



Motivation & Problem Statement

Motivation

Caring for a child with Type 1 Diabetes (T1D) demands constant vigilance, yet caregivers often lack a simple, immediate way to understand when blood sugar levels require action.

Problem Statement

Parents and caregivers of children with T1D often struggle to quickly see and interpret glucose readings, leading to stress and delayed decisions. The SugarSafe Band aims to solve this problem by providing a clear, visual representation of the child's current blood sugar.

Background & Competing Designs

Background

- Type 1 Diabetes (T1D) is an autoimmune disease that prevents insulin production, causing elevated blood glucose and risk of long-term complications if unmanaged [1].
- Standard management uses a continuous glucose monitor (CGM), carbohydrate tracking, and individualized insulin dosing [2].
- There are **364,000 pediatric T1D patients in the U.S.** [3].

Competing Designs

- **Apple Watch**
 - Can receive glucose level directly with Dexcom Direct-to-watch [4].
 - Parents find smart tech distracting and difficult to read [4].
- **Glowcase**
 - Uses a color scale for easier interpretation.
 - Stationary, requires a constant Wi-Fi connection [5].



Figure 1: Apple Watch using Direct-to-watch [4]



Figure 2: Glowcase smart light [5]

Design Criteria

- Display color-coded alerts for real-time glucose readings.
- Limit glucose reading delay to 5 minutes.
- Ensure compatibility with modern CGMs.
- Provide >8 hours of rechargeable battery life.
- Include visible indicator for CGM or Bluetooth errors.
- Signal is visible and connected via Bluetooth at 50 m.
- Operate reliably in typical active-child environments.
 - Temperature: $-20\text{ }^{\circ}\text{C}$ to $43\text{ }^{\circ}\text{C}$ [6].
 - Water resistance: \geq IP54 [7].
 - Drop resistance: Survive 2.5 m drops [8].
 - Fit pediatric wrists (12.5–17.5 cm circumference) [9].

Table 1: Blood glucose levels in mg/dL and their corresponding colors

<55 (Critically Low)
56 - 65
66 - 80
81 -139 (In Range)
140 - 200
>201 (Critically High)

Final Prototype

Software

- App connects to Dexcom's Share API using user credentials.
- Glucose data and trend information fetched every 30 seconds.
- App displays glucose value, trend, and color status.
 - Adjustable brightness slider.
 - Bluetooth pair button.
- App sends latest value to microcontroller every 5 minutes.
- Microcontroller maps value to color and updates LED.
- Band automatically blinks white after 12 minutes with no new data.

