Investigating the Efficacy of Using Hand Tremors for Early Detection of Hypoglycemic Events: A Scoping Literature Review

Zahed, K.1, Sasangohar, F.1, Zhu, Y.1, Mehta, R.1, Erraguntla, M.1, Lawley, M.1

k.zahed@tamu.edu; sasangohar@tamu.edu; zhuxx355@tamu.edu; mmehta@tamu.edu; merraguntla@tamu.edu; malawley@tamu.edu

1 Department of Industrial and Systems Engineering, Texas A&M University

1. Background

- Around 460 million people globally live with diabetes.

- Hypoglycemia is a dangerous condition that happens when the blood glucose level drops below 70mg/dL.

- Nocturnal Hypoglycemia is especially dangerous, patients can’t wake up to regulate.

2. Research Aims

Aim 1: Understand what physiological factors have been studied to detect hypoglycemia

Aim 2: Understand if tremors are a good indicator of hypoglycemia

Aim 3: Understand if any studies attempted to innovate a technology to detect hypoglycemic tremors

3. Methods & Results

3.1 Scoping Literature Review on Tremors and Hypoglycemia

Methods:
- Used Texas A&M EBSCOHost research databases such as MEDLINE and Compendex on October 18, 2017
- 7 papers were found fitting the inclusion criteria
- 78 results, using keywords [“hypoglycemia”] and [“tremor” OR “trembling”]
- Inclusion Criteria: Studies looking at non invasive technologies / Only studies published in English

Results:

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muhllehauser</td>
<td>1991</td>
<td>17% of respondents reported tremors as their first symptom</td>
</tr>
<tr>
<td>Chiarelli.</td>
<td>1998</td>
<td>74% of children with diabetes surveyed said a frequent symptom they notice is trembling</td>
</tr>
<tr>
<td>Berlin et al.</td>
<td>2005</td>
<td>77% of respondents reported tremors as symptoms of hypoglycemia</td>
</tr>
<tr>
<td>Heller et al.</td>
<td>1987</td>
<td>Hypoglycemic patients had a noticeable increase in tremor readings (RMS) when BG dropped to 2.5mmol/L</td>
</tr>
<tr>
<td>George et al.</td>
<td>1995</td>
<td>Tremors did not become impaired like the responses of sweat and adrenaline</td>
</tr>
<tr>
<td>Scheckter et al.</td>
<td>2012</td>
<td>Used a simplified measure of tremors as 1 of 4 symptoms to monitor onset of hypoglycemia</td>
</tr>
<tr>
<td>Rana &amp; Chou</td>
<td>2015</td>
<td>Hypoglycemic tremor categorized as a medium frequency enhanced physiological tremor</td>
</tr>
</tbody>
</table>

3.2 Non Invasive Technologies

An additional search looked at [“hypoglycemia”] and [“non invasive”] to survey the non invasive methods of detecting hypoglycemia

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</tr>
</thead>
<tbody>
<tr>
<td>Harris et al.</td>
<td>1996</td>
<td>Used 3 sensors to study the variations of pulse rates, humidity, and skin temperature around the wrist</td>
</tr>
<tr>
<td>Nguyen &amp; Jones</td>
<td>2010</td>
<td>Alpha frequency of EEG Signals affected during hypoglycemia</td>
</tr>
<tr>
<td>Siegel, Lee, &amp; Pikov</td>
<td>2014</td>
<td>Correlation between BG levels and millimeter wave absorption (MMW) was found with hypoglycemia</td>
</tr>
<tr>
<td>Yadav et al.</td>
<td>2015</td>
<td>Spectroscopy methods require more improvement in order to compete with popular CGMs on the market</td>
</tr>
<tr>
<td>Yotha et al.</td>
<td>2016</td>
<td>Monitored pulsatile changes in blood flow, internal pulse, body temp, and skin conductance</td>
</tr>
<tr>
<td>San, Ling, &amp; Nguyen</td>
<td>2016</td>
<td>Longer QT intervals of ECG signals analyzed in order to detect hypoglycemic episodes</td>
</tr>
<tr>
<td>Zanon et al.</td>
<td>2017</td>
<td>A biosensor that has shown promise when tested on T1DM subjects</td>
</tr>
<tr>
<td>Howson &amp; Bequette</td>
<td>2015</td>
<td>Exhaustive review of similar methods, concluded that sweat and body temperature are not accurate</td>
</tr>
</tbody>
</table>

4. Discussion

- Hypoglycemic tremors: Categorized as medium frequency enhanced physiological tremor

- Common issues to consider in the design:
  - Usability and ease of use
  - Maintenance and calibration
  - Recurring costs
  - Wearability and non-obtrusiveness
  - Data Processing: VS Battery Life

5. Work in Progress

- Currently, work is in progress to:
  - Design and test a wearable sensor that analyzes the tremor signals in real-time
  - Use Actigraphy to study the tremor signal
  - Develop a mobile application that communicates with the sensor
  - Provides extra features aimed at helping the patients manage their diabetes.
  - Survey patients with diabetes on their symptoms and their opinion regarding such a technology.

- Continuous work is in progress to:
  - Develop new methods to detect hypoglycemia: Articulography
  - Investigating the Efficacy of Using Hand Tremors for Early Detection of Hypoglycemic Events: A Scoping Literature Review
  - Design and test a wearable sensor that analyzes the tremor signals in real-time

6. Preliminary Survey Results

- Average BG at which Hypoglycemia was reported
  - % of respondents that experience Hypoglycemia
  - % of events reported that happened while sleeping

For more information about this work, contact Dr. Farzan Sasangohar: sasangohar@tamu.edu (979) 458-2337