

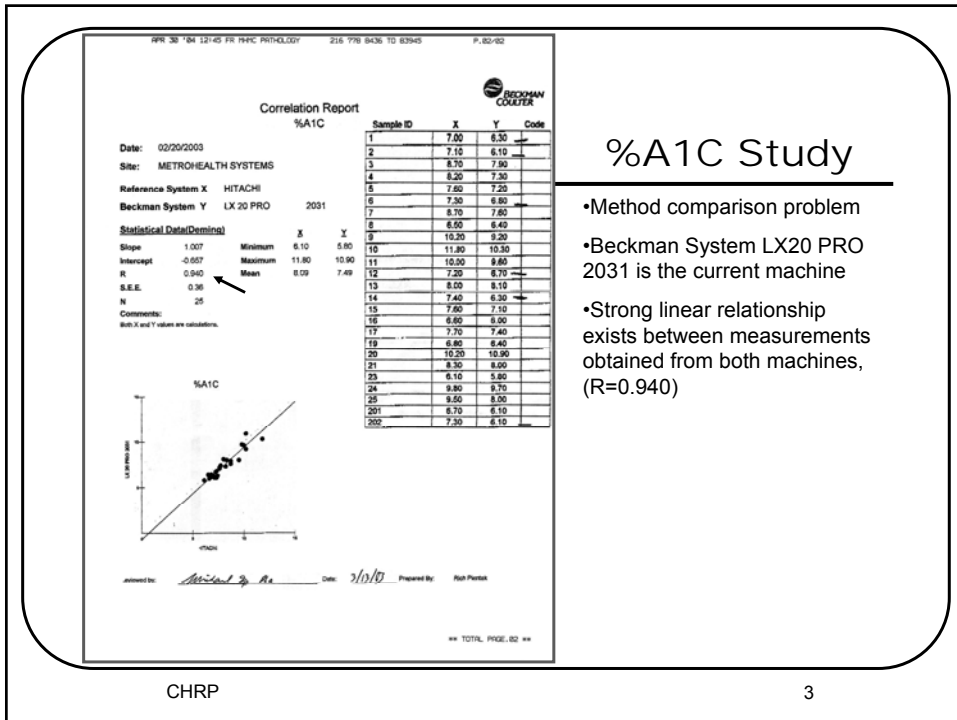
Measures of REPRODUCIBILITY

Part 1

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and N. Dawson

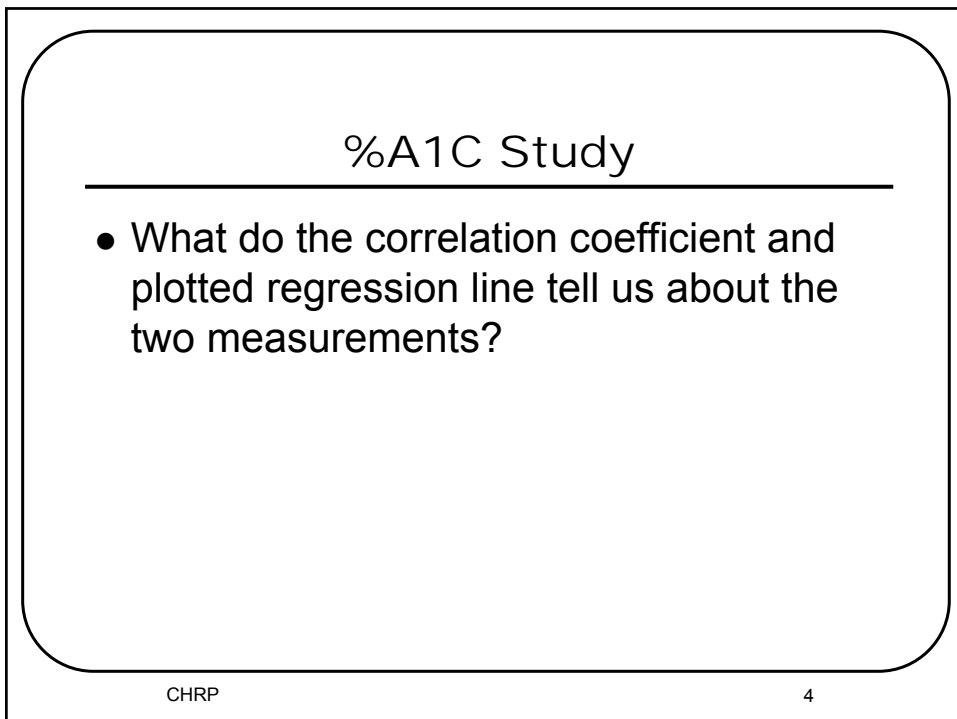
Measures of Reproducibility

- Test for the equality or agreement of measurements from two (2) different:
 - Methods (or instruments) – Method Comparison
 - Time Points – Reproducibility/Repeatability
 - Raters – Inter-rater Agreement
- Paired observations analyzed
- No additional covariates



%A1C Study

- Method comparison problem
- Beckman System LX20 PRO 2031 is the current machine
- Strong linear relationship exists between measurements obtained from both machines, (R=0.940)



Measures of Reproducibility

1. Association
 - a. Pearson's Product Moment (R)
 - b. Spearman's Rank (R_s)
 2. Method Comparison
 - a. Bland & Altman Plot ← **Graphical Tools**
 - b. Mountain Plot ← **Graphical Tools**
 - c. Passing & Bablok Regression Analysis ← **Model-Based Tools**
 - d. Deming Regression Analysis ← **Model-Based Tools**
-
- ```
graph LR; GT([Graphical Tools]) --> BAP[Bland & Altman Plot]; GT --> MP[Mountain Plot]; MBT([Model-Based Tools]) --> PBA[Passing & Bablok Regression Analysis]; MBT --> DR[Deming Regression Analysis];
```

## Correlation Coefficients

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1. Pearson's Product Moment (R)
2. Spearman's Rank ( $R_s$ )

## Correlation Coefficients

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- Typically used to measure the strength of linear association between two variables.
- Can take on the values from -1.0 to 1.0:
  - -1.0 → a perfect negative (inverse) correlation
