Demographic, Physical Activity, and Route Characteristics Related to School Transportation: An Exploratory Study

Chanam Lee, Associate Professor
Department of Landscape Architecture and Urban Planning, College of Architecture
Texas A&M University, College Station, Texas

Li Li, PhD Candidate
Department of Geography, College of Geosciences
Texas A&M University, College Station, Texas

ALR 2013 Annual Conference
San Diego, CA
February 8, 2013

Funding Source:
Robert Wood Johnson Foundation’s Active Living Research program
(Grant ID: 65539).
Background

• **Active travel to school** has been widely promoted as a means to reverse the children obesity epidemic.

• Evidence indicates built environments around **homes** and **schools** and along the **routes** influence **parental decisions** for children’s school travel mode choice.

• **Objective measurements** such as Global Positioning System (GPS) units and accelerometers emerge as promising tools to capture both the built environment and school commuting behaviors to overcome inherent limitations of conventional self-report measures, especially for children.

• **Challenges** exist in collecting such data especially among children, and due to the complexity in data processing/analysis.
Objectives

1. Investigate the characteristics of children’s home-to-school and school-to-home travels, in terms of demographic, physical activity, and route characteristics.

2. Assess the contribution of active travel modes to the overall daily moderate-to-vigorous physical activity (MVPA), and variations in school trip characteristics by community settings.
Participants:
- 113 children from 18 elementary schools in Austin Independent School District in Texas

Survey period:
- Fall semester of 2009 ~ Spring semester of 2011

Measurement Devices:
- GPS unit (Garmin Forerunner 205) with smart recording data capture
- Accelerometer (ActiGraph GT3X) with 15-sec data capture
- Travel Log (Self-report by children with parental help)
- Parental survey (personal, school travel, physical activity and environmental perception data)

Measurement Duration:
- 7 consecutive days
- 8 hours of daily accelerometer wearing time and 30% of active time considered valid
## Methods: Instruments


<table>
<thead>
<tr>
<th>Points Correctly plotted on sidewalk</th>
<th>Garmin Foretrex</th>
<th>Rating</th>
<th>% Correct</th>
<th>Garmin Forerunner</th>
<th>Rating</th>
<th>% Correct</th>
<th>Global Sat DG-100</th>
<th>Rating</th>
<th>% Correct</th>
<th>Wintec Easy Showily</th>
<th>Rating</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points Correctly plotted on the correct side of the road</td>
<td>O</td>
<td>67.1%</td>
<td>+</td>
<td>76.0%</td>
<td>+</td>
<td>74.9%</td>
<td>-</td>
<td>57.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points on course</td>
<td>-</td>
<td>71.6%</td>
<td>+</td>
<td>80.7%</td>
<td>+</td>
<td>80.49</td>
<td>-</td>
<td>71.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points on course with tree coverage</td>
<td>-</td>
<td>73.0%</td>
<td>+</td>
<td>100%</td>
<td>O</td>
<td>82.80%</td>
<td>+</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points on course while indoors**</td>
<td>+</td>
<td>100%</td>
<td>+</td>
<td>100%</td>
<td>-</td>
<td>46.1%</td>
<td>+</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. **GPS**: Geographic Information (Location, Speed, Time)

2. **Accelerometer**: Physical Activity Information (PA intensity, Step Counts, Time)

3. **Travel Log**: Self Recorded Daily Travel Information (Mode, Purpose, Time)
Methods: Data Processing

- Synthesizing GPS and Accelerometer
- Travel Mode Detection
- Trip Identification

