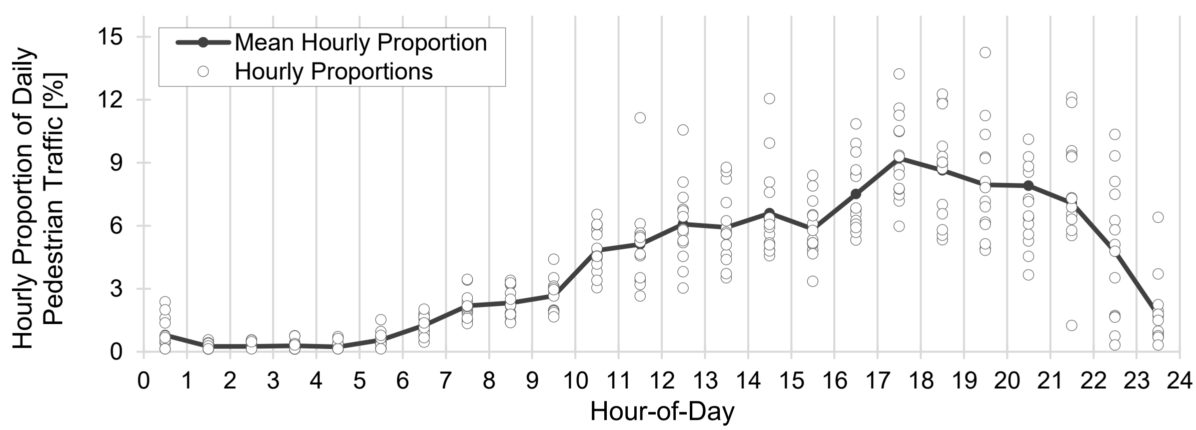
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.58	0.99	0.70	0.64	0.21	0.24	0.33	0.11	0.54	0.39	0.93	0.07	0.57	0.08	0.46	0.89	0.65	0.24	**2**
P2	0.14	0.29	0.11	0.23	0.18	0.39	0.85	0.06	0.40	0.71	0.63	0.63	0.99	0.55	0.19	0.75	0.88	0.15	**1**
P3	0.18	0.52	0.05	0.10	0.27	0.24	0.86	0.11	0.39	0.67	0.72	0.04	0.87	0.33	0.39	0.97	0.70	0.10	**2**
P4	0.40	0.47	0.01	0.18	0.32	0.32	0.51	0.31	0.68	0.61	0.79	0.02	0.98	0.56	0.32	0.63	0.59	0.20	**2**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

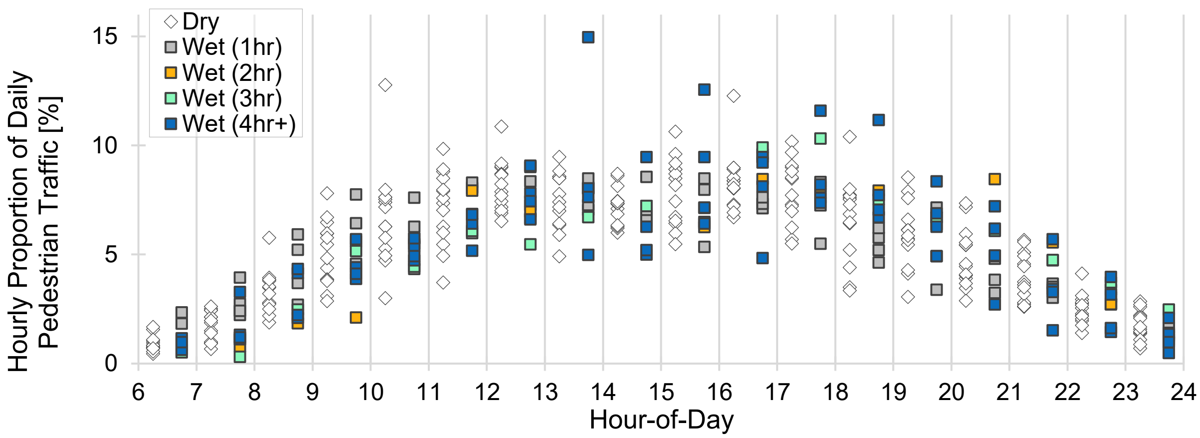
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Osborne West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Number of Rejected H_o
P1	0.46	0.68	0.75	0.88	0.07	0.73	0.16	0.52	0.50	0.77	0.75	0.63	0.63	0.72	0.56	0.96	0.24	0.15	**1**
P2	0.65	0.34	0.29	0.19	0.01	0.24	0.11	0.21	0.55	0.47	0.02	0.06	0.09	0.21	0.35	0.54	0.67	0.69	**4**
P3	0.33	0.86	0.46	0.15	0.02	0.37	0.49	0.45	0.57	0.24	0.07	0.23	0.11	0.27	0.52	0.31	0.80	0.28	**2**
P4	0.15	0.92	0.83	0.18	0.04	0.78	0.47	0.37	0.58	0.44	0.38	0.14	0.08	0.26	0.47	0.39	0.21	0.11	**2**

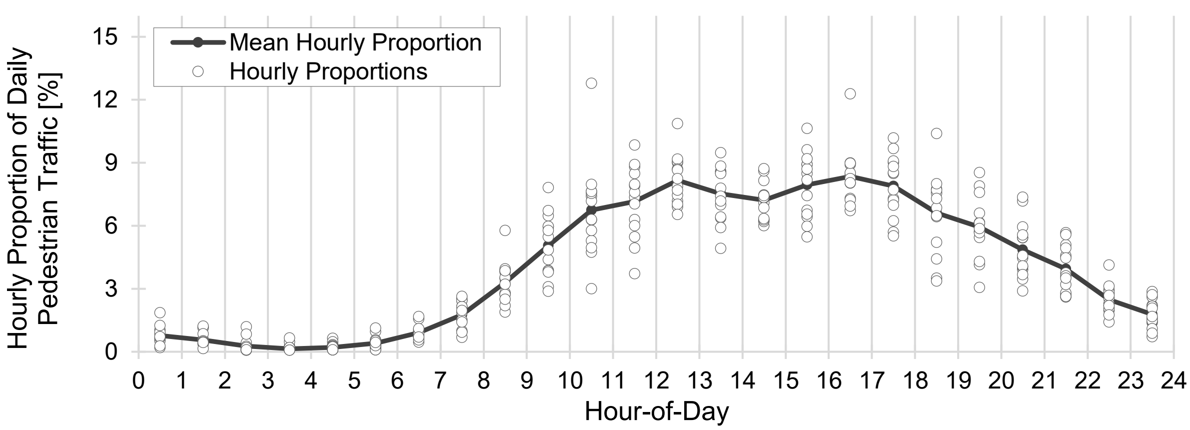
Hour-of-Day

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

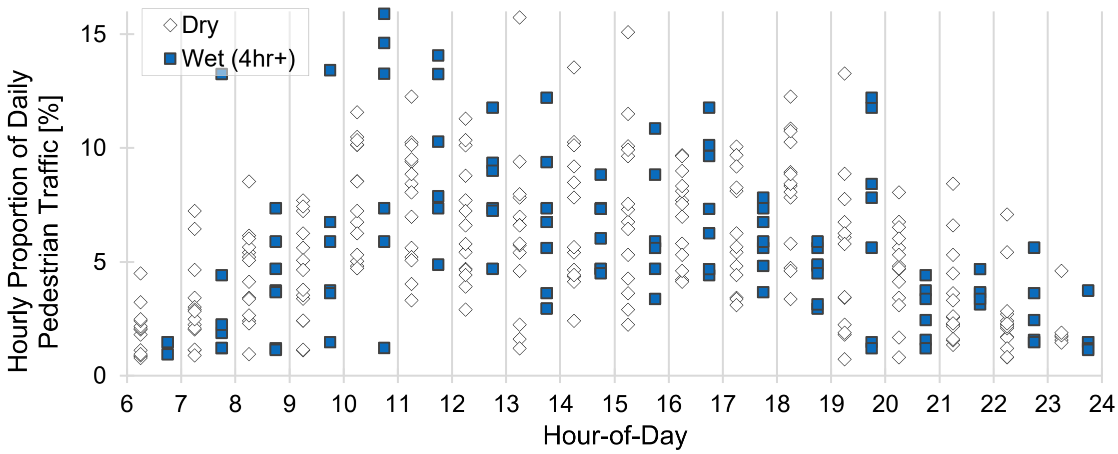
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Roblin North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

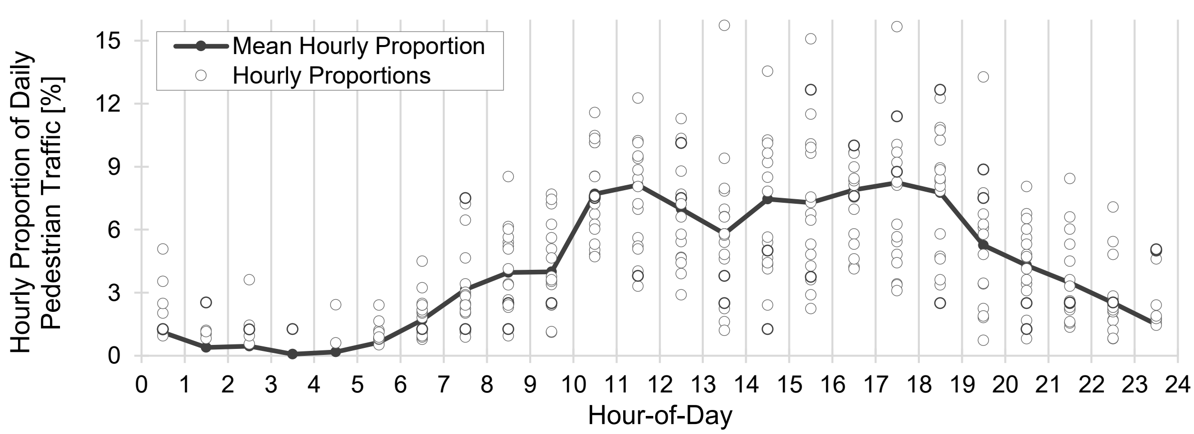
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.02	0.87	0.99	0.59	0.22	0.18	0.17	0.51	0.34	0.32	0.90	0.10	0.00	0.34	0.04	0.35	0.80	0.78	**3**
P2	0.02	0.87	0.99	0.59	0.22	0.18	0.17	0.51	0.34	0.32	0.90	0.10	0.00	0.34	0.04	0.35	0.80	0.78	**3**
P3	0.02	0.87	0.99	0.59	0.22	0.18	0.17	0.51	0.34	0.32	0.90	0.10	0.00	0.34	0.04	0.35	0.80	0.78	**3**
P4	0.02	0.87	0.99	0.59	0.22	0.18	0.17	0.51	0.34	0.32	0.90	0.10	0.00	0.34	0.04	0.35	0.80	0.78	**3**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

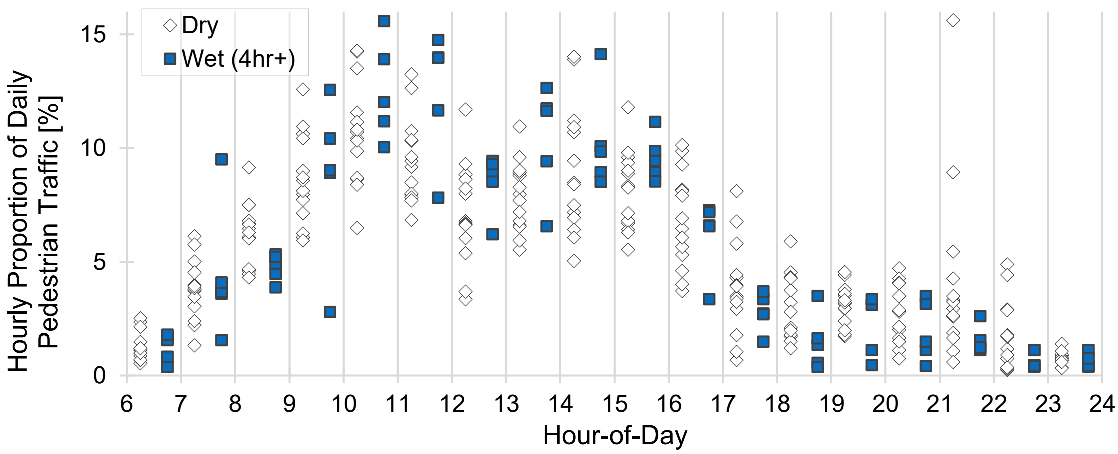
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at Roblin South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

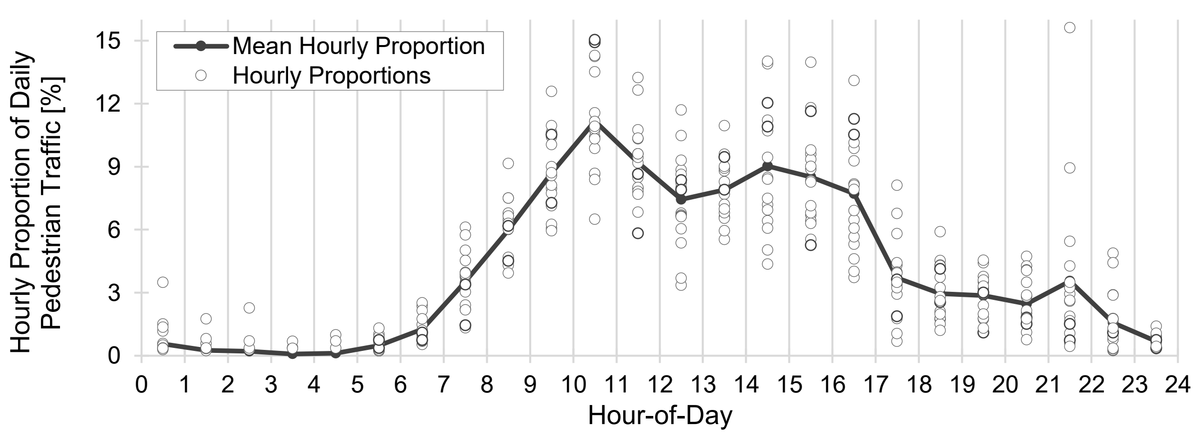
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.95	0.52	0.01	0.98	0.28	0.01	0.33	0.01	0.38	0.17	0.25	0.15	0.04	0.04	0.40	0.04	0.04	0.40	**7**
P2	0.95	0.52	0.01	0.98	0.28	0.01	0.33	0.01	0.38	0.17	0.25	0.15	0.04	0.04	0.40	0.04	0.04	0.40	**7**
P3	0.95	0.52	0.01	0.98	0.28	0.01	0.33	0.01	0.38	0.17	0.25	0.15	0.04	0.04	0.40	0.04	0.04	0.40	**7**
P4	0.95	0.52	0.01	0.98	0.28	0.01	0.33	0.01	0.38	0.17	0.25	0.15	0.04	0.04	0.40	0.04	0.04	0.40	**7**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

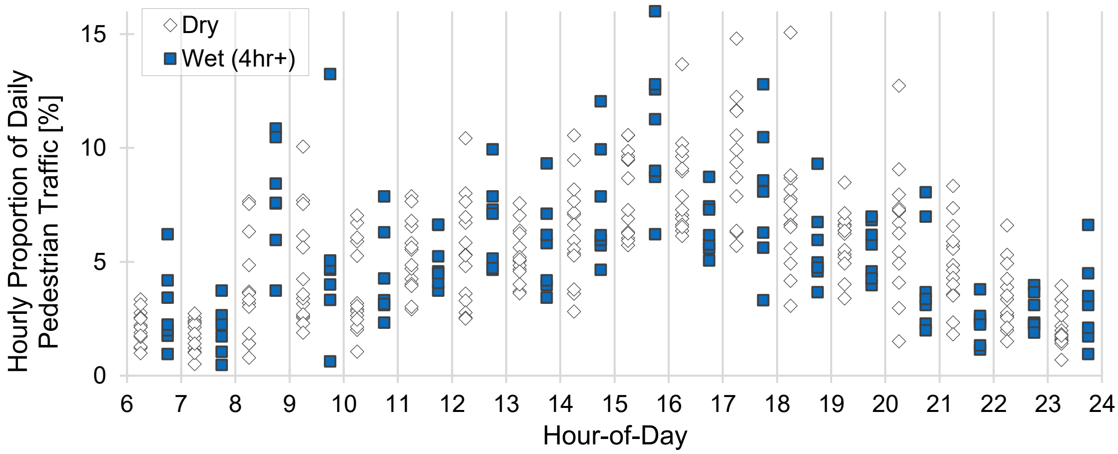
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at St Anne's East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