  - 0.0 → no correlation
  - 1.0 → a perfect positive correlation

## Pearson's Correlation Coefficient ( $r$ )

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- **Assumptions:** Both variables are interval/ratio, approximately normally distributed, and their joint distribution is bivariate normal.
- **Test:** The statistical significance of  $r$  is tested using a t-test with hypotheses:
  - H<sub>0</sub>:  $\rho = 0$
  - H<sub>a</sub>:  $\rho \neq 0$A low p-value for this test (e.g.,  $p < 0.05$ ) means that there is a statistically significant linear relationship between the two variable. This test is equivalent to the test of no slope in simple linear regression.
- **Related statistic:**  $R^2$  can be interpreted as the proportion of variance in Y that is contained in X.

## Spearman's Rank Correlation Coefficient ( $r_s$ )

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- Usually calculated on occasions when it is not convenient, economical, or even possible to give actual values to variables, but only to assign a rank order to instances of each variable.
- Calculated by ranking the data within each of the two groups, then finding the Pearson correlation for the ranked data.
  - Measures the association between the ranks of the data, not the data values themselves.
  - Commonly used for ordinal data.
  - Does not assume normality.
- Falls between -1.0 and 1.0, like Pearson's  $r$  and is similarly interpreted.

## Correlation Coefficients

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- Assess association, not measurement bias
  - Measurement bias can exist even with a high correlation coefficient.

