

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

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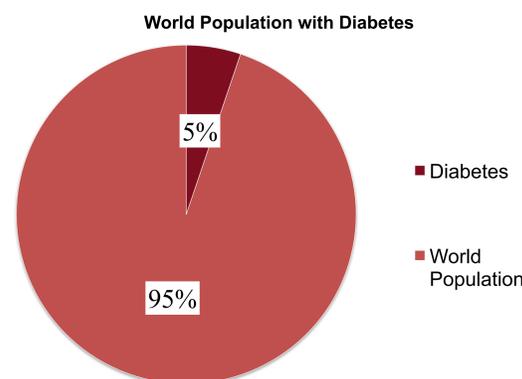
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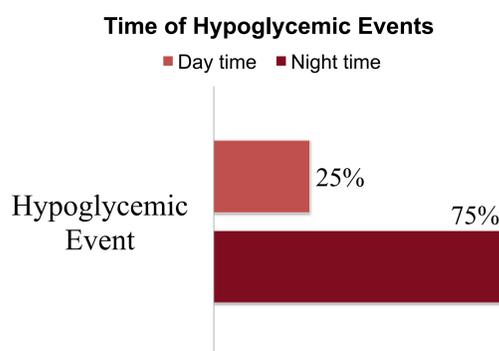
1. Background

- 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.



Continuous Glucose Monitoring devices (CGMs) are the most popular devices to monitor blood glucose and detect hypoglycemia:

- Pros:
- Provides glycaemic control
 - Provides continuous monitoring
 - Detects hypoglycemia

- Cons:
- Expensive
 - Accurate during the day, not so much at night
 - Invasive
 - Not prescribed for people with type 2 diabetes
 - Requires frequent calibration and part change

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
- 78 results, using keywords ["hypoglycemia"] and ["tremor" OR "trembling"]
 - Inclusion Criteria: Studies looking at non invasive technologies / Only studies published in English
 - 7 papers were found fitting the inclusion criteria

Results:

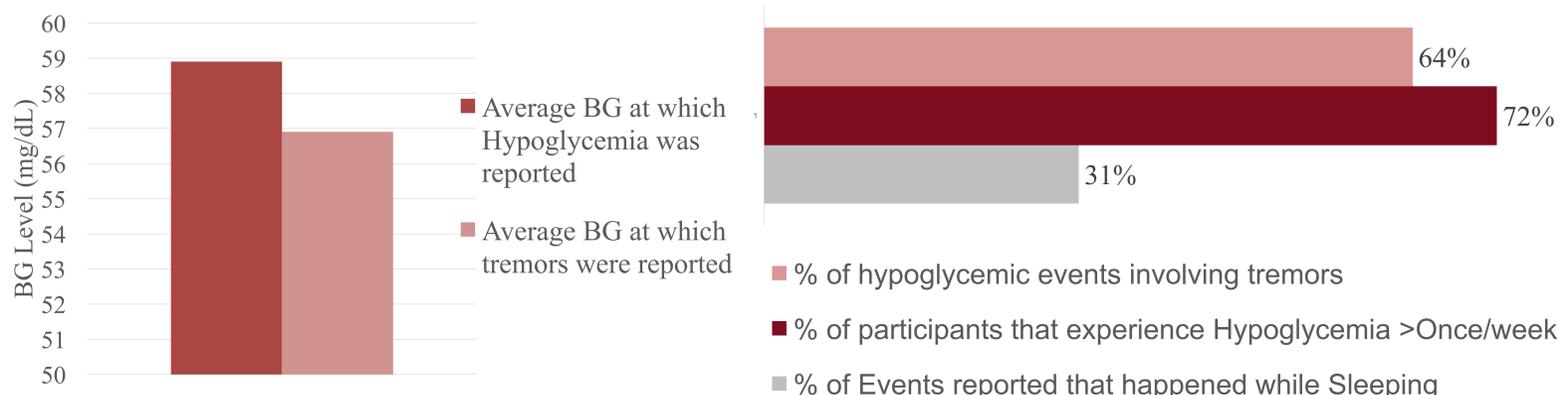
| | Author | Year | Findings |
|---|-------------------|------|---|
| 1 | Muhlhauser et al. | 1991 | 17% of respondents reported tremors as their first symptom |
| 2 | Chiarelli et al. | 1998 | 74% of children with diabetes surveyed said a frequent symptom they notice is trembling |
| 3 | Berlin et al. | 2005 | 77% of respondents reported tremors as symptoms of hypoglycemia |
| 4 | Heller et al. | 1987 | Hypoglycemic patients had a noticeable increase in tremor readings (RMS) when BG dropped to 2.5mmol/L |
| 5 | George et al. | 1995 | Tremors did not become impaired like the responses of sweat and adrenaline |
| 6 | Schechter et al. | 2012 | Used a simplified measure of tremors as 1 of 4 symptoms to monitor onset of hypoglycemia |
| 7 | Rana & Chou | 2015 | Hypoglycemic tremor categorized as a medium frequency enhanced physiological tremor |

3.2 Non Invasive Technologies

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

| | Author | Year | Findings |
|---|----------------------|------|--|
| 1 | Harris et al. | 1996 | Used 3 sensors to study the variations of pulse rates, humidity, and skin temperature around the wrist |
| 2 | Nguyen & Jones | 2010 | Alfa frequency of EEG Signals affected during hypoglycemia |
| 3 | Siegel, Lee, & Pikov | 2014 | Correlation between BG levels and millimeter wave absorption (MMW) was found with hypoglycemia |
| 4 | Yadav et al. | 2015 | Spectroscopy methods require more improvement in order to compete with popular CGMs on the market |
| 5 | Yotha et al. | 2016 | Monitored pulsatile changes in blood flow, internal pulse, body temp, and skin conductance |
| 6 | San, Ling, & Nguyen | 2016 | Longer QT intervals of ECG signals analyzed in order to detect hypoglycemic episodes |
| 7 | Zanon et al. | 2017 | A biosensor that has shown promise when tested on T1DM subjects |
| 8 | Howsmon & Bequette | 2015 | Exhaustive review of similar methods, concluded that sweat and body temperature are not accurate |

Preliminary Survey Results



4. Discussion

- Hypoglycemic tremors:
 - Categorized as medium frequency enhanced physiological tremor
 - Not impaired with time
 - Common among diabetics
 - Signal can be analyzed using Actigraphy
- Hypoglycemic tremors are worth studying.
- Other commercial technologies are very limited and have high false alarms

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.
- Most technologies have not been designed for usability and wearability, let alone user engagement
- Common issues to consider in the design:
 - Usability and ease of use
 - Maintenance and calibration
 - Recurring costs
 - Wearability and non-obtrusiveness
 - Data Processing V.S Battery Life
 - Age and type of diabetic patients
 - User engagement