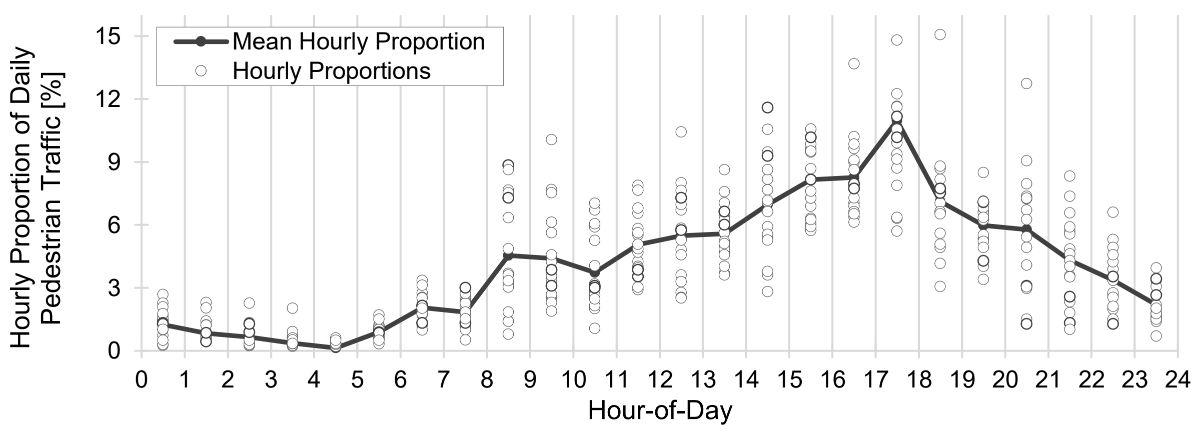
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.24	0.62	0.01	0.68	0.48	0.98	0.23	0.86	0.66	0.07	0.04	0.11	0.21	0.43	0.22	0.00	0.21	0.22	**4**
P2	0.24	0.62	0.01	0.68	0.48	0.98	0.23	0.86	0.66	0.07	0.04	0.11	0.21	0.43	0.22	0.00	0.21	0.22	**4**
P3	0.24	0.62	0.01	0.68	0.48	0.98	0.23	0.86	0.66	0.07	0.04	0.11	0.21	0.43	0.22	0.00	0.21	0.22	**4**
P4	0.24	0.62	0.01	0.68	0.48	0.98	0.23	0.86	0.66	0.07	0.04	0.11	0.21	0.43	0.22	0.00	0.21	0.22	**4**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

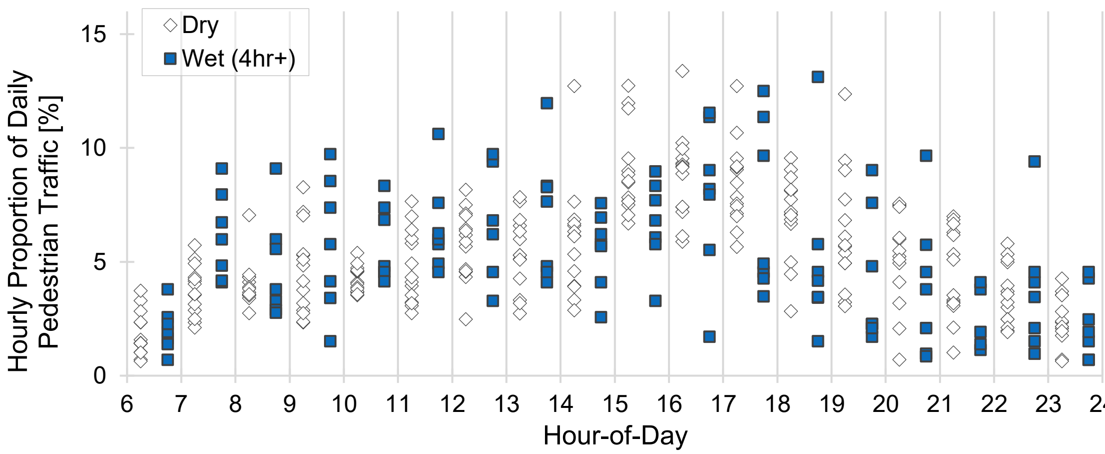
Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)



Typical Precipitation Condition at St Anne's West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Number of Hourly Precipitation Events



STATISTICAL COMPARISON

Student's T-Test Results: p-value

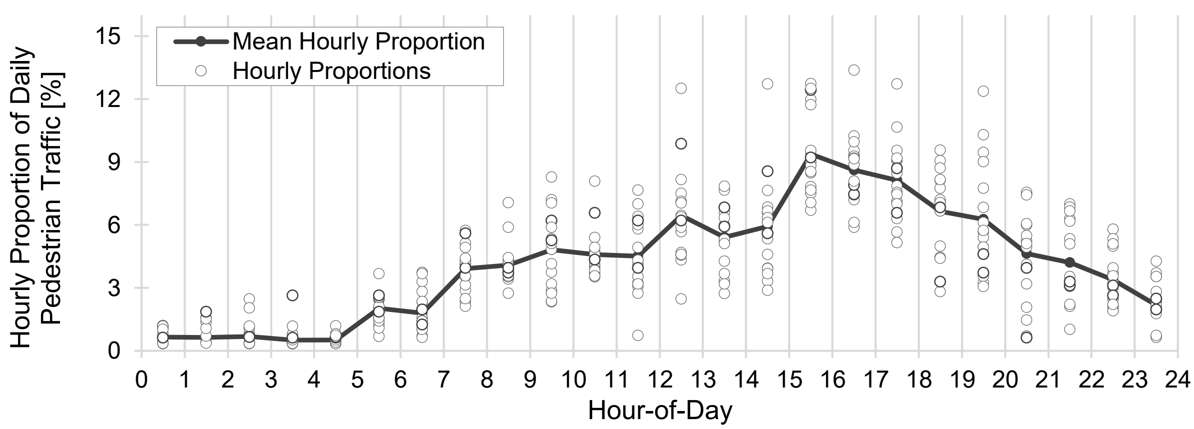
	Hour-of-Day																		Number of Rejected H_o
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
P1	0.63	0.02	0.48	0.33	0.06	0.03	0.56	0.18	0.70	0.01	0.62	0.58	0.35	0.12	0.56	0.01	0.77	0.84	**5**
P2	0.63	0.02	0.48	0.33	0.06	0.03	0.56	0.18	0.70	0.01	0.62	0.58	0.35	0.12	0.56	0.01	0.77	0.84	**5**
P3	0.63	0.02	0.48	0.33	0.06	0.03	0.56	0.18	0.70	0.01	0.62	0.58	0.35	0.12	0.56	0.01	0.77	0.84	**5**
P4	0.63	0.02	0.48	0.33	0.06	0.03	0.56	0.18	0.70	0.01	0.62	0.58	0.35	0.12	0.56	0.01	0.77	0.84	**5**

Precipitaion Conditions Tested:

- **P1** - Dry days have fewer than *one* hourly precipitation event during daytime hours
- **P2** - Dry days have fewer than *two* hourly precipitation events during daytime hours
- **P3** - Dry days have fewer than *three* hourly precipitation events during daytime hours
- **P4** - Dry days have fewer than *four* hourly precipitation events during daytime hours

RESULTS

Hourly Pedestrian Traffic Periodicity for Typical Precipitation Condition P4 (< 4 hourly precipitation events)

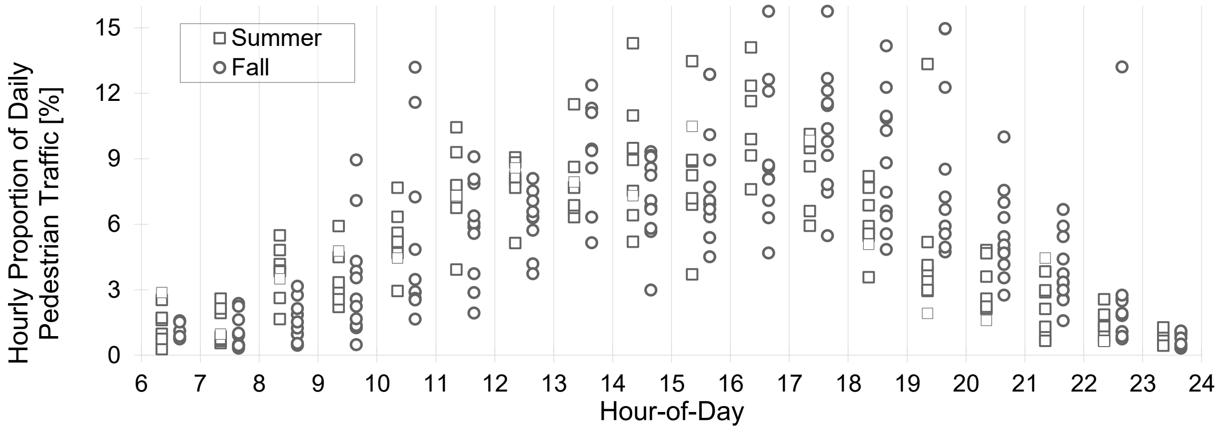


APPENDIX C: RESULTS FROM ANALYSIS OF SEASONALITY

Seasonality at Academy North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

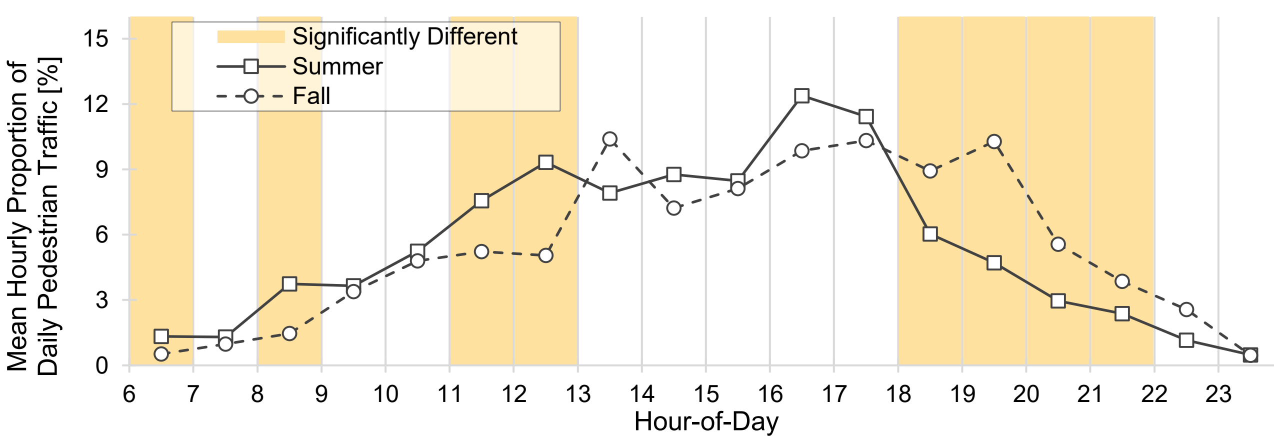
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.07	0.39	0.00	0.78	0.75	0.06	0.02	0.22	0.18	0.79	0.16	0.72	0.01	0.04	0.00	0.05	0.24	0.95

Number of Rejected H_o 8

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

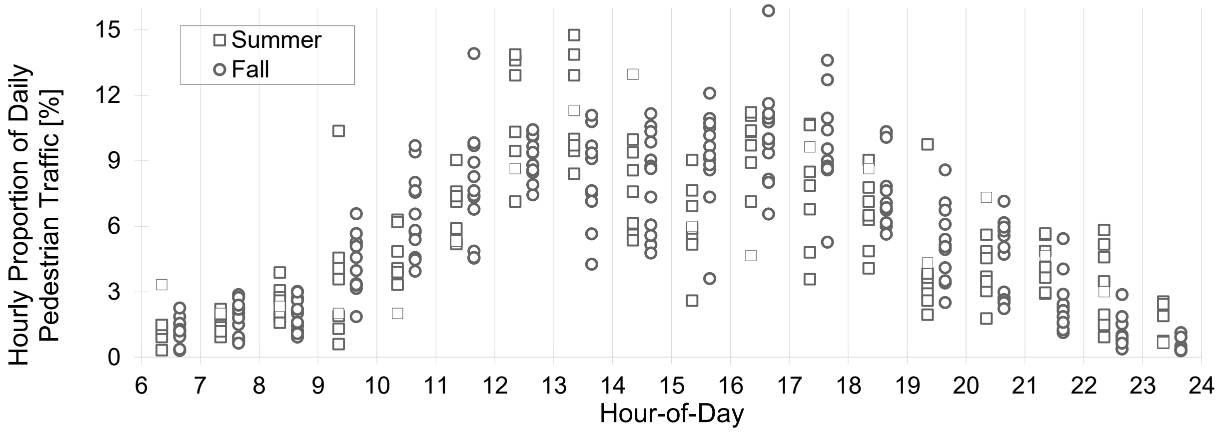
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.3	1.3	3.7	3.6	5.2	7.6	9.3	7.9	8.8	8.5	12.4	11.4	6.0	4.7	3.0	2.4	1.2	0.5
StDev	1.0	0.8	1.2	1.3	1.4	1.9	4.2	1.6	2.9	2.8	3.6	8.1	1.5	3.6	1.2	1.4	0.8	0.5
Fall																		
Mean	0.5	1.0	1.5	3.4	4.8	5.2	5.0	10.4	7.2	8.1	9.8	10.3	8.9	10.3	5.6	3.9	2.6	0.5
StDev	0.6	0.8	0.9	2.6	4.2	2.8	2.8	6.1	1.9	2.8	3.8	2.8	3.0	6.8	2.0	1.6	3.6	0.4



Seasonality at Academy South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

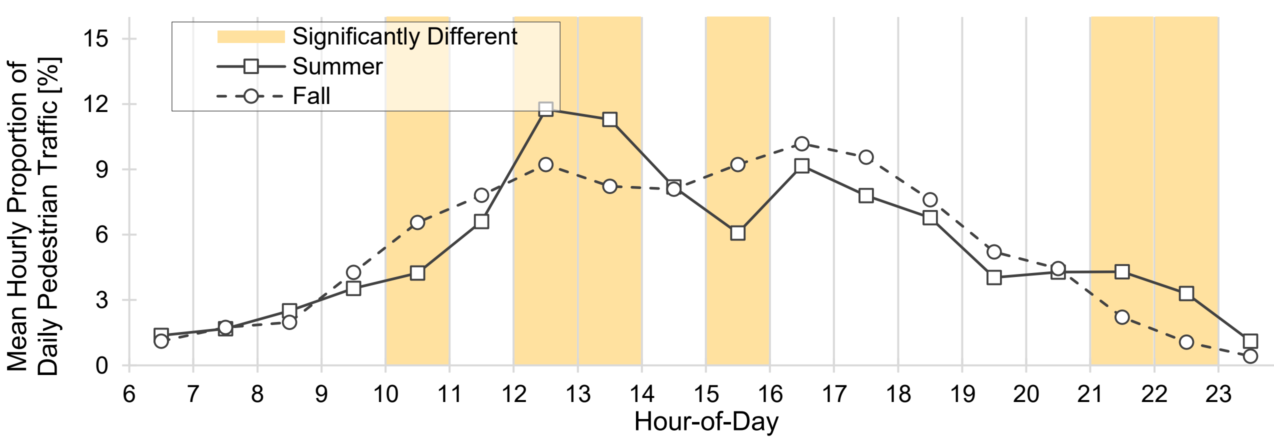
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.45	0.82	0.14	0.54	0.01	0.20	0.09	0.01	0.93	0.00	0.35	0.12	0.30	0.22	0.83	0.00	0.01	0.10