## Method Comparison

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### 1. Graphical Tools

- a. Bland & Altman Plot
- b. Mountain Plot

### 2. Model-Based Tools

- a. Passing & Bablok Regression Analysis
- b. Deming Regression Analysis

## Special Software

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- MedCalc\*
  - Method comparison tools, Quality control tools, and ROC analysis
- Analyse-It
  - Add-in method comparison software for MicroSoft EXCEL
- EP Evaluator
  - Software for clinical laboratory method evaluation

\* CHRP has license.

## Method Comparison Graphical Tools

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1. Bland & Altman Plot
2. Mountain Plot

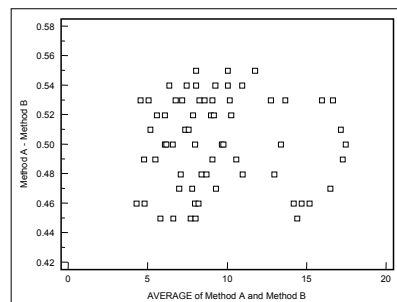
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## Bland & Altman Plot

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- Differences of the two measurements are plotted against the averages.<sup>1</sup>
  - Reveals relationship between the differences and magnitude of measurements.

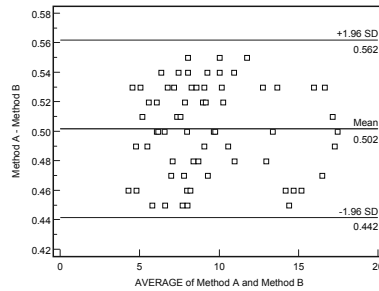


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## Bland & Altman Plot

- Uses quality control concept
- Horizontal lines drawn at the mean difference, and mean difference  $\pm 2$  sd.

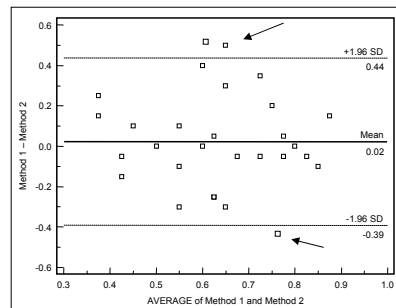


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## Bland & Altman Plot

- Identifies potential outliers.
- 95% of data points should lie within  $\pm 2$ sd of the mean difference.

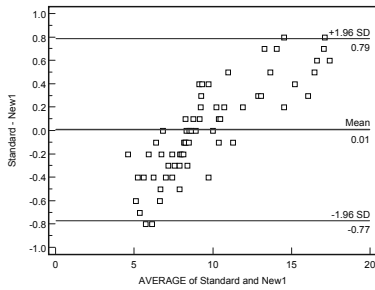


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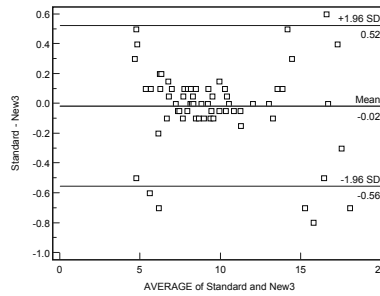
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## Bland & Altman Plot

- Reveals patterns among the differences.



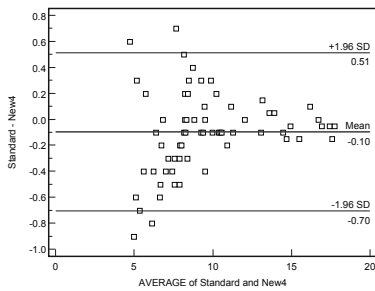
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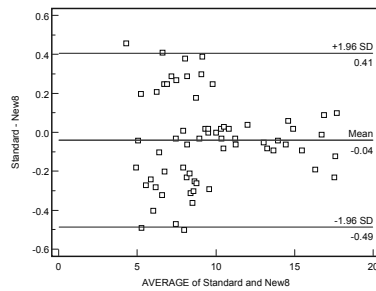
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## Bland & Altman Plot

- Reveals patterns among the differences.