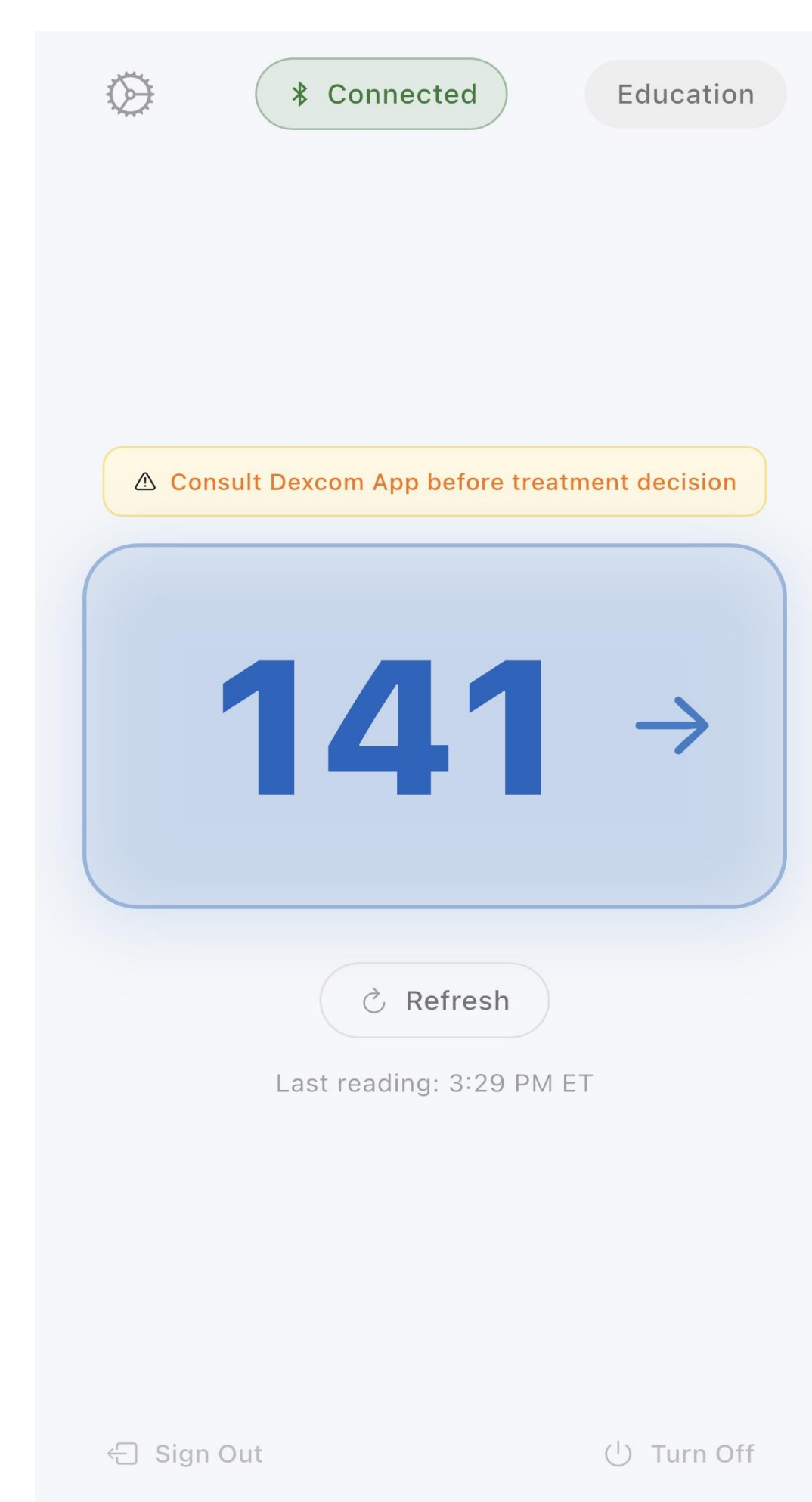


Figure 3: App Interface

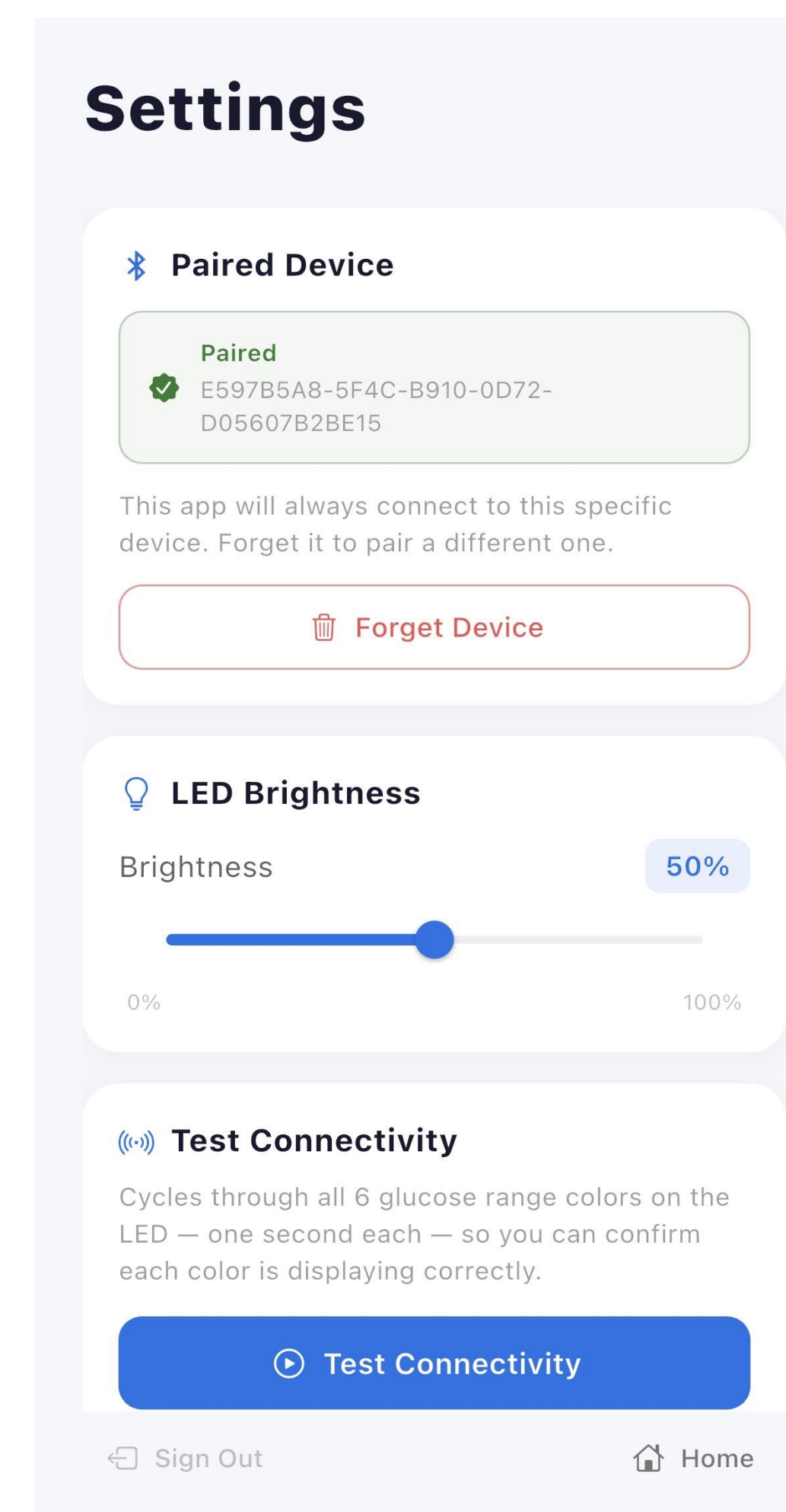


Figure 4: App Settings

Hardware

- Microcontroller with BLE capabilities.
- Rainbow integrated LED.
- Powered via USB-C connected to a 5000mAh portable 5V battery.
- 12-hour battery life at maximum BLE and LED usage (426mA load).