Number of Rejected H_o **6**

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

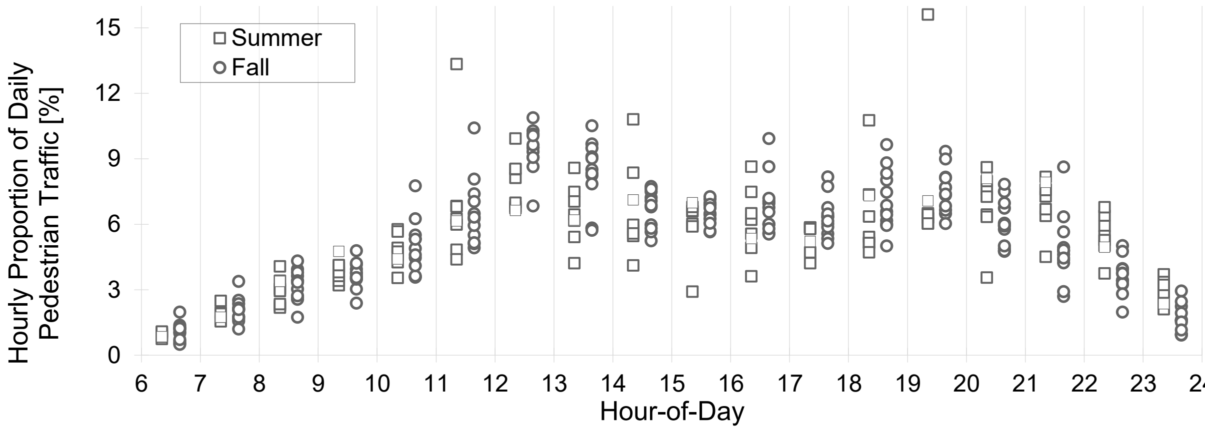
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.4	1.7	2.5	3.5	4.2	6.6	11.8	11.3	8.2	6.1	9.2	7.8	6.8	4.0	4.3	4.3	3.3	1.1
StDev	0.9	0.4	0.7	3.1	1.5	1.4	3.6	2.3	2.6	1.9	2.3	2.6	1.7	2.4	1.7	1.1	1.8	1.0
Fall																		
Mean	1.1	1.7	2.0	4.3	6.6	7.8	9.2	8.2	8.1	9.2	10.2	9.6	7.6	5.2	4.4	2.2	1.1	0.4
StDev	0.7	0.8	0.7	1.3	1.9	2.7	1.0	2.0	2.3	2.2	2.3	2.2	1.7	1.7	1.7	1.4	0.8	0.4



Seasonality at Corydon North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

Hour-of-Day

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.31	0.26	0.43	0.47	0.69	0.80	0.00	0.02	0.88	0.27	0.23	0.02	0.45	0.98	0.12	0.00	0.00	0.00

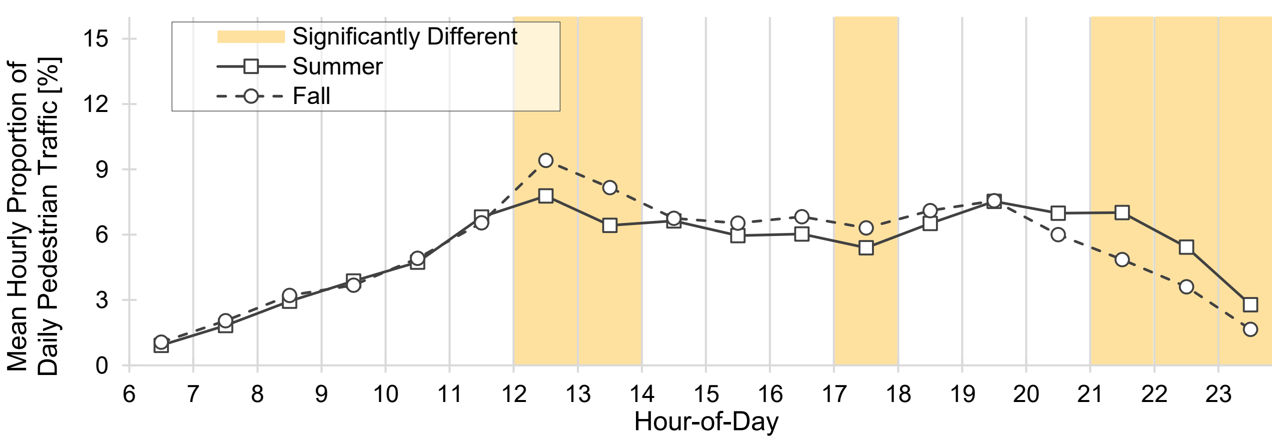
Number of Rejected H_o 6

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

Hour-of-Day

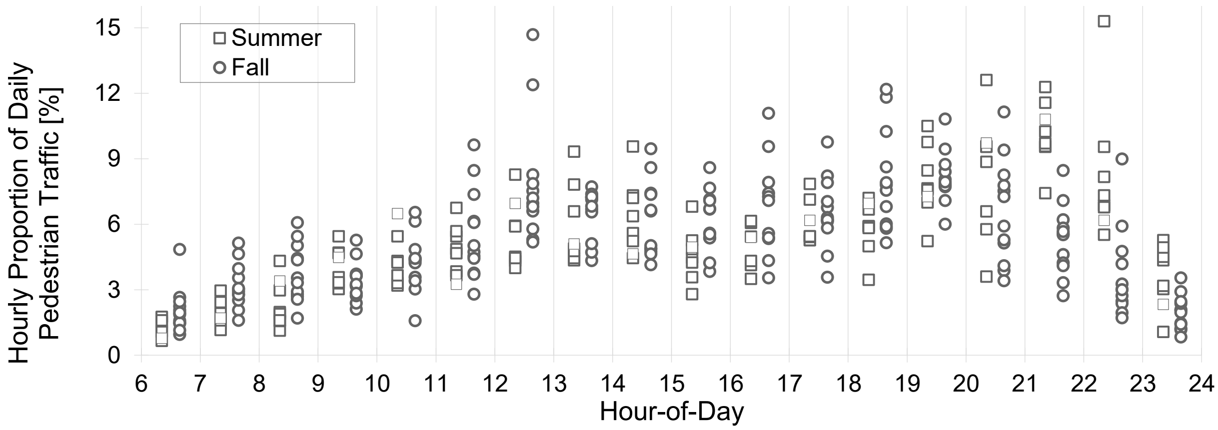
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	0.9	1.8	2.9	3.9	4.7	6.8	7.8	6.4	6.6	6.0	6.0	5.4	6.5	7.5	7.0	7.0	5.4	2.8
StDev	0.1	0.3	0.7	0.5	0.7	2.8	1.2	1.3	2.1	1.3	1.6	0.6	2.0	3.3	1.6	1.2	0.9	0.6
Fall																		
Mean	1.1	2.0	3.2	3.7	4.9	6.5	9.4	8.2	6.8	6.5	6.8	6.3	7.1	7.6	6.0	4.9	3.6	1.7
StDev	0.4	0.6	0.7	0.6	1.2	1.5	1.0	1.6	0.9	0.5	1.3	0.9	1.4	1.0	1.1	1.5	0.8	0.6



Seasonality at Corydon South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

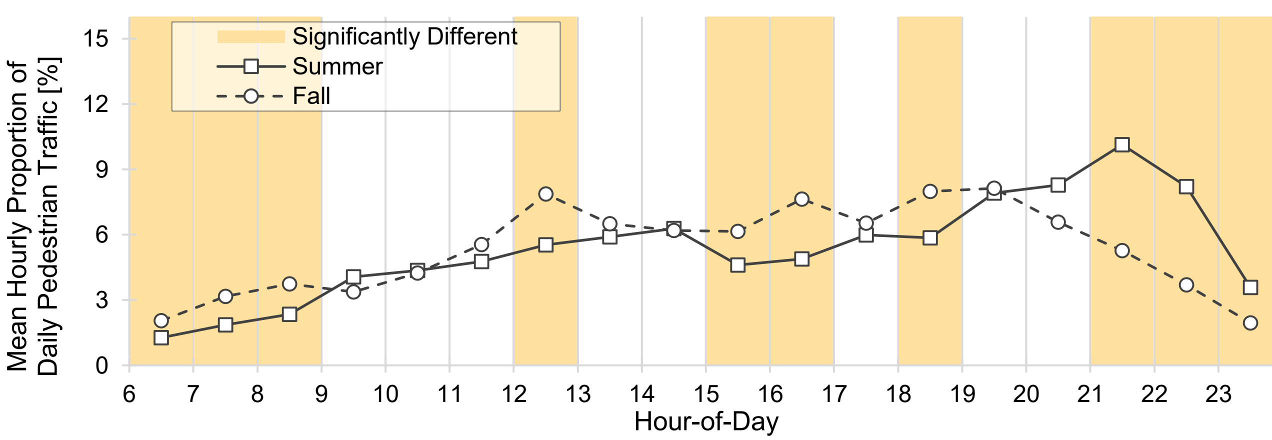
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.03	0.00	0.02	0.11	0.83	0.29	0.03	0.42	0.91	0.02	0.03	0.37	0.02	0.75	0.16	0.00	0.00	0.02

Number of Rejected H_o 10

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

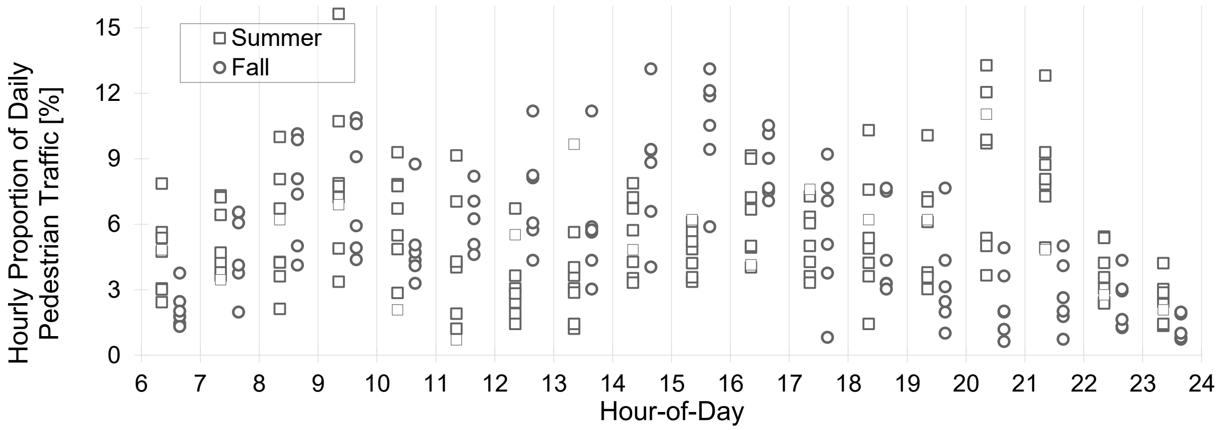
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.3	1.9	2.3	4.1	4.4	4.8	5.5	5.9	6.3	4.6	4.9	6.0	5.9	7.9	8.3	10.1	8.2	3.6
StDev	0.4	0.6	1.1	0.9	1.1	1.2	1.5	1.8	1.7	1.2	1.0	1.0	1.2	1.7	2.8	1.5	3.1	1.4
Fall																		
Mean	2.0	3.2	3.7	3.4	4.2	5.6	7.9	6.5	6.2	6.1	7.6	6.5	8.0	8.1	6.6	5.3	3.7	2.0
StDev	1.0	1.0	1.3	0.9	1.3	2.1	2.9	1.1	1.7	1.4	3.7	1.6	2.3	1.2	2.4	1.6	2.1	0.8



Seasonality at Dakota East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

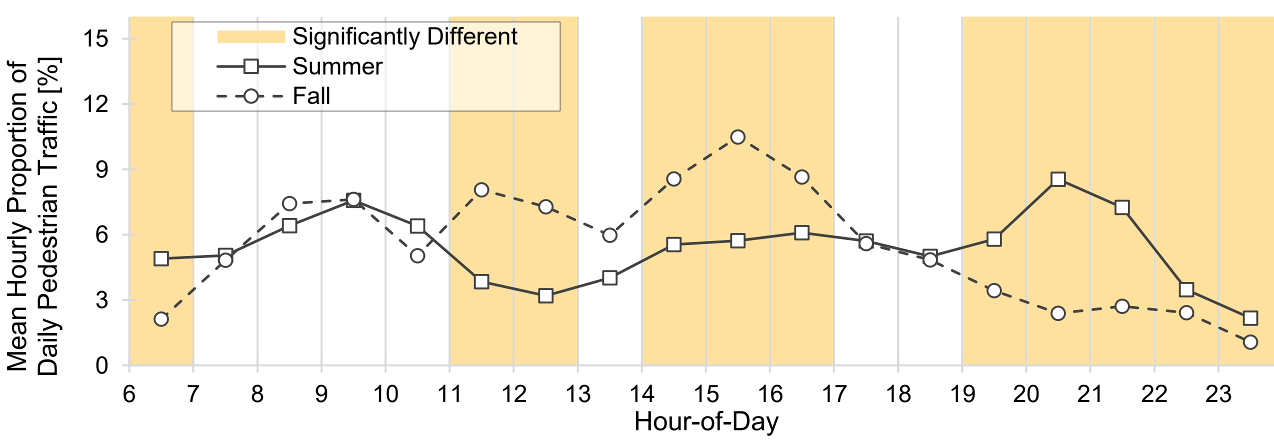
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.00	0.81	0.48	0.98	0.25	0.03	0.00	0.18	0.03	0.00	0.02	0.93	0.90	0.07	0.00	0.00	0.09	0.05

Number of Rejected H_o 11

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

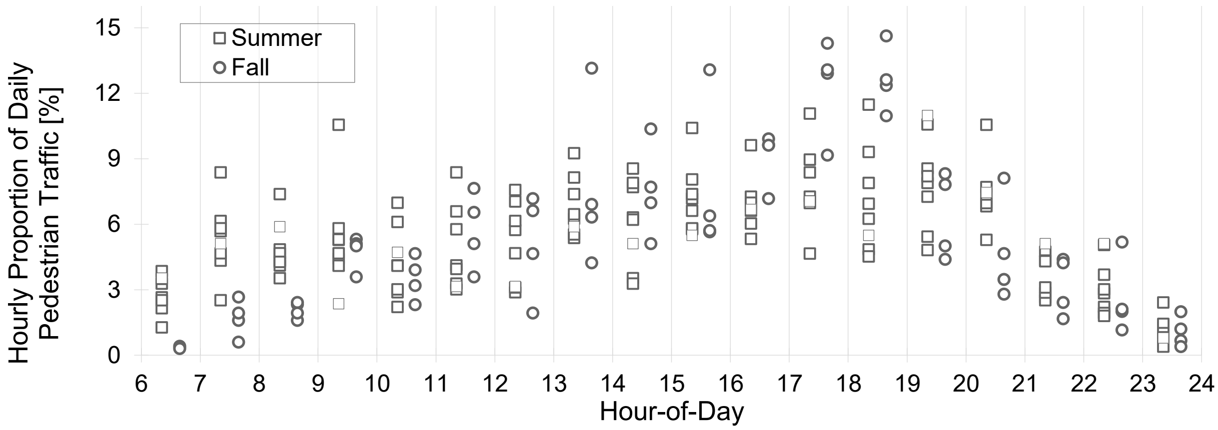
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	4.9	5.0	6.4	7.6	6.4	3.8	3.2	4.0	5.6	5.7	6.1	5.7	5.0	5.8	8.5	7.3	3.5	2.2
StDev	1.9	1.7	3.0	3.4	2.4	2.8	1.8	2.7	2.0	2.0	2.0	2.2	2.5	2.5	3.7	2.5	1.1	1.1
Fall																		
Mean	2.1	4.8	7.4	7.6	5.0	8.1	7.3	6.0	8.6	10.5	8.7	5.6	4.8	3.4	2.4	2.7	2.4	1.1
StDev	0.9	1.9	2.5	2.9	1.9	4.7	2.4	2.8	3.1	2.6	1.5	3.0	2.2	2.4	1.6	1.6	1.2	0.7