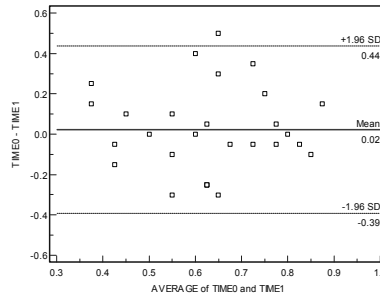
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## Bland & Altman Plot

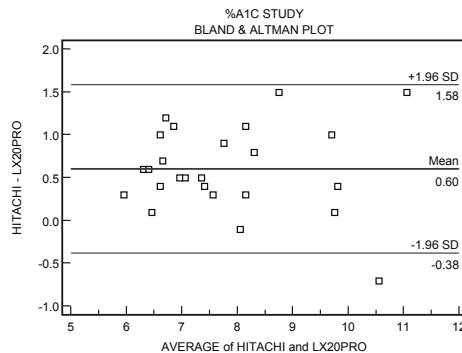
- Can assess the repeatability of a method by comparing repeated measurements using one single method on a series of subjects.



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## Bland & Altman Plot %A1C Study

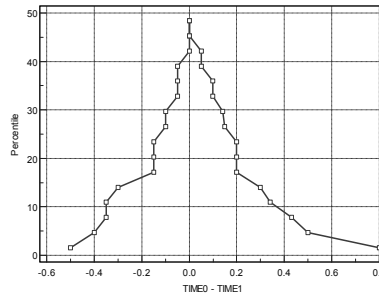


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## Mountain Plot

- “Folded Empirical Cumulative Distribution Plot”<sup>2</sup>
- Useful complementary plot to Bland & Altman plot.

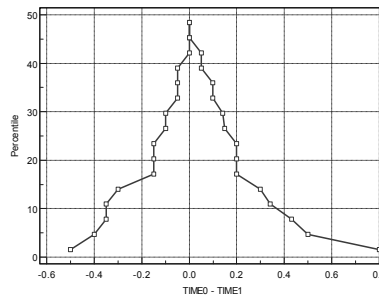


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## Mountain Plot

- Provides information about the distributions of the differences between the two measurements.

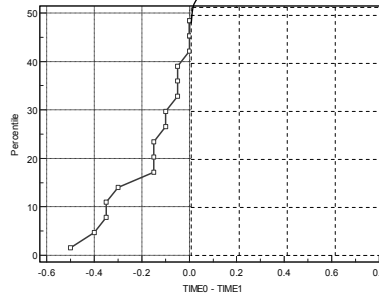


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## Mountain Plot

- Rank order the differences between measurements.
- Compute a percentile for each ranked difference.
- A transformation is performed on all percentiles above 50.
  - $\text{Newpercentile} = 1 - \text{Oldpercentile}$
  - $\text{Oldpercentile} = 75 \leftrightarrow \text{Newpercentile} = 25$

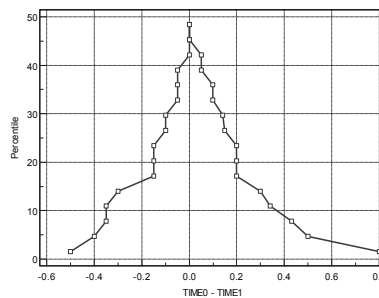


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## Mountain Plot

- The percentiles following the transformation are then plotted against the differences between the two measurements.

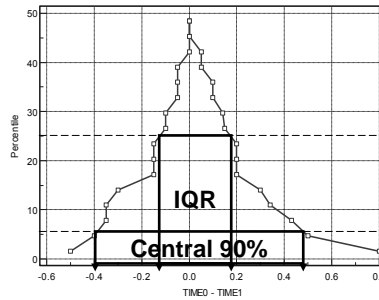


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## Mountain Plot

- Easy to view the central portion of the differences.
- Easier to estimate percentile for large differences (e.g., percentiles > 90%).