Compare
1. Download the Raw GPS data from the unit
2. Download the Raw Accelerometer data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Activity</th>
<th>Activity (Horizontal)</th>
<th>3rd Axis</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/30/2009</td>
<td>8:13:00</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:13:30</td>
<td>33</td>
<td>103</td>
<td>47</td>
<td>3</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:14:00</td>
<td>225</td>
<td>228</td>
<td>149</td>
<td>7</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:14:30</td>
<td>91</td>
<td>114</td>
<td>56</td>
<td>3</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:15:00</td>
<td>378</td>
<td>165</td>
<td>198</td>
<td>13</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:15:30</td>
<td>21</td>
<td>118</td>
<td>437</td>
<td>0</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:16:00</td>
<td>887</td>
<td>1108</td>
<td>1535</td>
<td>33</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:16:30</td>
<td>753</td>
<td>1008</td>
<td>1248</td>
<td>29</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:17:00</td>
<td>942</td>
<td>1110</td>
<td>1414</td>
<td>37</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:17:30</td>
<td>194</td>
<td>509</td>
<td>548</td>
<td>6</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:18:00</td>
<td>209</td>
<td>239</td>
<td>540</td>
<td>2</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:18:30</td>
<td>14</td>
<td>78</td>
<td>66</td>
<td>1</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:19:00</td>
<td>227</td>
<td>260</td>
<td>541</td>
<td>2</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:19:30</td>
<td>98</td>
<td>156</td>
<td>312</td>
<td>2</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:20:00</td>
<td>36</td>
<td>126</td>
<td>127</td>
<td>1</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:20:30</td>
<td>0</td>
<td>23</td>
<td>109</td>
<td>0</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:21:00</td>
<td>0</td>
<td>18</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:21:30</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6/30/2009</td>
<td>8:22:00</td>
<td>0</td>
<td>21</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
3. Link GPS with Accelerometer data

- Use “time” as the common link
- Issues/challenges:
  - Missing or erroneous GPS data while indoors or under heavy canopy (buildings/trees)
  - Lack of clear (valid) thresholds/guidelines for data processing
  - Labor-intensive (need to develop special program to handle large samples)

4. Classify the Synchronized data

- Route vs. destinations
- Modes (e.g. walking, driving) based on:
  - Speed (GPS)
  - Step count (Accelerometer)
  - Travel diary (if available)
- Individual Trips

Trip 1
Nov 21 2009 Saturday
Time: 11:51:29 AM - 11:55:34 AM
Duration: About 4 minutes
Length: 0.2 miles
Average Speed: 2.88 MPH
Origin: KRUEGER
Destination: EVANS LIBRARY
Purpose: Study
Total Steps: 506
Energy Expenditure: ~16 cal
Trip 2
Nov 21 2009 Saturday
Time: 1:14:42 PM - 1:18:23 PM
Duration: About 4 minutes
Length: 0.19 miles
Average Speed: 3.14 MPH
Origin: EVANS LIBRARY
Destination: KRUEGER
Purpose: Go Home
Total Steps: 394
Energy Expenditure: ~12 cal
Trip 3
Nov 21 2009 Saturday
Time: 1:55:41 PM - 2:02:26 PM
Duration: About 7 minutes
Length: 0.29 miles
Average Speed: 2.57 MPH
Origin: KRUEGER
Destination: HART R-HALL
Purpose: Meet Friends
Total Steps: 797
Energy Expenditure: ~ 22 cal
Trip 4
Nov 21 2009 Saturday
Time: 2:11:22 PM - 2:17:30 PM
Duration: About 6 minutes
Length: 0.28 miles
Average Speed: 2.74 MPH
Origin: HART R-HALL
Destination: KYLE FIELD
Purpose: Watch sports games
Total Steps: 655
Energy Expenditure: ~ 19 cal
Results: Participants

Age: 9.5 Years

Gender: 50.8% Girl

Ethnicity/Race: 58.3% Hispanic origin, 34.2% White

Economic Status: 50% qualified for the free or reduced price lunch program
Results: Trip Summary

112 (85%) out of 132 participants with at least one valid home-to/from-school route identified

303 person-days & 579 trip segments extracted
Automobiles (private car and school bus): 61.4%
Walking: 34.9%
Bicycling: 3.7%

39% were chained trips
Chained trips: 1+ stops en route to/from school for other purposes (72% of chained trips were school-to-home trips)
Results: Travel mode