Seasonality at Dakota West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

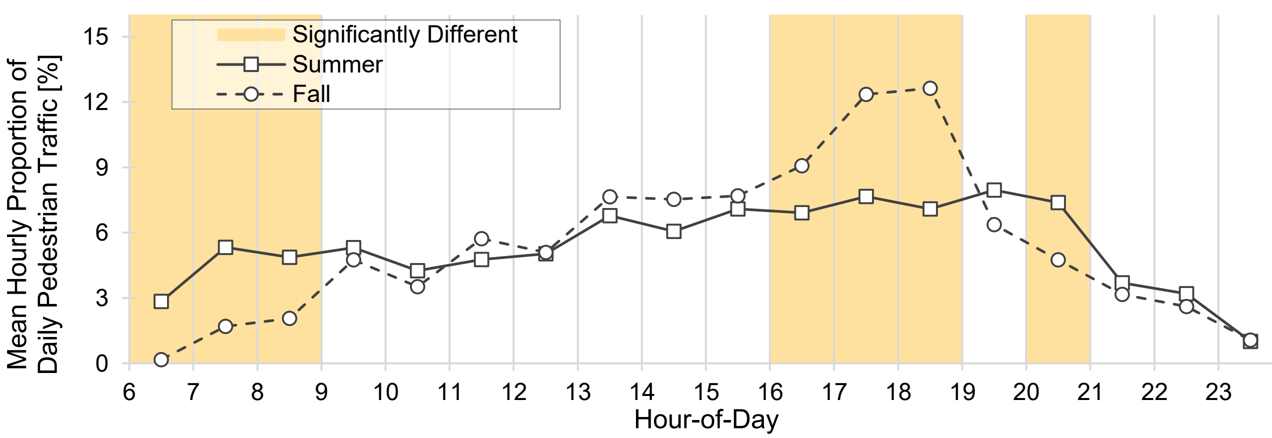
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.00	0.00	0.00	0.56	0.43	0.43	0.97	0.69	0.27	0.68	0.02	0.00	0.00	0.25	0.04	0.46	0.52	0.91

Number of Rejected H_o 7

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

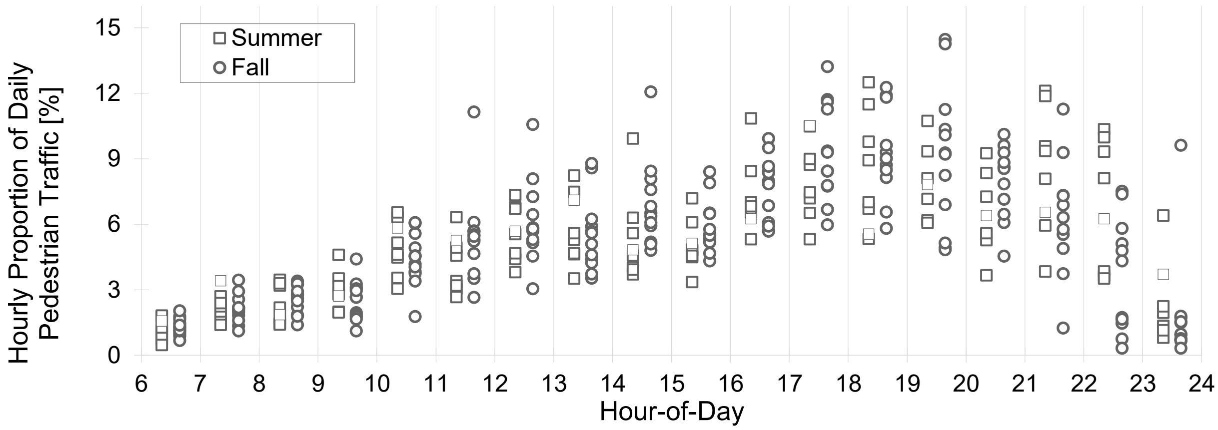
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.8	5.3	4.9	5.3	4.3	4.8	5.0	6.8	6.1	7.1	6.9	7.7	7.1	8.0	7.4	3.7	3.2	1.0
StDev	0.9	1.7	1.2	2.4	1.6	1.9	1.9	1.4	2.0	1.6	1.2	1.9	2.4	2.2	1.5	1.0	1.3	0.7
Fall																		
Mean	0.2	1.7	2.1	4.8	3.5	5.7	5.1	7.6	7.5	7.7	9.1	12.4	12.6	6.4	4.8	3.2	2.6	1.1
StDev	0.2	0.9	0.4	0.8	1.0	1.8	2.4	3.8	2.2	3.6	1.3	2.2	1.5	2.0	2.4	1.3	1.8	0.7



Seasonality at Osborne East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

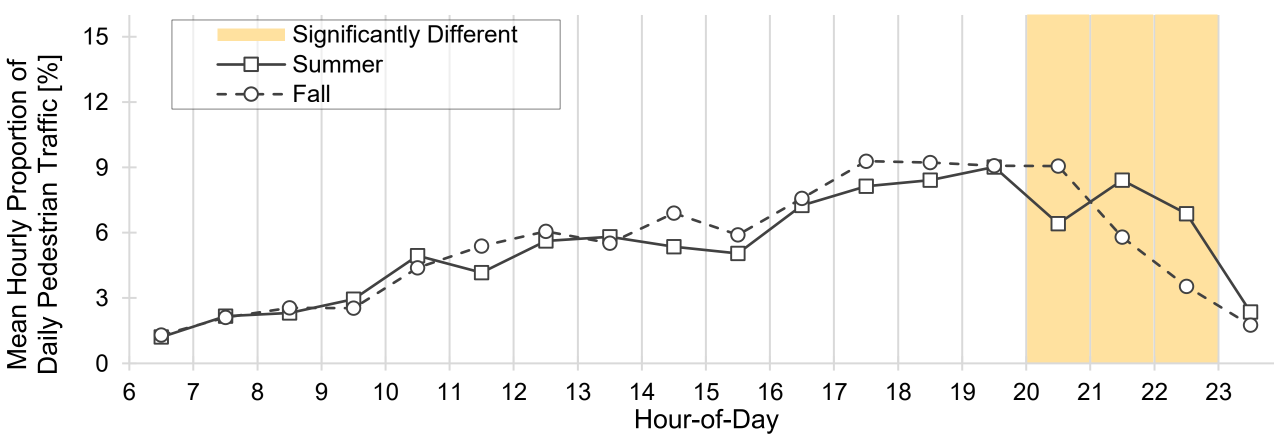
Student's T-Test Results: p-value

Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.64	0.82	0.47	0.32	0.34	0.13	0.56	0.71	0.11	0.14	0.66	0.25	0.45	0.97	0.08	0.08	0.02	0.57
														Number of Rejected H_o			**3**

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

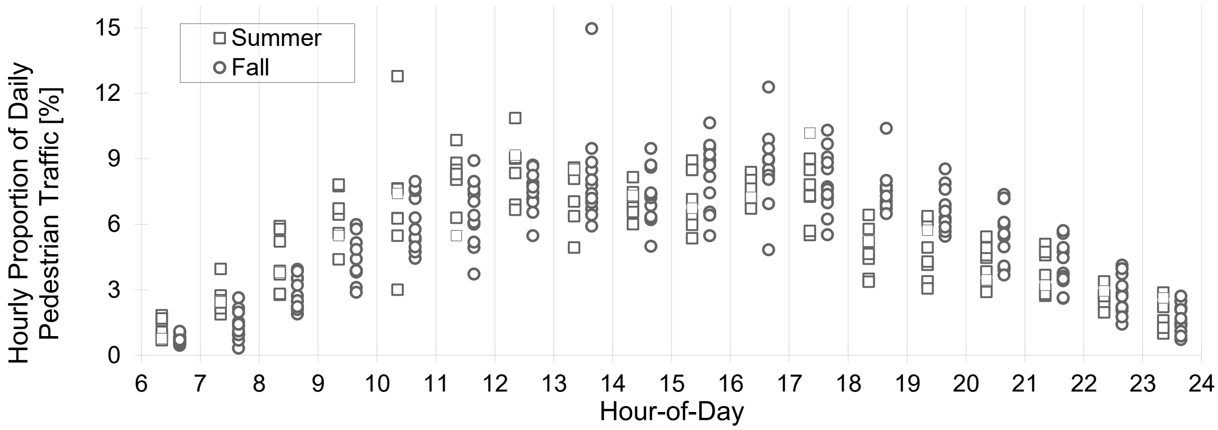
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.2	2.2	2.3	2.9	4.9	4.2	5.6	5.8	5.4	5.0	7.2	8.1	8.4	9.0	6.4	8.4	6.9	2.4
StDev	0.5	0.7	0.9	0.9	1.3	1.3	1.3	1.6	2.0	1.1	1.7	1.9	2.7	3.5	1.8	2.9	2.9	1.9
Fall																		
Mean	1.3	2.1	2.6	2.5	4.4	5.4	6.1	5.5	6.9	5.9	7.6	9.3	9.2	9.1	9.1	5.8	3.5	1.8
StDev	0.4	0.6	0.6	0.9	1.2	2.1	1.9	1.7	2.0	1.2	1.5	2.2	2.0	3.3	4.3	3.1	2.6	2.5



Seasonality at Osborne West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

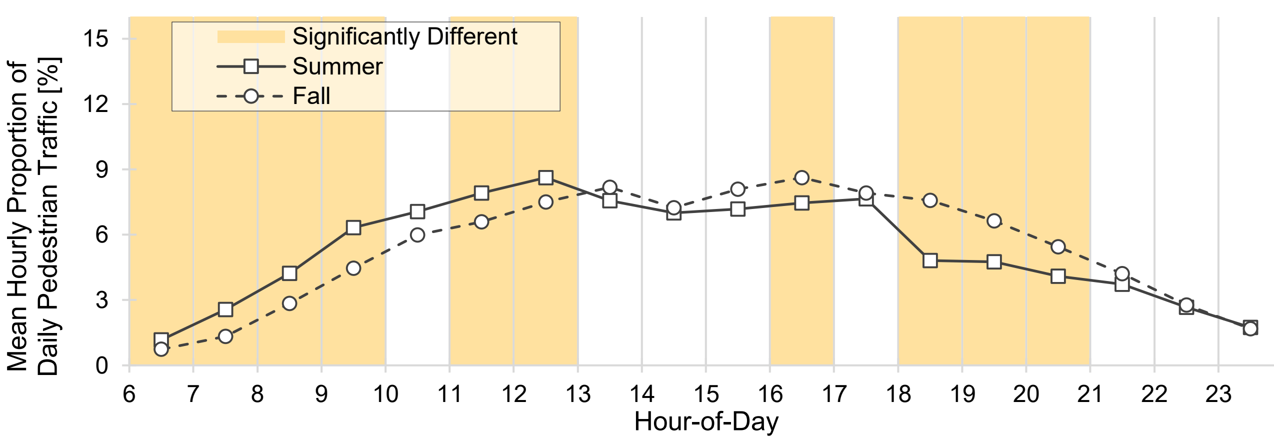
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.03	0.00	0.02	0.00	0.33	0.06	0.04	0.47	0.60	0.20	0.05	0.70	0.00	0.00	0.02	0.32	0.74	0.82

Number of Rejected H_o 10

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

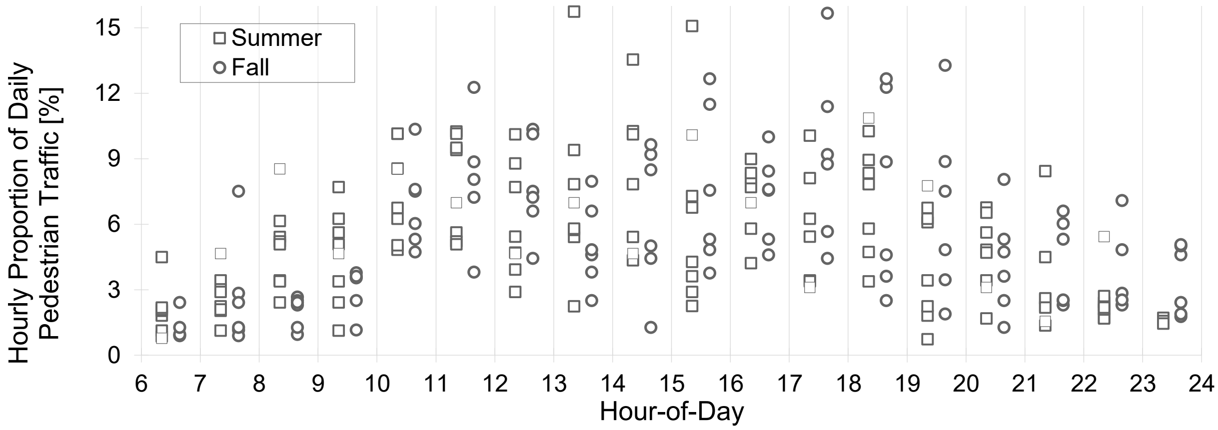
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.2	2.6	4.2	6.3	7.1	7.9	8.6	7.6	7.0	7.2	7.5	7.7	4.8	4.8	4.1	3.7	2.7	1.7
StDev	0.5	0.6	1.3	1.2	2.8	1.4	1.3	1.3	0.7	1.3	0.5	1.6	1.1	1.2	0.9	0.9	0.4	0.7
Fall																		
Mean	0.7	1.3	2.8	4.5	6.0	6.6	7.5	8.2	7.2	8.1	8.6	7.9	7.6	6.6	5.5	4.2	2.8	1.7
StDev	0.2	0.7	0.7	1.1	1.3	1.5	0.9	2.4	1.2	1.6	1.8	1.4	1.0	0.9	1.3	1.1	0.9	0.6



Seasonality at Roblin North

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

Hour-of-Day

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.03	0.50	0.00	0.03	0.29	0.27	0.40	0.43	0.48	0.81	0.53	0.58	0.80	0.24	0.94	0.29	0.32	0.00

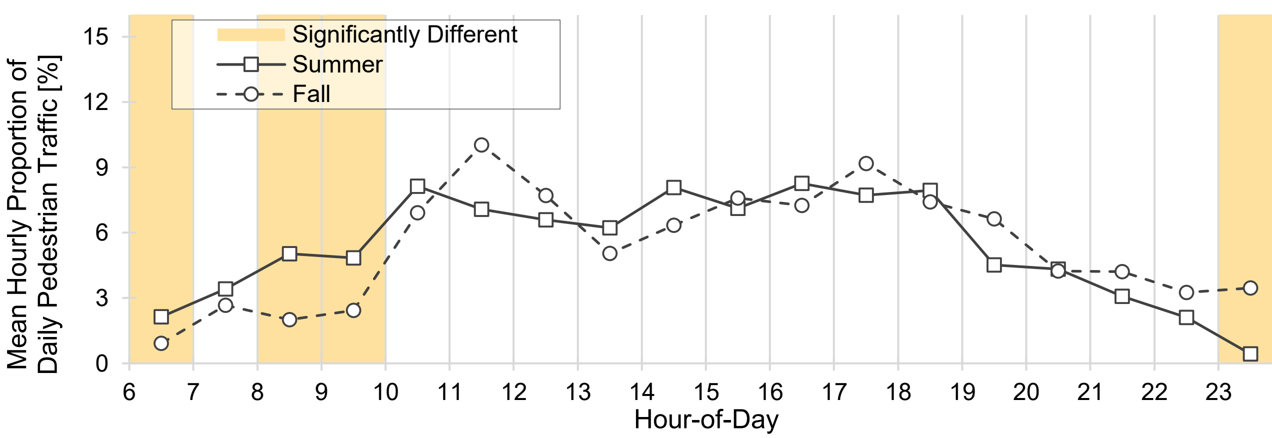
Number of Rejected H_o 4

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

Hour-of-Day

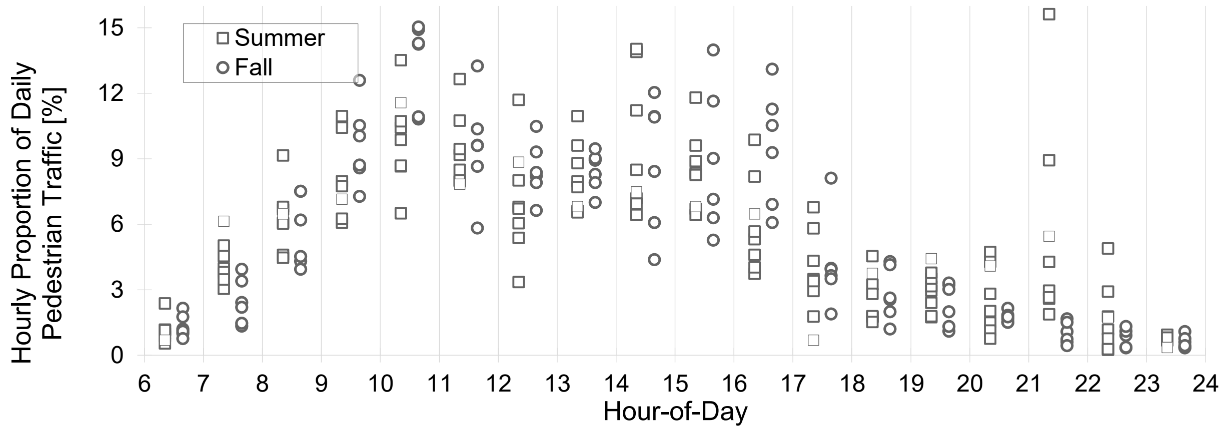
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	3.4	5.0	4.8	8.1	7.1	6.6	6.2	8.1	7.1	8.3	7.7	7.9	4.5	4.3	3.1	2.1	0.4
StDev	1.1	1.9	1.7	2.3	2.3	2.6	2.7	4.1	5.3	3.9	3.6	5.5	2.4	3.0	1.9	2.0	1.3	0.7
Fall																		
Mean	0.9	2.7	2.0	2.4	6.9	10.0	7.7	5.0	6.3	7.6	7.2	9.2	7.4	6.6	4.2	4.2	3.3	3.5
StDev	0.9	2.5	0.7	1.5	2.0	5.6	2.2	2.0	3.3	3.7	2.0	4.1	4.5	4.1	2.4	2.0	2.4	1.6



