Measurement Statistics: Repeated Determination of Glucose Using Commercial Glucometers

More than 16 million Americans have diabetes, a condition produced by a deficiency in the secretion or action of the pancreatic hormone insulin, which in turn produces profound abnormalities in metabolism. This includes the regulation of blood glucose concentration. Diabetes is the fourth leading cause of death in the United States. The discovery of insulin 75 years ago ended what was once a death sentence to those suffering from diabetes, however, close monitoring of an individual's blood glucose level is essential in determining when insulin should be taken. The exact time when insulin should be taken is critical as life and death. As a result the measurement of glucose in blood is one of the most important and widely performed chemical measurements today.

In this experiment you will assess the reliability of test strip glucometers. Since this is a relatively simple and quick analysis you will perform the experiment many times for statistical analysis. Before coming to lab make sure to do some research to understand the principles behind the glucometer and know what are the normal glucose levels in humans.

Required Reading

D.C. Harris***, Quantitative Chemical Analysis*** (7th ed., W. H. Freeman, NY, 2007) pp. 53-68.

Data rejection and Data Reporting sections of the ***Analytical Lab Manual***.

REAGENTS AND APPARATUS

- 2 Commercial Glucometers (different manufacturers)
- Glucose Test Strips
- Glucose Solution of Known Concentration (note the exact value on the label)
- beakers
- Pasteur pipets

General Procedure

Take 6 test strips (make sure you are using the test strips appropriate for the meter). Record the value of the glucose concentration from the label on the bottle. Put one drop of the solution of each strip and measure the glucose concentration with the glucometer. Make sure you also write down the make and model of the meter. Also, note the tolerance of meter from the instructions.

Once you have completed the tests with one meter. Repeat with a second meter of a different make.

After you have completed all of the measurements. enter the glucose concentrations into the spreadsheet on the laptop in the lab. We will use the data from everyone in class to analyze the glucometers' performance.

CALCULATIONS

Discrepant Data

At the bottom of each column of values list the average concentration and standard deviation for each meter. Use the spreadsheet "sort" function to sort each column by increasing concentration. This makes it easy to identify an outlier in any list. Discard grossly discrepant masses lying ≥ 4 standard deviations from the mean. (For example, if one column has an average conc of 300.0 g/dL and a standard deviation of 30.0 g/dL, the 4 standard deviation limit is $300.0 \pm (4 \times 30.0) = 300.0 \pm 120.0$ g/dL.) This is a conservative criterion in which only the most discrepant data will be rejected. Make a note of any values that are rejected and mention these rejections in the report. After rejecting discrepant data, recompute the average mass and standard deviation of the concentration for each column. Do not apply the same test again to the same data with the new standard deviation.

Confidence Intervals and t Tests

Comparison of Concentration determined by meters of the same model

Select the two sets of data for two meters of the same make and model. Compute the 95% and the 99% confidence intervals for the average concentrations using the Student's t values in Table 4-2 in the text. After the confidence intervals have been calculated, use the "Comparison of Means with Student's t – Case 2: Comparing Replicate Measurements" as described in section 4-3 of the text to determine if the average concentrations determined by the two meters of the same make and model are the same or different within experimental uncertainty at 95% and 99% confidence intervals.

Comparison of Concentration determined by meters of different manufacturers

Select the two sets (one from each type of meter) of data in which the average concentrations are the most different. Compute the 95% and 99% confidence intervals and perform the same comparison of means as performed in the preceding paragraph.

Calculation of Average Concentration of the Sample

For the **entire set of concentrations**, calculate the average concentrations of the entire set of data and 95% and 99% confidence intervals. *(The "entire set of concentrations" at this point has had the "discrepant" data values removed.)*

Comparison of the measured results with the Known Value.

Using the calculated confidence intervals for the pooled data from each manufacturer and the entire data set, determine if there is a significant difference between the known concentration of the glucose solution and the values obtained from the glucometers. To accomplish this apply "Comparison of Means with Student's t – Case 1: Comparing a Measured Result with a "Known" Value" as described in section 4-3 of the text at both the 95% and 99% confidence intervals.

Include in the Report

1. What is the average concentration of the glucose solution?

2. Do the concentrations from different meters from the same manufacturer (same make and model) have the same value?

   Report the values obtained in the section **Concentration determined by meters of the same model.**

3. Do the concentrations from different meters from different manufacturers have the same value?

   Report the values obtained in the section **Comparison of Concentration determined by meters of different manufacturers.**

4. Is the concentration obtained from the meters of different manufacturers the same or different from the pooled data. And how does the know concentration compare with the values experimentally obtained?

5. Finally consider glucose monitoring will become a multi-million or even multi-billion dollar growth industry in the near future as a large population of baby boomers experience the onset of diabetes as they grow older. Can you think of any improvements that could be made in the measurement of blood glucose to make it easier, faster, or less painful?