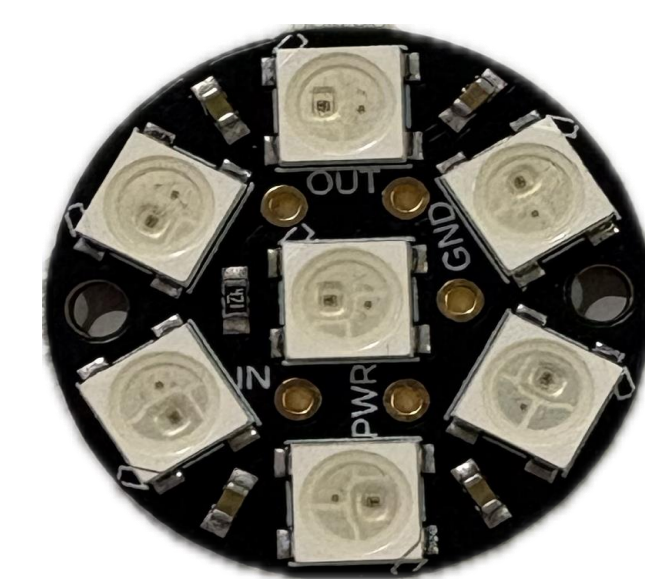


Figure 5: NeoPixel Jewel LED



Figure 6: XIAO ESP32-C6

Band Design

- 3-D printed black resin case, measures 26 x 30 mm.
- Clear resin snap-fit lid and USB-C charging opening.
- Bilateral band connection holds silicon band, with double loop latching mechanism.
- Adjustable band to fit child-size wrists.