Seasonality at Roblin South

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

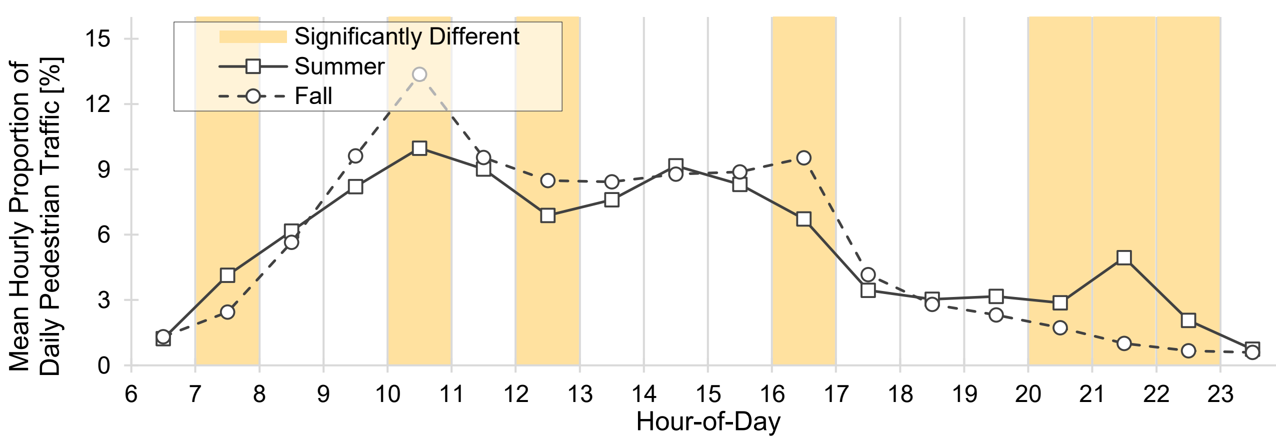
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.78	0.01	0.49	0.15	0.00	0.60	0.10	0.20	0.81	0.71	0.04	0.47	0.73	0.10	0.02	0.01	0.02	0.41

Number of Rejected H_o 7

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

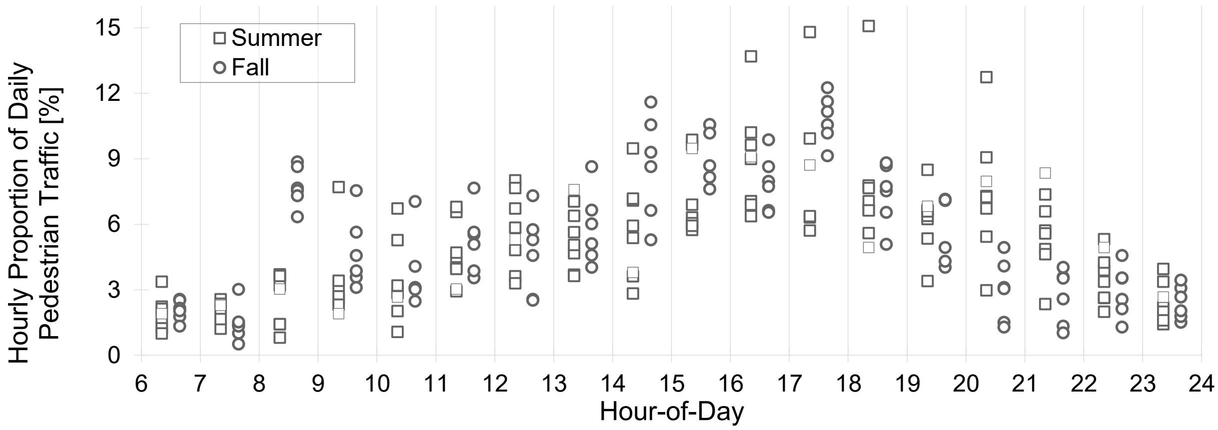
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.2	4.1	6.2	8.2	10.0	9.0	6.9	7.6	9.2	8.3	6.7	3.4	3.0	3.2	2.9	4.9	2.1	0.7
StDev	0.7	1.2	1.3	1.8	1.9	1.7	2.4	1.6	3.0	1.8	2.3	1.9	1.4	0.9	1.4	4.0	1.6	0.3
Fall																		
Mean	1.3	2.4	5.7	9.6	13.4	9.5	8.5	8.4	8.8	8.9	9.5	4.2	2.8	2.3	1.7	1.0	0.7	0.6
StDev	0.5	1.0	1.6	1.9	2.0	2.4	1.3	0.9	3.1	3.4	2.7	2.1	1.2	1.0	0.2	0.5	0.5	0.3



Seasonality at St Anne's East

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

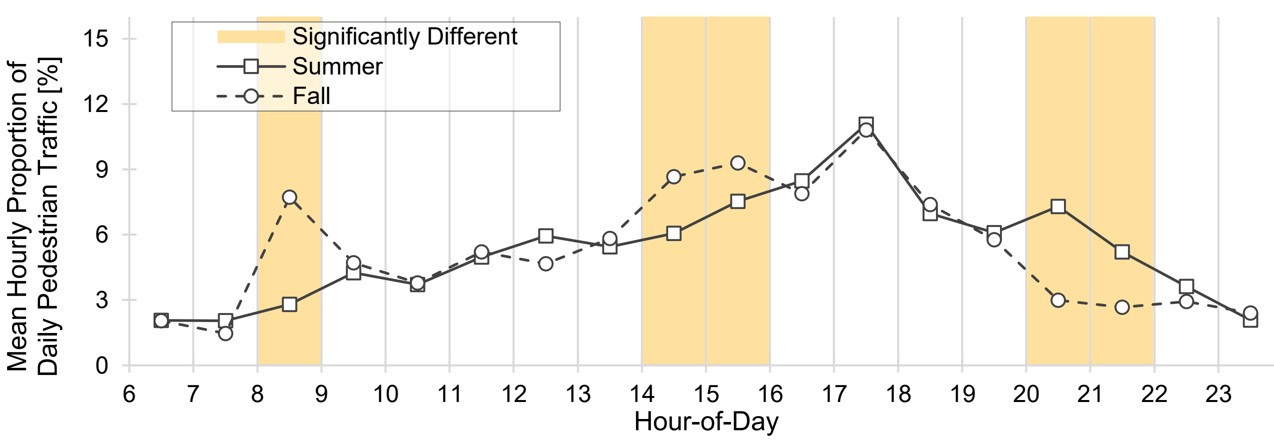
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.97	0.10	0.00	0.70	0.93	0.77	0.26	0.61	0.03	0.05	0.56	0.88	0.71	0.64	0.00	0.01	0.36	0.47

Number of Rejected H_o 5

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

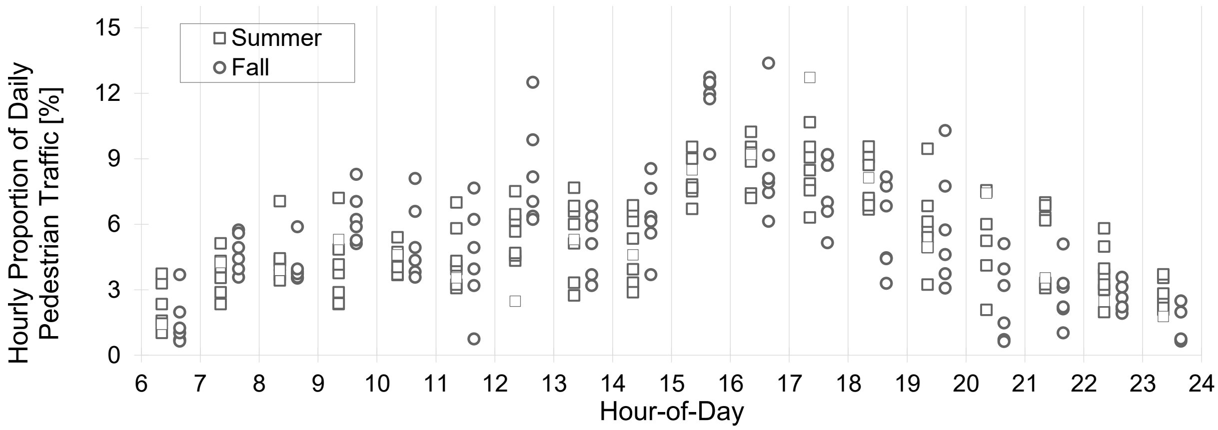
	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	2.0	2.8	4.2	3.7	5.0	5.9	5.4	6.1	7.5	8.5	11.1	7.0	6.1	7.3	5.2	3.6	2.1
StDev	0.8	0.5	1.3	2.6	1.9	1.6	2.3	1.3	2.1	1.7	2.2	5.6	3.1	1.3	2.4	2.0	1.5	0.9
Fall																		
Mean	2.1	1.5	7.7	4.7	3.8	5.2	4.7	5.8	8.7	9.3	7.9	10.8	7.4	5.8	3.0	2.7	2.9	2.4
StDev	0.5	0.8	0.9	1.6	1.7	1.5	1.9	1.7	2.4	1.3	1.3	1.1	1.4	1.5	1.4	1.3	1.2	0.8



Seasonality at St Anne's West

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Season (summer & fall)



STATISTICAL COMPARISON

Student's T-Test Results: p-value

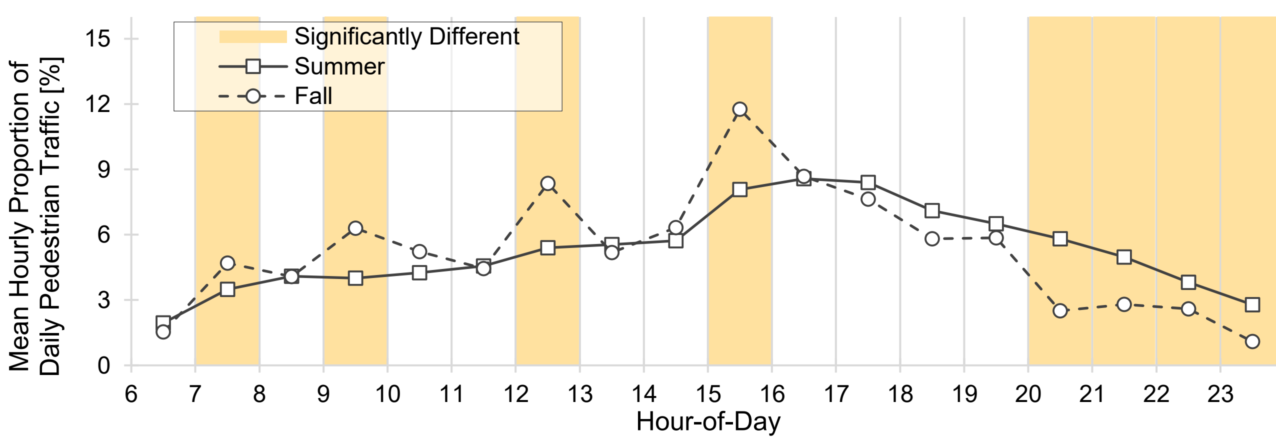
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.48	0.02	0.97	0.01	0.24	0.90	0.01	0.66	0.63	0.00	0.91	0.44	0.21	0.65	0.00	0.02	0.02	0.00

Number of Rejected H_o 8

RESULTS

Hourly Pedestrian Traffic Periodicities for Summer and Fall

	Hour-of-Day																	
Summer	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.9	3.5	4.1	4.0	4.3	4.6	5.4	5.5	5.7	8.1	8.6	8.4	7.1	6.5	5.8	5.0	3.8	2.8
StDev	1.1	1.0	1.1	1.5	0.6	1.5	1.4	1.7	2.7	0.9	1.4	2.0	1.9	2.8	1.7	1.7	1.3	0.8
Fall																		
Mean	1.5	4.7	4.1	6.3	5.2	4.4	8.4	5.2	6.3	11.8	8.7	7.6	5.8	5.9	2.5	2.8	2.6	1.1
StDev	1.2	0.9	0.9	1.2	1.8	2.4	2.4	1.5	1.7	1.3	2.5	1.6	2.0	2.7	1.9	1.4	0.6	0.9

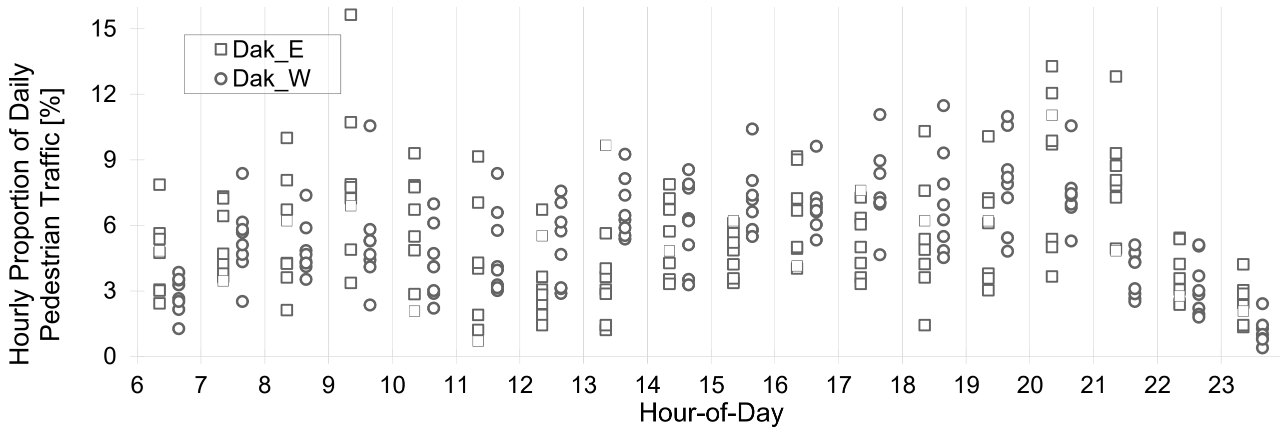


APPENDIX D: RESULTS FROM ANALYSIS OF ADJACENT SIDEWA

Character of Adjacent Sidewalks at Dakota in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

Hour-of-Day

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.01	0.73	0.14	0.12	0.04	0.43	0.04	0.01	0.58	0.14	0.32	0.05	0.09	0.07	0.36	0.00	0.63	0.02