Gender
- Boy
- Girl

Race
- Hispanic
- White
- African American

Free Lunch
- No Free Lunch
- Free Lunch

Trip Percentage (%)
- Driving
- Walking & Driving
- Walking
- Bicycling
- Walking & Bicycling
Travel **to** School

mean = 1.4 miles

(7.4 minutes)
Travel FROM School
Mean = 2.0 miles (12.1 minutes)
Results: Trip Length

Mean and Median Trip Lengths (Mile)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Drive</th>
<th>Drive &amp; Walk</th>
<th>Walk</th>
<th>Bicycle</th>
<th>Walk &amp; Bicycle</th>
<th>Home to School</th>
<th>School to Home</th>
<th>Direct Trip</th>
<th>Chained Trip</th>
<th>Boy</th>
<th>Girl</th>
<th>No Free Lunch</th>
<th>Free Lunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (Mile)</td>
<td>2.2</td>
<td>2.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>
**Results: Trip duration**

Mean and Median Trip Duration (Minute)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive &amp; Walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk &amp; Bicycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home to School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School to Home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chained trip</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results: Route Directness

Route Directness = Direct (Straight) Distance / Actual Trip Length

Mean Route Directness

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mean Route Directness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving</td>
<td>0.65</td>
</tr>
<tr>
<td>Walking &amp; Driving</td>
<td>0.66</td>
</tr>
<tr>
<td>Walking</td>
<td>0.70</td>
</tr>
<tr>
<td>Bicycling</td>
<td>0.65</td>
</tr>
<tr>
<td>Walking &amp; Bicycling</td>
<td>0.70</td>
</tr>
<tr>
<td>Home to School</td>
<td>0.70</td>
</tr>
<tr>
<td>School to Home</td>
<td>0.70</td>
</tr>
</tbody>
</table>
## Results: Geographic Settings

<table>
<thead>
<tr>
<th>Geographic Setting Type (# of schools)</th>
<th>Population Density</th>
<th>Percentage of Hispanic</th>
<th>Median Household Income</th>
<th>Location Clustering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner-city low income (3)</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>East</td>
</tr>
<tr>
<td>Urban low income (8)</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Northeast &amp; Southeast</td>
</tr>
<tr>
<td>Urban middle income (3)</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>South</td>
</tr>
<tr>
<td>Sub-urban high income (4)</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>West</td>
</tr>
</tbody>
</table>
Results: Geographic Settings

[Bar chart showing the distribution of transportation modes in different geographic settings: Inner-city Low-income, Urban Low-income, Urban Middle-income, Suburban High-income. Modes include Driving, Walking & Driving, Walking, Bicycling, Walking & Bicycling.]
### Results: Geographic Settings

#### Trip Length

- **Inner-city**
  - Low-income: 2.36
  - Urban: 1.34
  - Middle-income: 1.15

- **Trip Duration**
  - Inner-city Low-income: 9.3
  - Urban Low-income: 8.4
  - Middle-income: 7.0

- **Route Directness**
  - Inner-city Low-income: 0.68
  - Urban Low-income: 0.68
  - Middle-income: 0.73

#### Trip Duration

- **Inner-city**
  - Low-income: 9.6
  - Urban: 7.1
  - Middle-income: 12.3

- **Trip Duration**
  - Inner-city Low-income: 0.7
  - Urban Low-income: 0.73
  - Middle-income: 0.77

- **Route Directness**
  - Inner-city Low-income: 0.68
  - Urban Low-income: 0.68
  - Middle-income: 0.73
  - Suburban High-income: 0.67