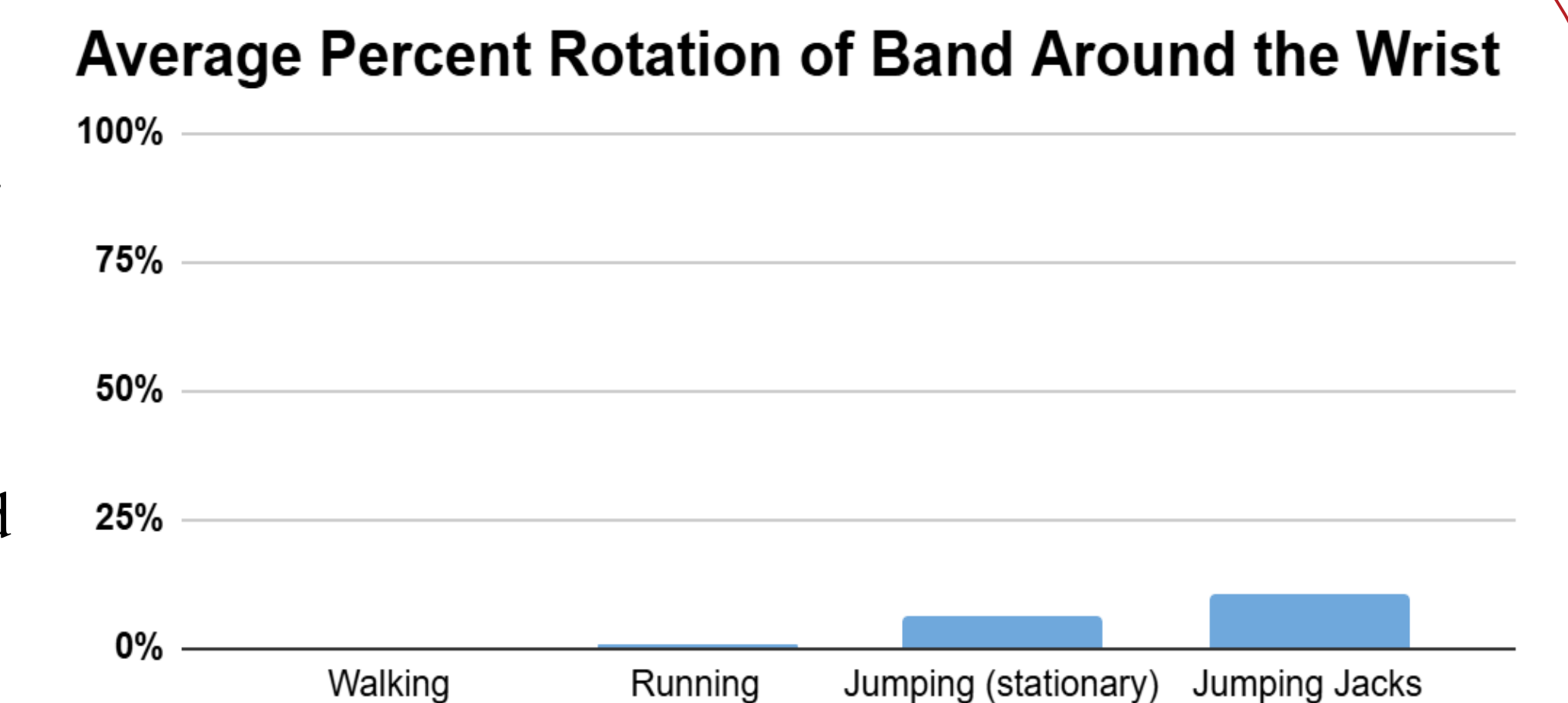
Figure 7: SugarSafe Band

Testing & Results

Band Security Testing

- Shift recorded as a percentage of total wrist circumference.
- Maximum shift observed was ~10%.
- Minimal to no shift was observed after walking, running and jumping.