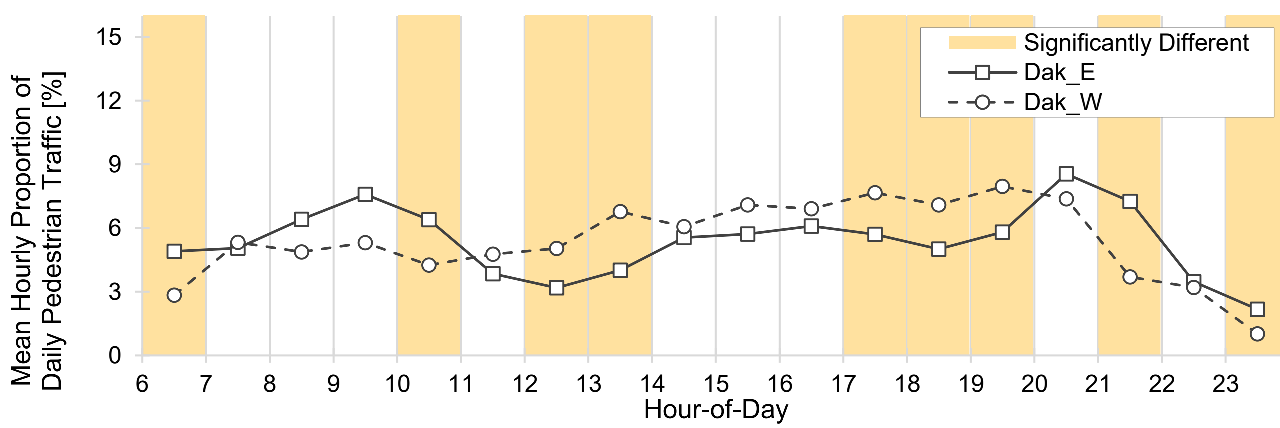
Number of Rejected H_o 9

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

Hour-of-Day

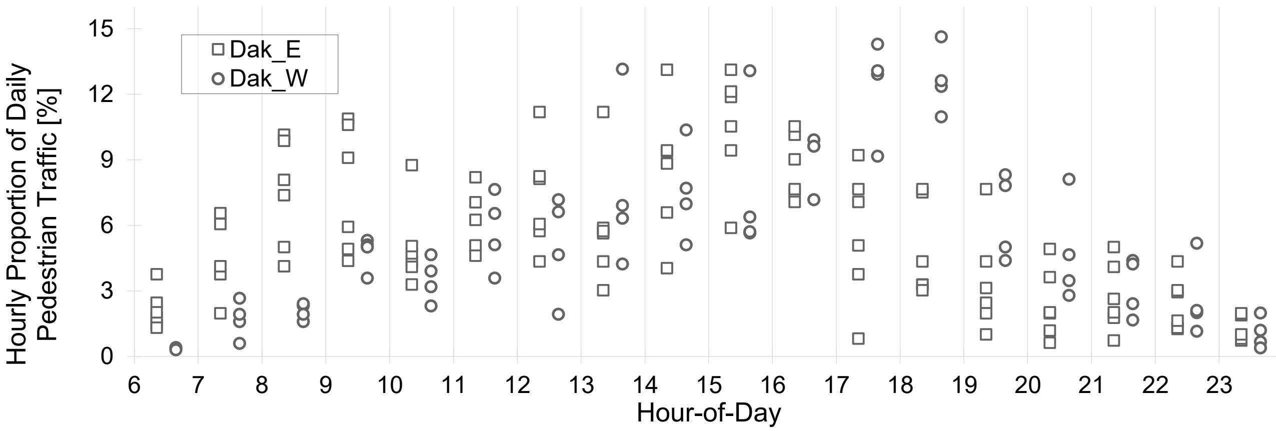
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Dak_E																		
Mean	4.9	5.0	6.4	7.6	6.4	3.8	3.2	4.0	5.6	5.7	6.1	5.7	5.0	5.8	8.5	7.3	3.5	2.2
StDev	1.9	1.7	3.0	3.4	2.4	2.8	1.8	2.7	2.0	2.0	2.0	2.2	2.5	2.5	3.7	2.5	1.1	1.1
Dak_W																		
Mean	2.8	5.3	4.9	5.3	4.3	4.8	5.0	6.8	6.1	7.1	6.9	7.7	7.1	8.0	7.4	3.7	3.2	1.0
StDev	0.9	1.7	1.2	2.4	1.6	1.9	1.9	1.4	2.0	1.6	1.2	1.9	2.4	2.2	1.5	1.0	1.3	0.7



Character of Adjacent Sidewalks at Dakota in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

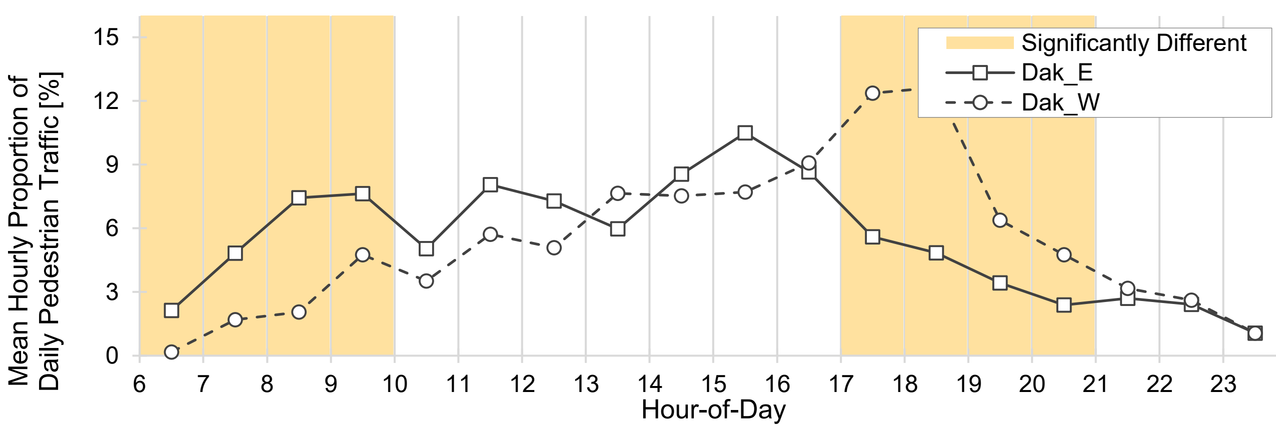
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.00	0.01	0.00	0.06	0.19	0.30	0.19	0.44	0.58	0.19	0.65	0.01	0.00	0.07	0.09	0.65	0.85	0.99

Number of Rejected H_o **8**

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

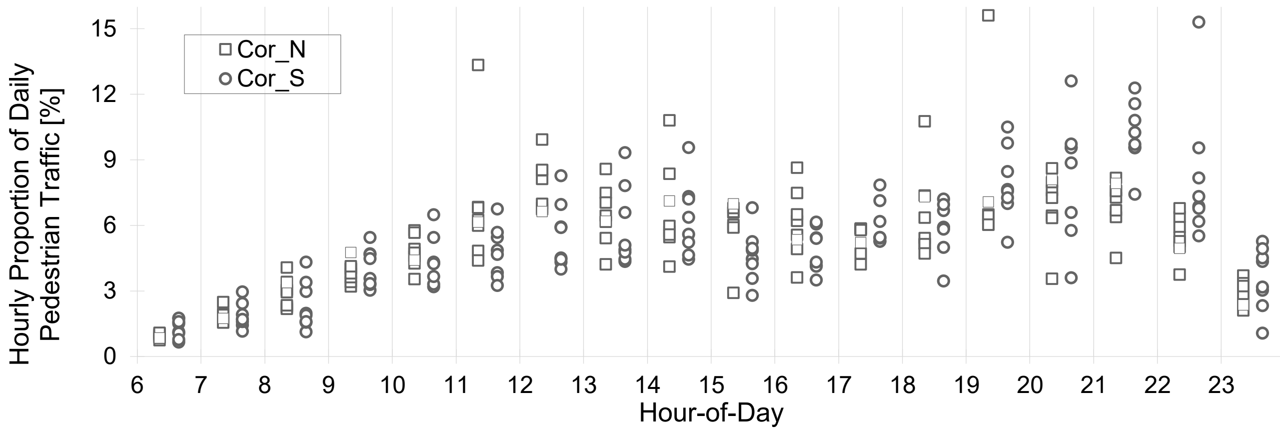
	Hour-of-Day																	
Dak_E	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	4.8	7.4	7.6	5.0	8.1	7.3	6.0	8.6	10.5	8.7	5.6	4.8	3.4	2.4	2.7	2.4	1.1
StDev	0.9	1.9	2.5	2.9	1.9	4.7	2.4	2.8	3.1	2.6	1.5	3.0	2.2	2.4	1.6	1.6	1.2	0.7
Dak_W																		
Mean	0.2	1.7	2.1	4.8	3.5	5.7	5.1	7.6	7.5	7.7	9.1	12.4	12.6	6.4	4.8	3.2	2.6	1.1
StDev	0.2	0.9	0.4	0.8	1.0	1.8	2.4	3.8	2.2	3.6	1.3	2.2	1.5	2.0	2.4	1.3	1.8	0.7



Character of Adjacent Sidewalks at Corydon in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

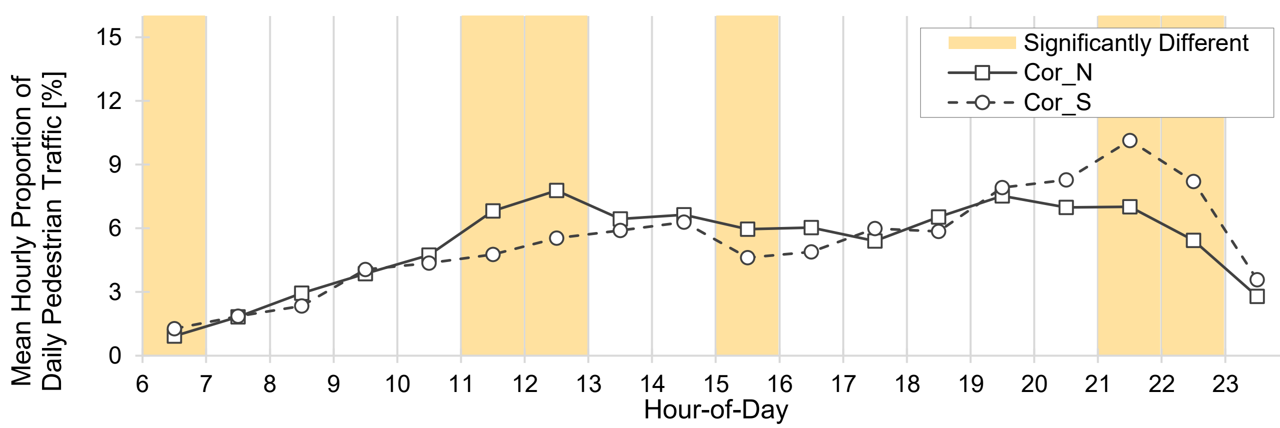
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.06	0.89	0.21	0.59	0.45	0.08	0.01	0.52	0.72	0.05	0.10	0.18	0.43	0.77	0.28	0.00	0.04	0.19

Number of Rejected H_o 6

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

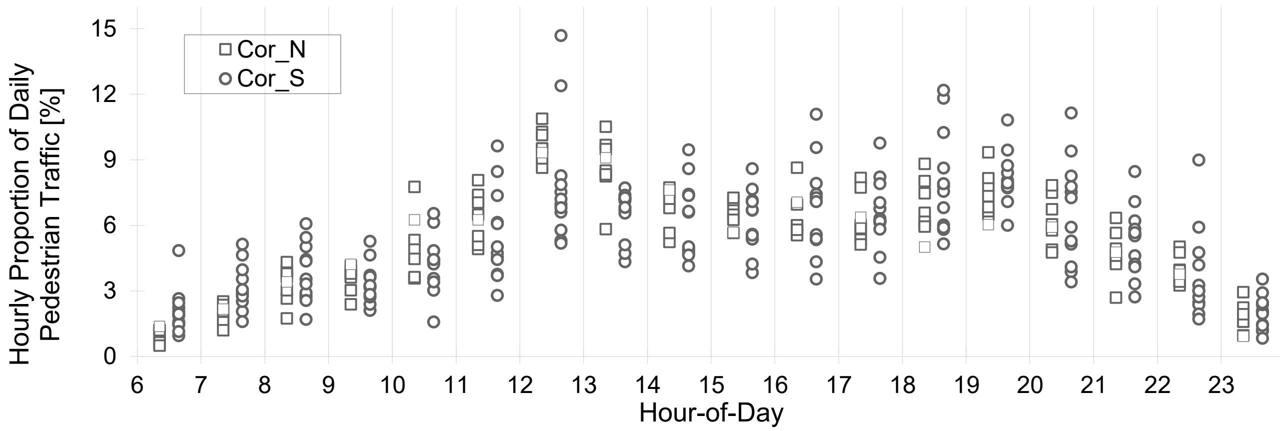
	Hour-of-Day																	
Cor_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	0.9	1.8	2.9	3.9	4.7	6.8	7.8	6.4	6.6	6.0	6.0	5.4	6.5	7.5	7.0	7.0	5.4	2.8
StDev	0.1	0.3	0.7	0.5	0.7	2.8	1.2	1.3	2.1	1.3	1.6	0.6	2.0	3.3	1.6	1.2	0.9	0.6
Cor_S																		
Mean	1.3	1.9	2.3	4.1	4.4	4.8	5.5	5.9	6.3	4.6	4.9	6.0	5.9	7.9	8.3	10.1	8.2	3.6
StDev	0.4	0.6	1.1	0.9	1.1	1.2	1.5	1.8	1.7	1.2	1.0	1.0	1.2	1.7	2.8	1.5	3.1	1.4



Character of Adjacent Sidewalks at Corydon in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

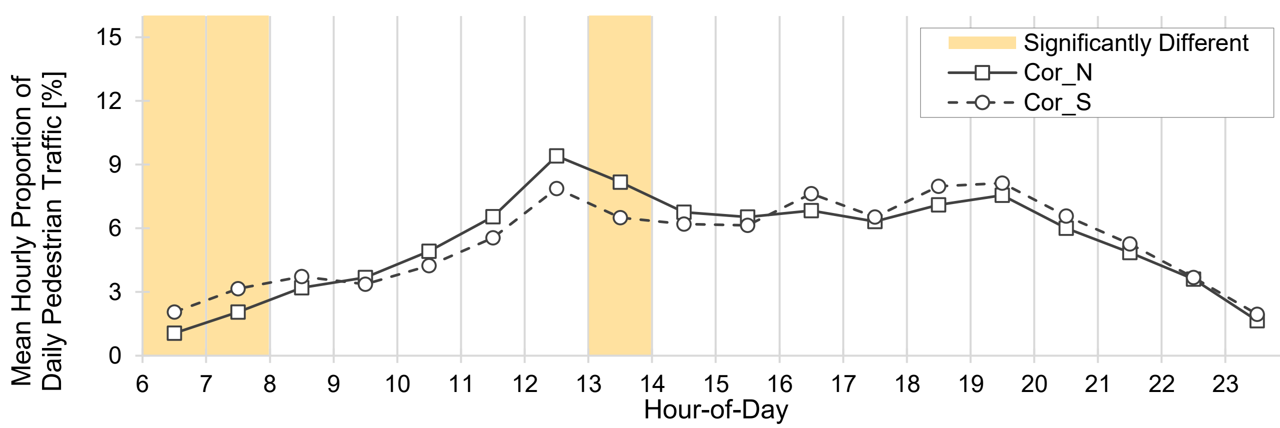
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.01	0.00	0.24	0.34	0.21	0.19	0.10	0.01	0.33	0.39	0.49	0.69	0.28	0.21	0.46	0.53	0.90	0.32

Number of Rejected H_o **3**

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

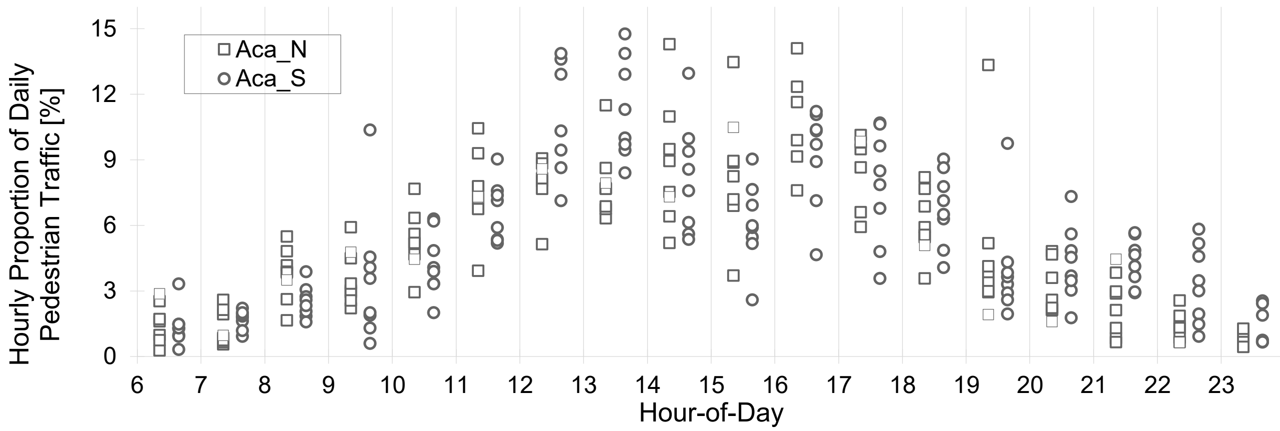
	Hour-of-Day																	
Cor_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.1	2.0	3.2	3.7	4.9	6.5	9.4	8.2	6.8	6.5	6.8	6.3	7.1	7.6	6.0	4.9	3.6	1.7
StDev	0.4	0.6	0.7	0.6	1.2	1.5	1.0	1.6	0.9	0.5	1.3	0.9	1.4	1.0	1.1	1.5	0.8	0.6
Cor_S																		
Mean	2.0	3.2	3.7	3.4	4.2	5.6	7.9	6.5	6.2	6.1	7.6	6.5	8.0	8.1	6.6	5.3	3.7	2.0
StDev	1.0	1.0	1.3	0.9	1.3	2.1	2.9	1.1	1.7	1.4	3.7	1.6	2.3	1.2	2.4	1.6	2.1	0.8



