A feasibility study to examine whether time spent outdoors during the summer affects acute daily fasting blood glucose and steps

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INTRODUCTION
Physical activity has been positively associated with glycemic control in persons with type 2 diabetes (T2D); however potential exposure to heat may be a barrier to physical activity outdoors in the summer months. This study investigated whether it would be feasible to detect changes in glycemic control in persons with Type 2 Diabetes (T2D) related to a small change (additional 30 minutes) in time spent outdoors during the summer months.

Aims:
We hypothesize increasing time spent outdoors may lead to increased steps, and only minimal increases in heat exposure thereby leading to an overall reduction in fasting glucose levels the next day.
1. Assess whether fasting blood glucose values decreased on days following an intervention day.
2. Assess whether steps and personal heat exposure (daily mean and daily max) increase on intervention days and whether they have a mediating effect on fasting blood glucose.
3. Assess whether self-reported management of T2D modifies the relationship between intervention and fasting blood glucose.

METHODS

Figure 1. Flow Diagram of Study Design

• Inclusion: Women, aged 19-66 years old, availability to participate in a week long study
• Exclusion: inability to spend time outdoors
• N=180

Participants were women, primarily African American with mean (range) BMI 37.9 (24, 65) and age 54.8 (27, 66). Participants reported compliance on n=286 of 322 person-days (88.9%).

Table 1: Mean (Range) of outcome variable and potential mediating factors

<table>
<thead>
<tr>
<th>Glucose</th>
<th>Mean (mg/dL)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Mean Temperature (hourly) (°F)</td>
<td>78.9</td>
<td>(69, 90)</td>
</tr>
<tr>
<td>Daily Mean Temperature (hourly) (°F)</td>
<td>88.3</td>
<td>(76, 118)</td>
</tr>
<tr>
<td>Steps</td>
<td>4305.2</td>
<td>(97, 68487)</td>
</tr>
</tbody>
</table>

RESULTS

Aim 1: On average, fasting blood glucose was reduced by 6.1 mg/dL in mornings after intervention days (95%CI -11.5, -0.6 p-value 0.03) after adjusting for age, BMI, and weather conditions.

Table 2: Primary Model

<table>
<thead>
<tr>
<th>Glucose</th>
<th>β (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-64.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Age</td>
<td>0.8</td>
<td>-0.8</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.5</td>
<td>-2.1</td>
</tr>
<tr>
<td>Intervention</td>
<td>-6.1</td>
<td>-11.5</td>
</tr>
</tbody>
</table>

Models include adjustment for weather (Weather station data on maximum and minimum temperature and precipitation).

Additional model with only compliant intervention days prior was similar to the model presented in Table 2 (Intervention day prior β = 7.3 (95% CI -12.8, -1.7) p-value 0.01).

Data Sources and Statistical Analysis
• Linear Mixed Effects Models were performed in MATLAB R2017b.
• All models presented include adjustment for weather (Weather station data on daily mean hourly average).

Summary of Results
• Analysis of this dataset suggests fasting blood glucose decreased on days following the intervention of an additional 30 minutes spent outdoors.
• Neither personal temperature experienced nor steps were significantly increased, which were the hypothesized mediators.
• Potential limitations are low sample size, imprecise measurement of steps and/or temperature, and reliance on self-report for compliance. Blood glucose is highly influenced by food intake; however, ad libitum food records for this week were beyond the scope of this study.
• The association between intervention and reduced fasting blood glucose was stronger in participants who reported that at a recent appointment their glucose was out of the doctor recommended range, indicating challenges with management of their condition.

CONCLUSIONS
This pilot study contributes evidence regarding time spent outdoors, physical activity, and glucose control and responds to a call for assessing the relationship between time spent outdoors and health outcomes like glucose control. Further research is necessary before any future recommendations related to heat exposure in this vulnerable population should be considered.

Next Steps:
• Assess additional measures of compliance (phone and exit surveys).
• Explore pre/post- body composition measurements.
• Explore original participant population (n=180) physical activity, time spent outdoors, and environmental-related deterrents to physical activity.
• Determine appropriate method to assess dietary intake in this population (food diary, 24-hour recall, doubly-labeled water, etc.).

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