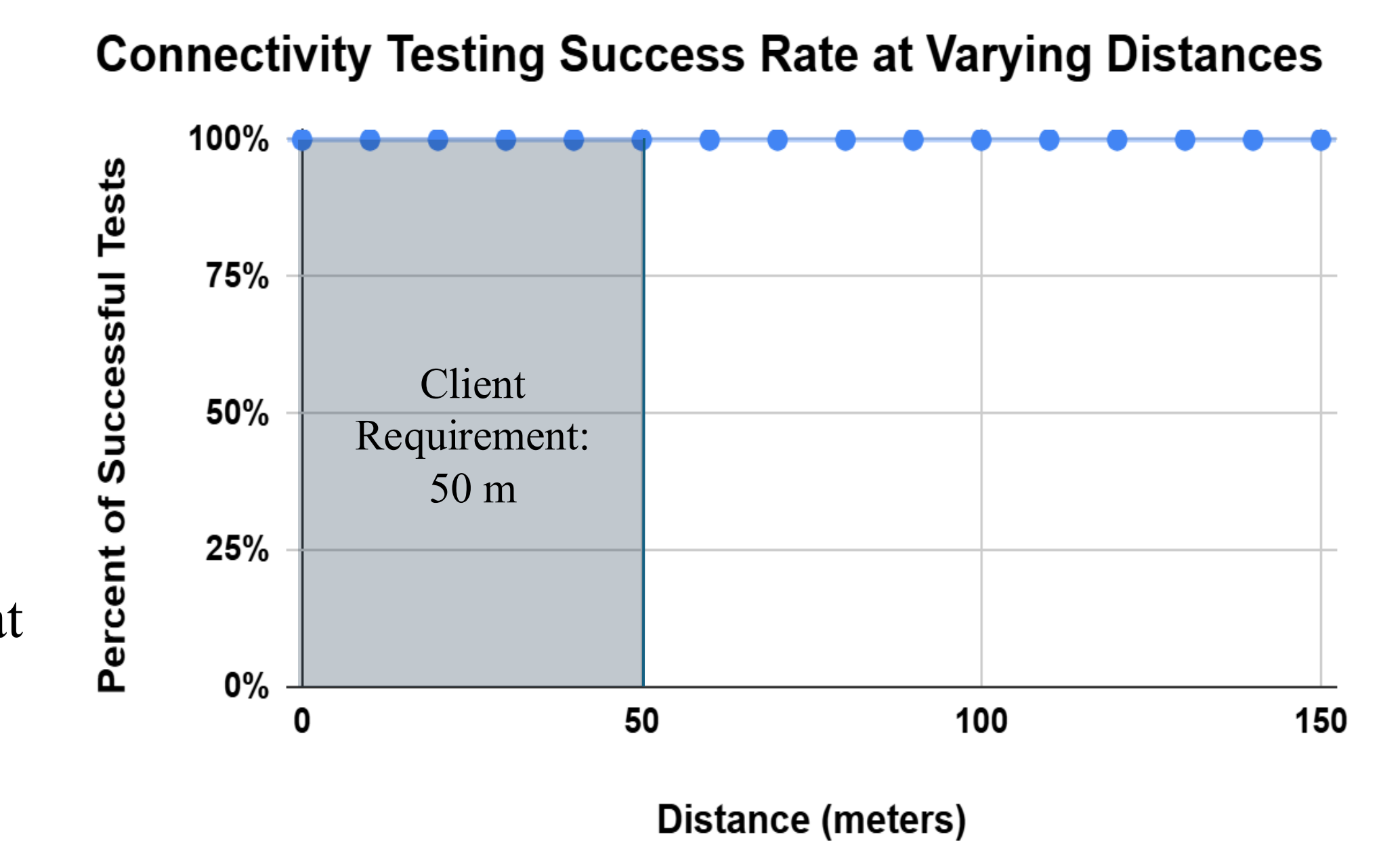
Figure [8] : Graph of rotation around wrist after activities were performed for 60 seconds, results averaged over 3 trials