Character of Adjacent Sidewalks at Academy in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

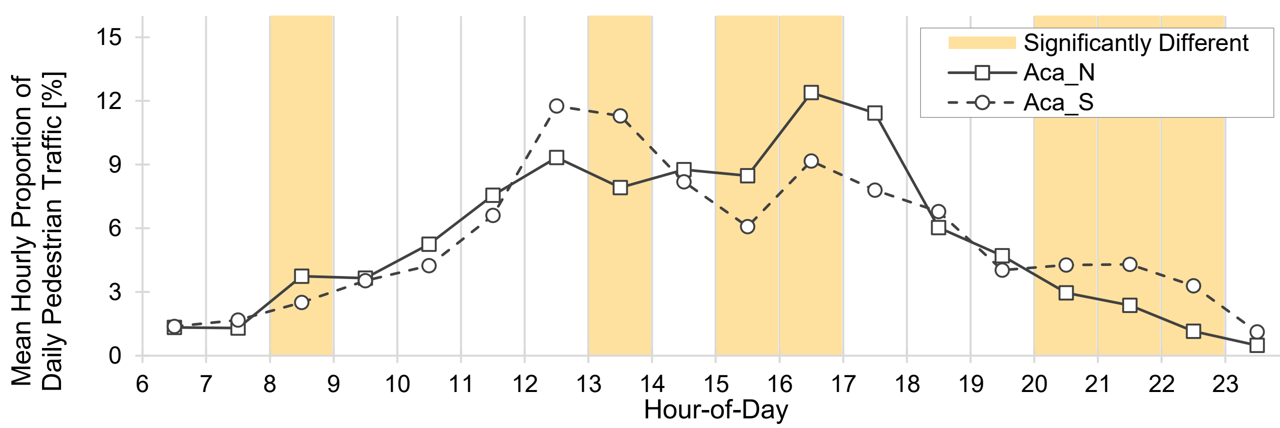
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.93	0.25	0.03	0.92	0.18	0.27	0.23	0.00	0.68	0.07	0.05	0.26	0.37	0.67	0.10	0.01	0.01	0.15

Number of Rejected H_o 7

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

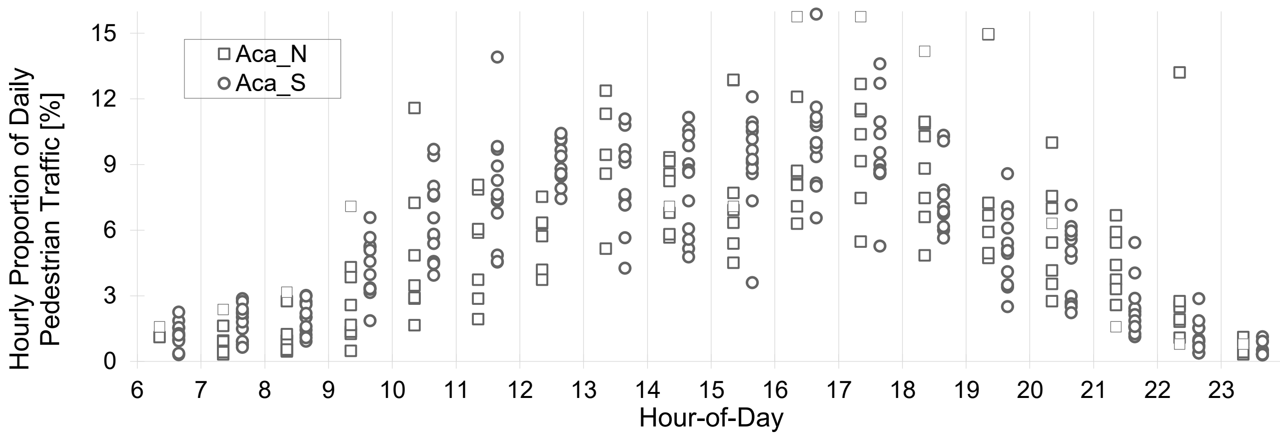
	Hour-of-Day																	
Aca_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.3	1.3	3.7	3.6	5.2	7.6	9.3	7.9	8.8	8.5	12.4	11.4	6.0	4.7	3.0	2.4	1.2	0.5
StDev	1.0	0.8	1.2	1.3	1.4	1.9	4.2	1.6	2.9	2.8	3.6	8.1	1.5	3.6	1.2	1.4	0.8	0.5
Aca_S																		
Mean	1.4	1.7	2.5	3.5	4.2	6.6	11.8	11.3	8.2	6.1	9.2	7.8	6.8	4.0	4.3	4.3	3.3	1.1
StDev	0.9	0.4	0.7	3.1	1.5	1.4	3.6	2.3	2.6	1.9	2.3	2.6	1.7	2.4	1.7	1.1	1.8	1.0



Character of Adjacent Sidewalks at Academy in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

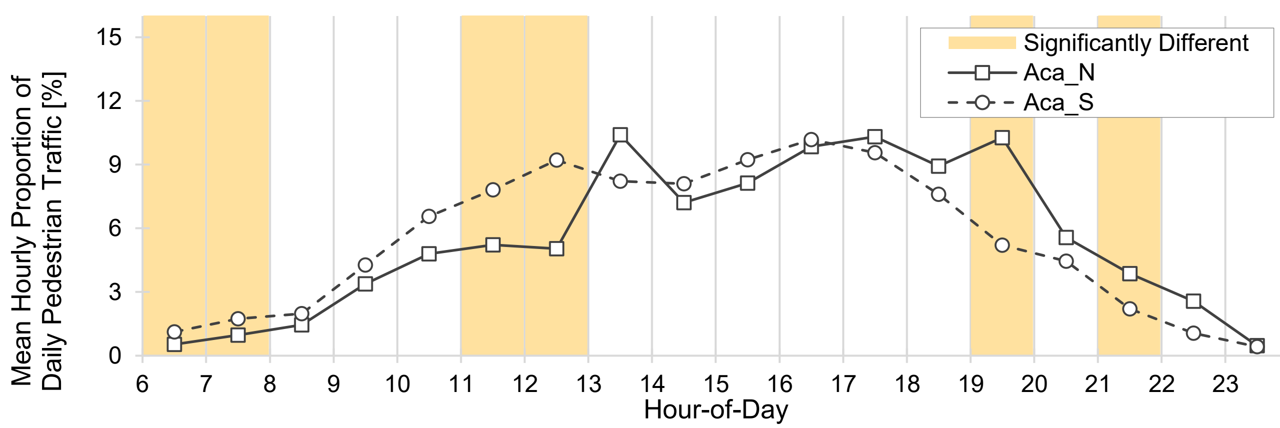
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.04	0.03	0.15	0.33	0.22	0.03	0.00	0.28	0.33	0.30	0.81	0.48	0.22	0.03	0.17	0.02	0.21	0.79

Number of Rejected H_o 6

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

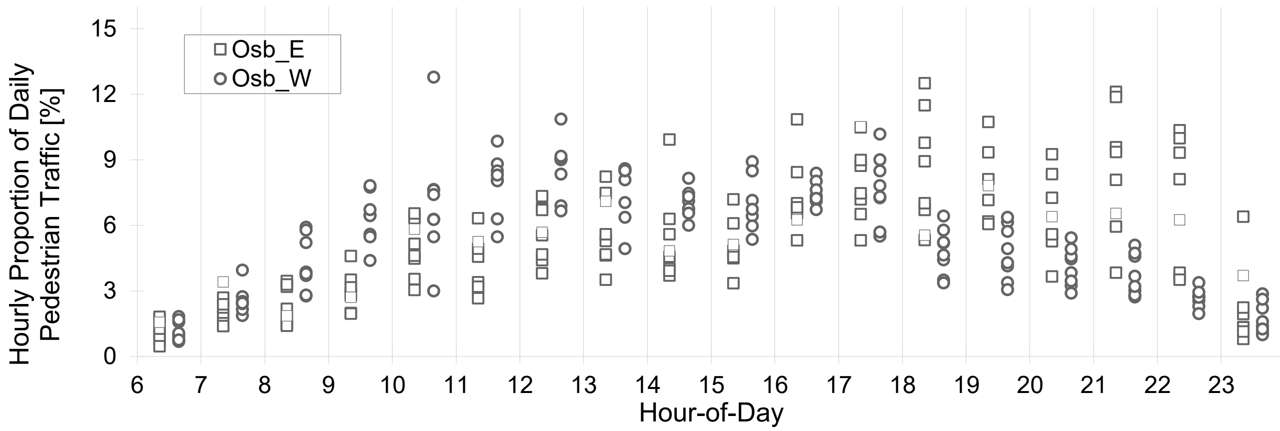
	Hour-of-Day																	
Aca_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	0.5	1.0	1.5	3.4	4.8	5.2	5.0	10.4	7.2	8.1	9.8	10.3	8.9	10.3	5.6	3.9	2.6	0.5
StDev	0.6	0.8	0.9	2.6	4.2	2.8	2.8	6.1	1.9	2.8	3.8	2.8	3.0	6.8	2.0	1.6	3.6	0.4
Aca_S																		
Mean	1.1	1.7	2.0	4.3	6.6	7.8	9.2	8.2	8.1	9.2	10.2	9.6	7.6	5.2	4.4	2.2	1.1	0.4
StDev	0.7	0.8	0.7	1.3	1.9	2.7	1.0	2.0	2.3	2.2	2.3	2.2	1.7	1.7	1.7	1.4	0.8	0.4



Character of Adjacent Sidewalks at Osborne in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

Hour-of-Day

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.88	0.24	0.00	0.00	0.08	0.00	0.00	0.03	0.06	0.00	0.74	0.58	0.01	0.01	0.01	0.00	0.00	0.41

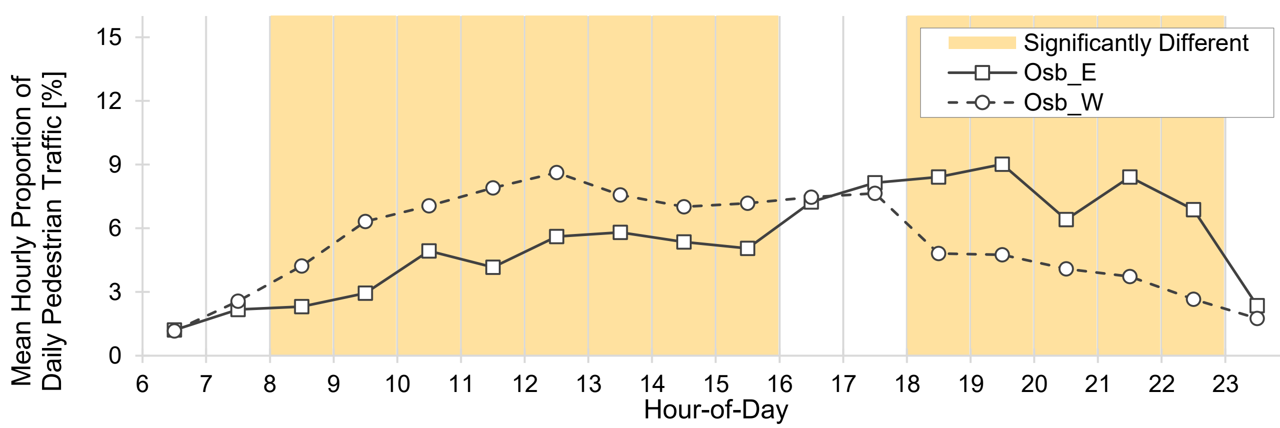
Number of Rejected H_o 13

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

Hour-of-Day

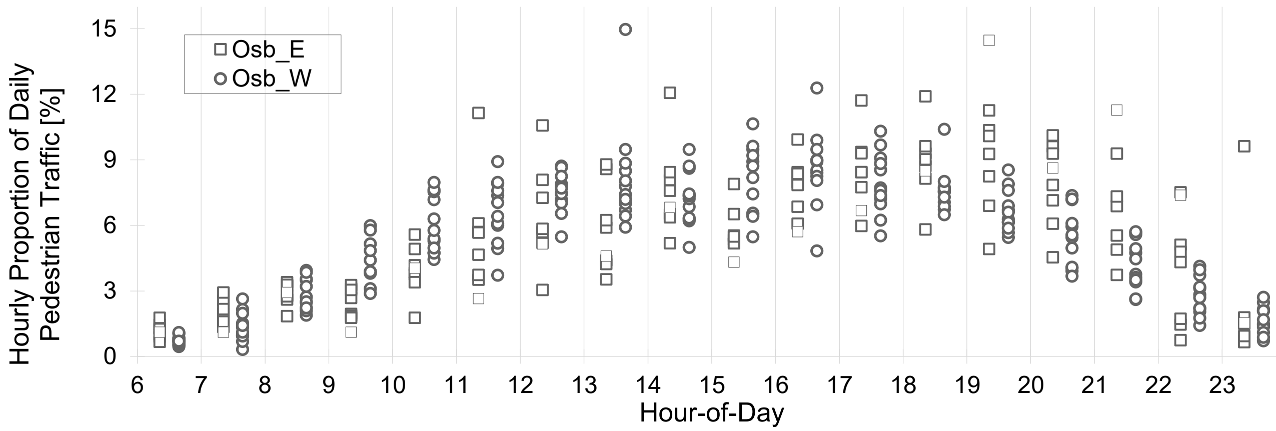
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Osb_E																		
Mean	1.2	2.2	2.3	2.9	4.9	4.2	5.6	5.8	5.4	5.0	7.2	8.1	8.4	9.0	6.4	8.4	6.9	2.4
StDev	0.5	0.7	0.9	0.9	1.3	1.3	1.3	1.6	2.0	1.1	1.7	1.9	2.7	3.5	1.8	2.9	2.9	1.9
Osb_W																		
Mean	1.2	2.6	4.2	6.3	7.1	7.9	8.6	7.6	7.0	7.2	7.5	7.7	4.8	4.8	4.1	3.7	2.7	1.7
StDev	0.5	0.6	1.3	1.2	2.8	1.4	1.3	1.3	0.7	1.3	0.5	1.6	1.1	1.2	0.9	0.9	0.4	0.7



Character of Adjacent Sidewalks at Osborne in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

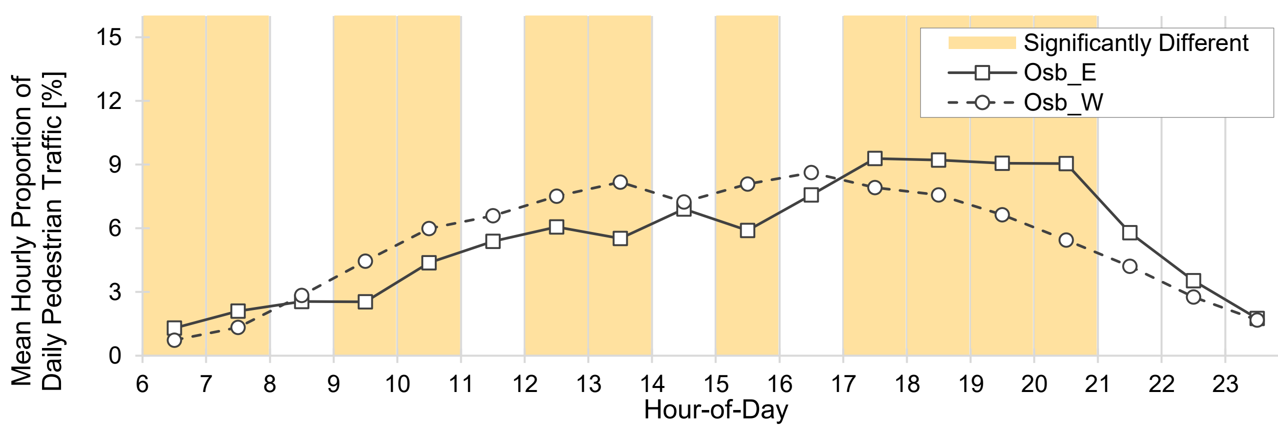
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.00	0.01	0.32	0.00	0.00	0.12	0.03	0.00	0.63	0.00	0.13	0.09	0.02	0.03	0.02	0.12	0.34	0.91