---

**Legend:**
- Mean Trip Length
- Median Trip Length
- Mean Trip Duration
- Median Trip Duration
- Mean Route Directness
- Median Route Directness
Three ways to compare daily MVPA:

a. Minutes of MVPA 1
   Thresholds: bout length - 5 minutes; tolerance - 1 minute

b. Minutes of MVPA 2
   Thresholds: bout length - 10 minutes; tolerance - 2 minutes

b. Daily accumulated minutes of MVPA
   No bout threshold

Results: Physical Activity
Results: Physical Activity

Daily Minutes of MVPA

<table>
<thead>
<tr>
<th>Group</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Boy</td>
<td>50</td>
</tr>
<tr>
<td>Girl</td>
<td>40</td>
</tr>
<tr>
<td>Hispanic</td>
<td>30</td>
</tr>
<tr>
<td>White</td>
<td>20</td>
</tr>
<tr>
<td>African American</td>
<td>10</td>
</tr>
<tr>
<td>Non-walker</td>
<td>9</td>
</tr>
<tr>
<td>Walker</td>
<td>8</td>
</tr>
</tbody>
</table>
Results: Physical Activity

Average daily MVPA was **34.6 minutes**

Walkers had **10 more minutes** of daily MVPA than non-walkers (39.1 vs. 28.7)

The average contribution in percentage from active travel modes to the total daily MVPA was **33.5%**

More sedentary participants had a greater proportion of their MVPA accounted for by active school travels. For example, a student with 10 minutes of total daily MVPA had 7 minutes (70%) from school travels, while a student with 1 hour of daily MVPA had 9 minutes (15%) from school travels.
Conclusion

• Continued decline in PA with age among elementary school students

→ intervention at younger age

• 0.5 miles confirmed as feasible distance for walking (and also likely bicycling)

→ intervention efforts targeting students living within 0.5 mile
Conclusion

- Boys (vs. girls), White and African American (vs. Hispanic), and high SES (vs. low SES) with higher share of walking to school (WTS)

- Boys (vs. girls), White (vs. Hispanic, African American), high SES (vs. low SES) and walkers (vs. non-walkers) with more PA

- More sedentary children had a greater proportion of their MVPA accounted for by active school travels.

- Significant variations in WTS and PA across different settings and income levels

→ Interventions for WTS vs. PA; currently sedentary vs. active children; by different environmental contexts
Discussions

• Accuracy and completeness of GPS-accelerometer data for children (85% with at least 1 valid school trip extracted from 7 days of wearing).

• Further analyses to include detailed spatial analyses of the GPS-accelerometer data with GIS and audit data.

• Travel behavior and PA variations by neighborhood/school contexts and the need for context-specific interventions; but challenges in classifying heterogeneous contexts into meaningful groups.

• Inner-city schools and schools close to major employment centers with longer travel distance primarily due to parents’ work locations (residential vs. work locations/populations)
The Design Research for Active Living group is devoted to interdisciplinary research aimed at linking elements of the built environment with human health behaviors and outcomes. We believe that the homes, neighborhoods, cities and regions in which we live, work, study and play form an important health infrastructure that can promote or hinder good health. Made up of faculty members and students from Texas A&M University, our teams focus on identifying the specific and modifiable attributes of the built environment that can contribute to active and healthy living for all, especially vulnerable populations such as children, minorities and older adults. Toward this end, we conduct research projects examining people-environment relationships from the smaller architectural scale to the larger neighborhood and regional scales. Our work also focuses on multiple perspectives, from practitioners to policy-makers perspective, and from a people-oriented view to an environment-oriented view. Finally, we are committed to advancing theoretical and methodological approaches to better characterize the built environment for research, practice, and intervention purposes.

**RESEARCH HIGHLIGHT**

**The "Whys" and "Why Nots" of Active Living: Barriers and Motivators among High-Risk Children.**

This research examines multi-level natural and virtual experiments to identify specific interventions effective in promoting walking and physical activity and reducing obesity... more

**Safety, Health, and Equity for Active School Transportation: Interactions among Multi-Level Factors and Specific Needs of Low-Income Hispanic Children.**

This research aims: 1) to examine the mediating and moderating factors in the relationship between objective physical environment and active school transportation; ... more

**Institute for Obesity Research and Program Evaluation, Texas A&M University; and College Research and Interdisciplinary Council, College of Architecture, Texas A&M University.**

This pilot study is to explore the impact of food and physical activity environments where students live, work and study. It will also compare diet and physical... more