Distance Testing

- App and microcontroller programmed with "Test Connectivity" cycle.
 - Flashes through all 6 colors.
 - Instant verification of connection.
- Test performed from 0 to 150 m at increments of 10 m.

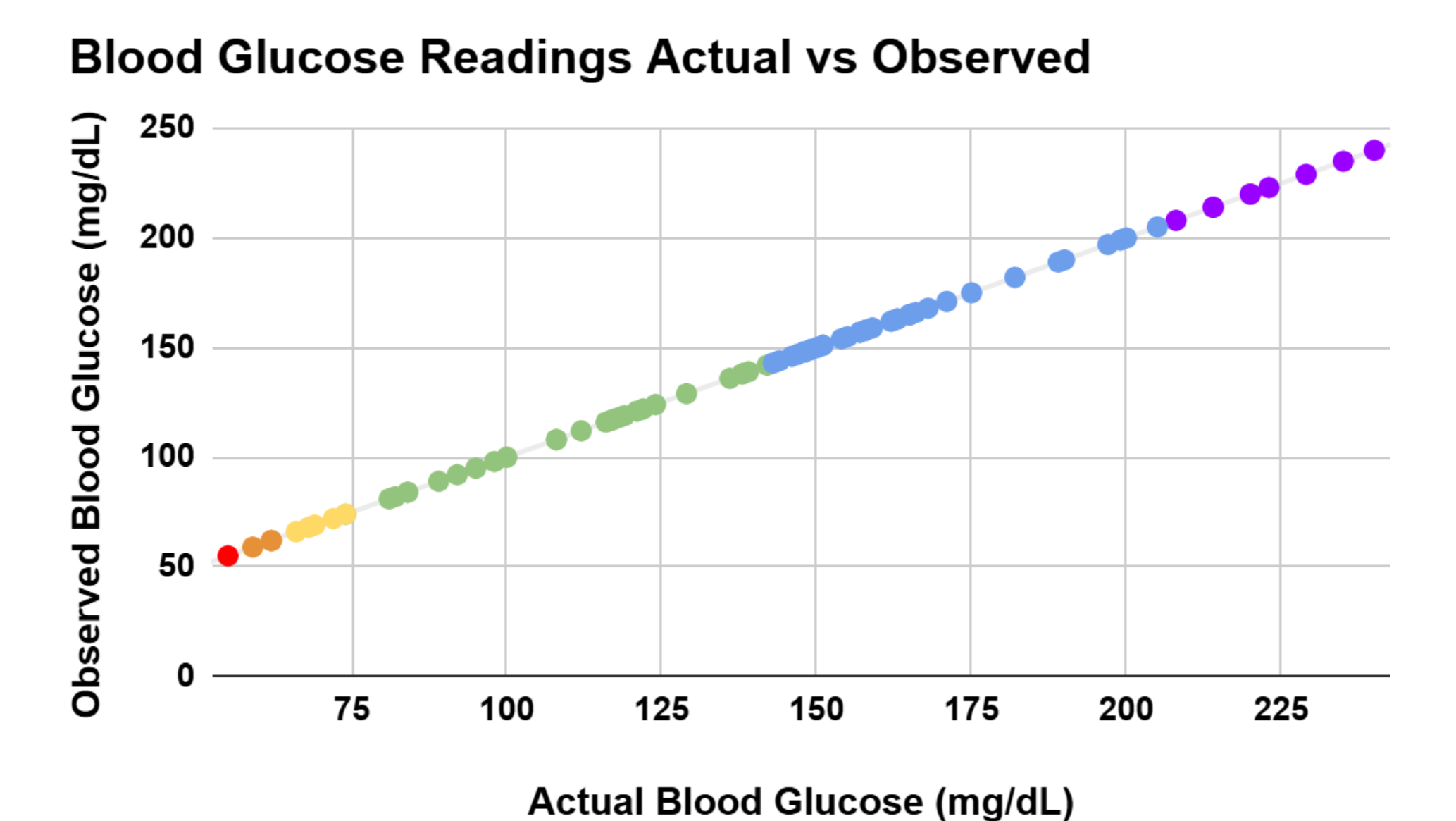
Figure [9] : Graph comparing successful connectivity test at varying distances, results averaged over 3 trials