Number of Rejected H_o **11**

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

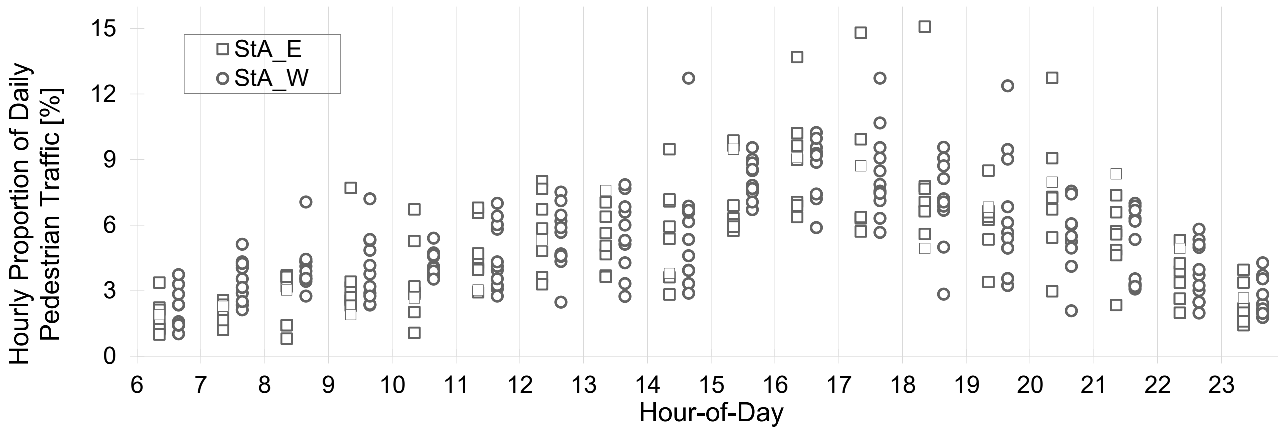
	Hour-of-Day																	
Osb_E	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	1.3	2.1	2.6	2.5	4.4	5.4	6.1	5.5	6.9	5.9	7.6	9.3	9.2	9.1	9.1	5.8	3.5	1.8
StDev	0.4	0.6	0.6	0.9	1.2	2.1	1.9	1.7	2.0	1.2	1.5	2.2	2.0	3.3	4.3	3.1	2.6	2.5
Osb_W																		
Mean	0.7	1.3	2.8	4.5	6.0	6.6	7.5	8.2	7.2	8.1	8.6	7.9	7.6	6.6	5.5	4.2	2.8	1.7
StDev	0.2	0.7	0.7	1.1	1.3	1.5	0.9	2.4	1.2	1.6	1.8	1.4	1.0	0.9	1.3	1.1	0.9	0.6



Character of Adjacent Sidewalks at St Anne's in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

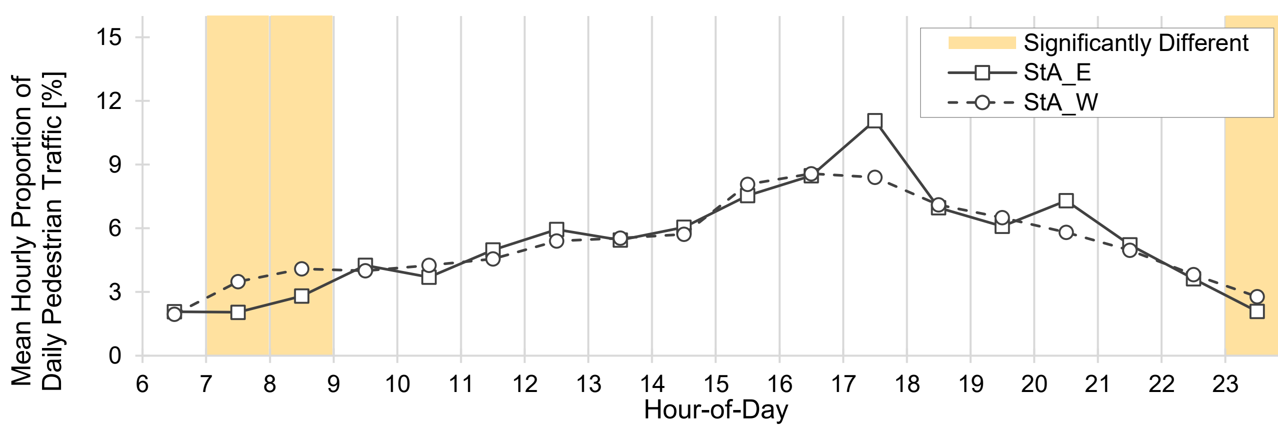
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.76	0.00	0.02	0.79	0.38	0.53	0.52	0.89	0.75	0.37	0.90	0.16	0.91	0.66	0.11	0.75	0.75	0.08

Number of Rejected H_o **3**

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

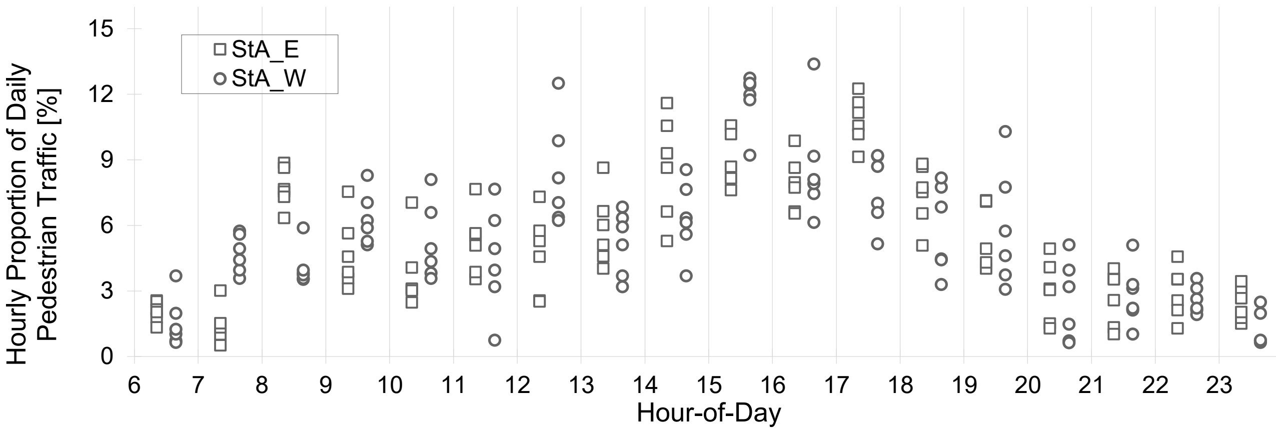
	Hour-of-Day																	
StA_E	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	2.0	2.8	4.2	3.7	5.0	5.9	5.4	6.1	7.5	8.5	11.1	7.0	6.1	7.3	5.2	3.6	2.1
StDev	0.8	0.5	1.3	2.6	1.9	1.6	2.3	1.3	2.1	1.7	2.2	5.6	3.1	1.3	2.4	2.0	1.5	0.9
StA_W																		
Mean	1.9	3.5	4.1	4.0	4.3	4.6	5.4	5.5	5.7	8.1	8.6	8.4	7.1	6.5	5.8	5.0	3.8	2.8
StDev	1.1	1.0	1.1	1.5	0.6	1.5	1.4	1.7	2.7	0.9	1.4	2.0	1.9	2.8	1.7	1.7	1.3	0.8



Character of Adjacent Sidewalks at St Anne's in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

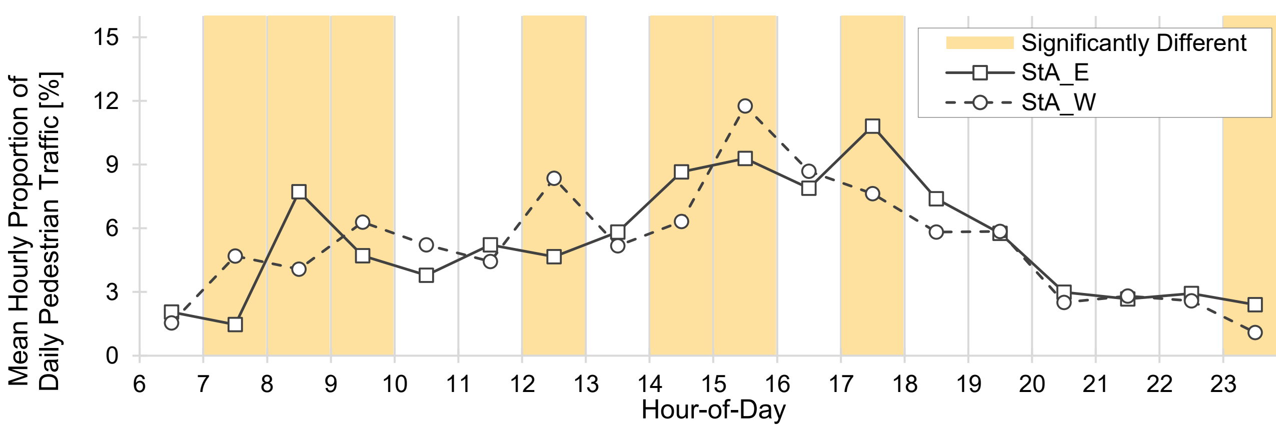
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.35	0.00	0.00	0.09	0.18	0.52	0.01	0.49	0.08	0.01	0.51	0.00	0.15	0.94	0.62	0.87	0.55	0.02

Number of Rejected H_o 8

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

	Hour-of-Day																	
StA_E	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	1.5	7.7	4.7	3.8	5.2	4.7	5.8	8.7	9.3	7.9	10.8	7.4	5.8	3.0	2.7	2.9	2.4
StDev	0.5	0.8	0.9	1.6	1.7	1.5	1.9	1.7	2.4	1.3	1.3	1.1	1.4	1.5	1.4	1.3	1.2	0.8
StA_W																		
Mean	1.5	4.7	4.1	6.3	5.2	4.4	8.4	5.2	6.3	11.8	8.7	7.6	5.8	5.9	2.5	2.8	2.6	1.1
StDev	1.2	0.9	0.9	1.2	1.8	2.4	2.4	1.5	1.7	1.3	2.5	1.6	2.0	2.7	1.9	1.4	0.6	0.9



Character of Adjacent Sidewalks at Roblin in the Summer Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk

STATISTICAL COMPARISON

Student's T-Test Results: p-value

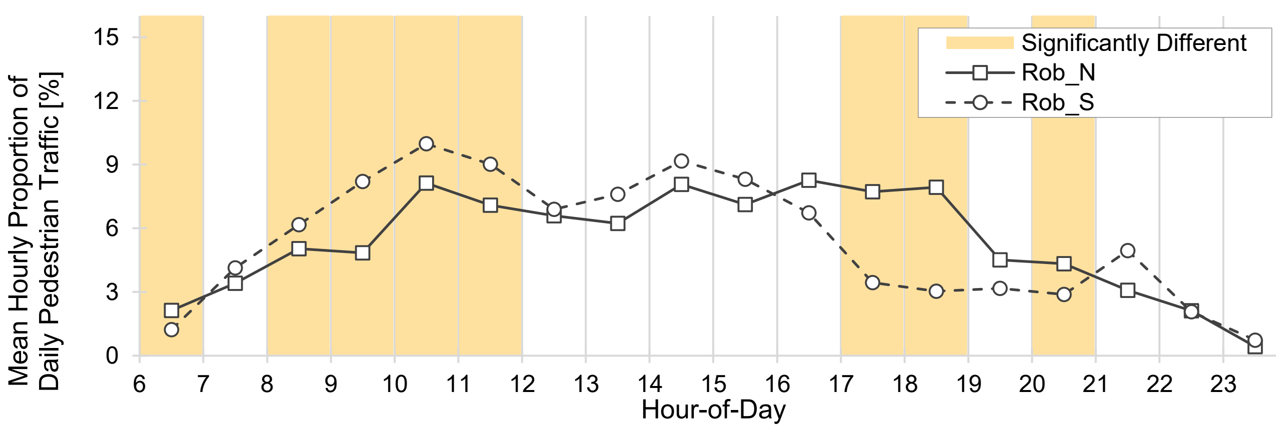
Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.03	0.30	0.09	0.00	0.05	0.05	0.78	0.32	0.56	0.37	0.25	0.03	0.00	0.18	0.06	0.19	0.94	0.23

Number of Rejected H_o **8**

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Summer

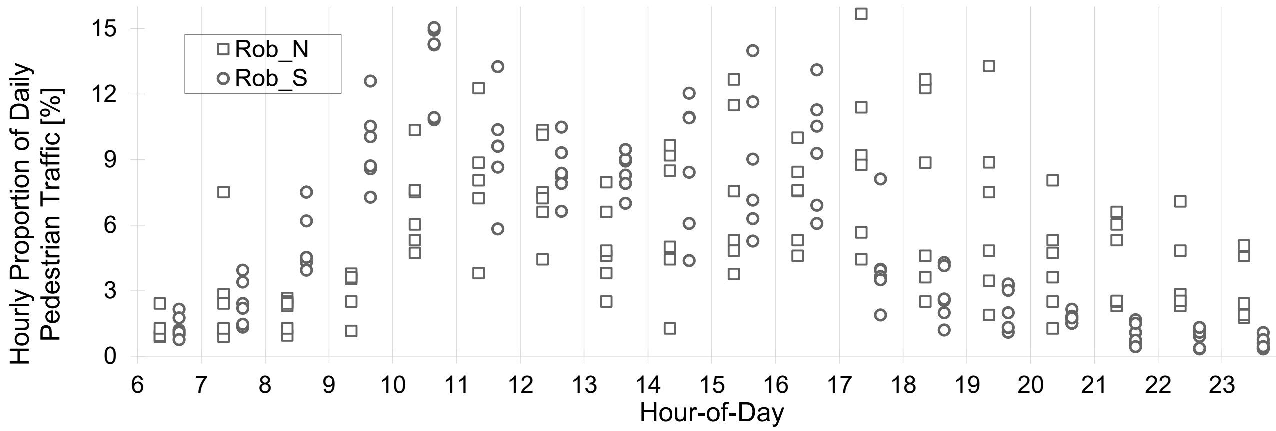
	Hour-of-Day																	
Rob_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	2.1	3.4	5.0	4.8	8.1	7.1	6.6	6.2	8.1	7.1	8.3	7.7	7.9	4.5	4.3	3.1	2.1	0.4
StDev	1.1	1.9	1.7	2.3	2.3	2.6	2.7	4.1	5.3	3.9	3.6	5.5	2.4	3.0	1.9	2.0	1.3	0.7
Rob_S																		
Mean	1.2	4.1	6.2	8.2	10.0	9.0	6.9	7.6	9.2	8.3	6.7	3.4	3.0	3.2	2.9	4.9	2.1	0.7
StDev	0.7	1.2	1.3	1.8	1.9	1.7	2.4	1.6	3.0	1.8	2.3	1.9	1.4	0.9	1.4	4.0	1.6	0.3



Character of Adjacent Sidewalks at Roblin in the Fall Season

INITIAL DATA SET

Hourly Proportion of Daily Pedestrian Traffic by Adjacent Sidewalk



STATISTICAL COMPARISON

Student's T-Test Results: p-value

Hour-of-Day																	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.36	0.84	0.00	0.00	0.00	0.85	0.48	0.01	0.21	0.54	0.13	0.03	0.05	0.05	0.05	0.01	0.05	0.01

Number of Rejected H_o 11

RESULTS

Hourly Pedestrian Traffic Periodicities of Adjacent Sidewalks in the Fall

	Hour-of-Day																	
Rob_N	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean	0.9	2.7	2.0	2.4	6.9	10.0	7.7	5.0	6.3	7.6	7.2	9.2	7.4	6.6	4.2	4.2	3.3	3.5
StDev	0.9	2.5	0.7	1.5	2.0	5.6	2.2	2.0	3.3	3.7	2.0	4.1	4.5	4.1	2.4	2.0	2.4	1.6
Rob_S																		
Mean	1.3	2.4	5.7	9.6	13.4	9.5	8.5	8.4	8.8	8.9	9.5	4.2	2.8	2.3	1.7	1.0	0.7	0.6
StDev	0.5	1.0	1.6	1.9	2.0	2.4	1.3	0.9	3.1	3.4	2.7	2.1	1.2	1.0	0.2	0.5	0.5	0.3