Clinical Area: GlucoWatch biographer continuous glucose monitor
Keywords: Glucose monitor, diabetes

Study Type: Comparison of diagnostic tests (for monitoring blood glucose levels)
Study Aim: To determine the accuracy of the GlucoWatch compared with serial blood glucose measurements.

Outcomes
- **Primary**: Mean difference, correlation, Clarke error grid analysis (method developed by Clarke et al. Diabetes Care, 1987 for determining the accuracy of devices for self-monitoring of blood glucose levels)

Design
- **Number of subjects**: n=92 patients
- **Method of subject selection (inclusion/exclusion criteria)**: At least 18 years old; type 1 or 2 diabetes requiring insulin injections. No exclusion criteria were mentioned.
- **Consecutive patients?** Not discussed.
- **Description of study population**: Mean age=42.1 ± 15.1 years; 40% men/60% women; mean body mass index=27.8 ± 5.4 kg/m².
- **Procedure**: Individuals wore the GlucoWatch Biographer on their forearms in a controlled clinical environment. Patients were required to remain indoors during the study period and to refrain from smoking. Two fingerstick capillary blood samples and up to 3 GlucoWatch measurements were obtained per hour. The blood glucose (BG) level in the fingerstick samples were analyzed using a BG analyzer (HemoCue). Due to the time lag with the GlucoWatch, a BG measurement was compared with the GlucoWatch measurement obtained 15 minutes later. Measurements were taken for 12 hours; there were 23 matched measurement pair (the initial measurement, used for calibration, was omitted). Diet and insulin were manipulated during the study period to produce a range of glycemic values.

Validity
- **Independent blind comparison with a gold standard or follow-up of those not receiving the gold standard test?** Yes, the gold standard was fingerstick blood glucose measurements.
- **Was “normal” defined?** NA because the purpose of the device is not to diagnose diabetes, but to monitor people known to have diabetes.
- **Appropriate spectrum of disease?** Unclear, spectrum of disease not reported. No normal patients were included.
- **Consecutive patients?** Not reported.
- **Methods described in enough detail to enable you to replicate the test?** Yes.
- **Reproducible results?** May not be reproducible outside of a controlled clinical setting.
Conclusions regarding validity of methods:
The study measured the ability of the GlucoWatch to monitor glucose levels but did not assess health outcomes. Exclusion criteria were not specified and it is not known whether patients were consecutive—there may have been selection bias. The study was conducted under controlled clinical conditions and results may not be reproducible outside of an investigational setting. The study was conducted by investigators affiliated with Cygnus, the device manufacturer which may have led to biases in the study design or reporting of results.

Results

- 109 GlucoWatch Biographers were used; 31 patients wore two watches at the same time.
- There were a total of 2507 possible data pairs; of these, 2354 were available for analysis.
- 187 (7.9%) of the 2354 were skipped by the predetermined threshold screens reached e.g. when the person is sweating which can confound the measurement.
- 2167 data pairs were analyzed.

Outcomes for the 2167 data pairs

- Correlation coefficient (r) 0.88
- MAE 15.6%
- ME -0.07 mmol/L (-1 mg/dL)
- SD 1.82 mmol/L (33 mg/dL)
- Clarke Error Grid Analysis 70% of the data fell in Zone A
  96.8% of the data fell in Zone A&B

\[ \text{MAE} = \text{Mean of the absolute value of the difference between the GlucoWatch and the comparative fingerstick blood glucose value: } \text{ME} = \text{Mean error, mean over all data pairs of the difference between the GlucoWatch value and the comparative fingerstick blood glucose value: } \text{SD} = \text{standard deviation of the mean error: Clarke error grid analysis evaluates self-monitoring glucose devices compared to a reference e.g. finger-stick measurement. Values falling in Zone A of the grid indicate that use of the device would lead to clinically correct treatment decisions. Values in Zone B indicate that use of the device would lead to benign treatment decisions or no decision. Zones A&B are generally considered to be clinically acceptable (Clarke et al. Diabetes Care 1987; 10: 622-628).} \]

Mean error and SD by blood glucose range

<table>
<thead>
<tr>
<th>Blood Glucose Range</th>
<th>Total data</th>
<th>ME</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mmol/L</td>
<td>Points</td>
<td>mmol/L</td>
<td>mmol/L</td>
</tr>
<tr>
<td>( \leq 3.9 )</td>
<td>116</td>
<td>0.68</td>
<td>0.97</td>
</tr>
<tr>
<td>( &gt;3.9 \text{ to } \leq 10 )</td>
<td>1324</td>
<td>-0.03</td>
<td>1.36</td>
</tr>
<tr>
<td>( &gt;10 \text{ to } \leq 13.3 )</td>
<td>469</td>
<td>-0.25</td>
<td>2.42</td>
</tr>
<tr>
<td>( &gt;13.3 )</td>
<td>258</td>
<td>-0.35</td>
<td>2.61</td>
</tr>
</tbody>
</table>

Data for patients who wore two watches worn at the same time (n=31)

Linear regression analysis (watch 1 vs. watch 2)

- Slope 1.03
- Intercept -0.24 mmol/L (-4 mg/dL)
- Correlation coefficient (r) 0.93
- Difference, averaged over all data -0.04 mmol/L (-0.7 mg/dL)
- SD -1.34 mmol/L (24 mg/dL)

Adverse effects

All patients had mild skin irritation at the site of iontophoresis; the irritation resolves in 3-7 days.
Authors’ Conclusions
“These results demonstrate close agreement between GlucoWatch biographer readings and blood glucose measurements using repeated fingerstick blood samples. The automatic, frequent and noninvasive measurements obtained with the biographer provides more information about glucose levels than the current standard of care.”

Reviewer’s Conclusions
This study addressed the accuracy of the GlucoWatch biographer in comparison to fingerstick measurements. The Clarke Error Grid Analysis suggests that the GlucoWatch gave clinically correct readings about 70% of the time and readings that led to benign decisions or no decision an additional 27% of the time. The reliability of the GlucoWatch (two watches worn at the same time) seemed reasonable e.g. correlation coefficient=.93. This study was conducted in a controlled clinical environment (e.g. patients were not permitted to go outdoors while testing the GlucoWatch) and findings may not generalizable outside of an investigational setting. The study was conducted by investigators affiliated with the device manufacturer which may introduce bias.