Accuracy Testing

- Evaluated over a 5-hour period at 5-minute intervals.
- Blood glucose value between Dexcom app and SugarSafe app compared.
- 100 % accuracy observed.
- $R^2 = 1$.

Figure [10] : Graph comparing blood glucose level in mg/dL as seen on SugarSafe App as compared to Dexcom App



Future Work

- Obtain Dexcom collaborator access to enable direct retrieval of user data.
- Expand mobile application to additional platforms.
- Expand device compatibility to other popular CGM companies.
- Increase IP rating with the goal of full waterproofing (IP67).
- Select an enclosed battery with optimized voltage and capacity specifications.

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References

- [1] M. Campbell-Thompson, T. Rodriguez-Calvo, and M. Battaglia, "Abnormalities of the Exocrine Pancreas in Type 1 Diabetes," *Current Diabetes Reports*, vol. 15, no. 10, Aug. 2015, doi: <https://doi.org/10.1007/s11892-015-0653-z>.
- [2] Centers for Disease Control and Prevention, "Type 1 Diabetes," CDC, May 15, 2024. <https://www.cdc.gov/diabetes/about/about-type-1-diabetes.html>
- [3] American Diabetes Association, "Statistics about diabetes," diabetes.org, 2023. <https://diabetes.org/about-diabetes/statistics/about-diabetes>
- [4] Dexcom, "Dexcom G7 Direct to Apple Watch: Easy Glucose Monitoring," Dexcom All Access, Jun. 25, 2025. [Online]. Available: <https://www.dexcom.com/all-access/dexcom-g7-explained/direct-to-apple-watch> [Accessed: Apr. 15, 2026].
- [5] "Glowcase," Glowcase, 2024. <https://glowcase.com/> [Accessed: Sep. 17, 2025].
- [6] United States Climate, Weather By Month, Average Temperature - Weather Spark, Weather Spark, [Online]. Available: https://weatherspark.com/countries/US/google_vignette [Accessed: Sep. 15, 2025].
- [7] D. Greeney, "Exploring Waterproof Ratings: IP54, IP64, IP65, and IP67," Ledlightexpert.com, Jun. 20, 2023. <https://www.ledlightexpert.com/jun-20-2023-https://www.ledlightexpert.com/waterproof-ip-54-ip-64-ip-65-ip-67/> [Accessed: Oct. 02, 2025].
- [8] "What Is Critical Fall Height? - Zeager," Zeager, Jun. 21, 2021. <https://zeager.com/what-is-critical-fall-height/> [Accessed Sep. 18, 2025].
- [9] The Jewelry Vine, "Child bracelet size Chart by Age & length| Bangle Size Chart," The Jewelry Vine, Oct. 27, 2024. <https://www.thejewelryvine.com/bracelet-size-chart/>
- [10] I. Ploessl, C. Beckwith, L. Klein, E. Prose, A. Zeller, and K. Klemm, *Wearable Glucose Alerting System Final Report*, BME 200/300 Final Report, University of Wisconsin-Madison, Dec. 10, 2025.