IQR (-0.12, 0.18)

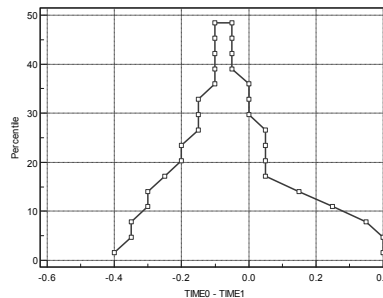
Central 90% (-0.40, 0.48)

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## Mountain Plot

- If the two methods/times are unbiased wrt each other, the mountain will be centered over zero.
- Long tails in the plot reflect large differences between the measurements.

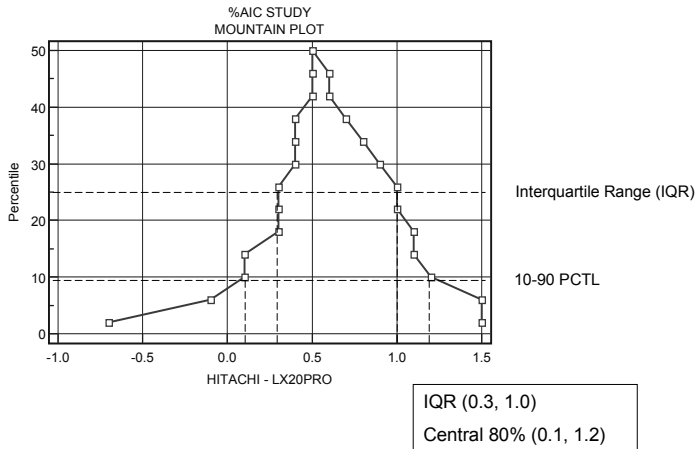


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# Mountain Plot

## %A1C Study

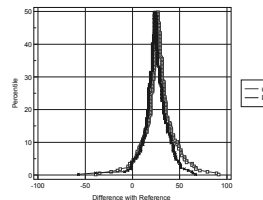
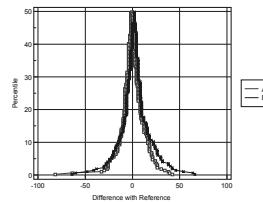
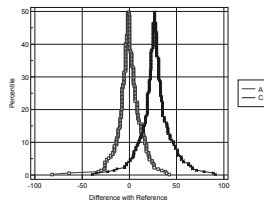


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# Mountain Plot

- Can also compare two measurements against a reference measurement.



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## Method Comparison

### Model-Based Tools

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1. Passing & Bablok Regression Analysis
2. Deming Regression Analysis

## Passing & Bablok Regression Analysis

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- A linear regression procedure originating in 1983.<sup>3</sup>
- Formal test for detecting constant and/or proportional bias using  $Y = A + BX$ .
- Result does not depend on the assignment of the methods (or instruments) to X or Y.
- No special assumptions regarding the distribution of the samples and measurement errors.
- Provides Linearity Test.

## Passing & Bablok Regression Analysis

2 Hypotheses Tested

---

### No Constant Bias (A=0)

- *Accepted* if the confidence interval for A contains 0.
- If *rejected*, conclude A is different from 0 and both methods differ at least by a constant amount.

### No Proportional Bias (B=1)

- *Accepted* if the confidence interval for B contains 1.
- If *rejected*, conclude B is different from 1 and there is at least a proportional difference between the two methods.

$$Y = A + BX$$

## Passing & Bablok Regression Analysis

Possible Outcomes

---

### Four (4) possible outcomes

1. No bias
2. Constant bias only
3. Proportional bias only
4. Both Constant and proportional bias

## Passing & Bablok Regression Analysis Output

```

Variable X : TIME1
Variable Y : TIME0

Sample size = 28

----- REGRESSION EQUATION -----
Y = 0.0952 + 0.9048 X

Intercept A : 0.0952
95% CI : -0.2222 to 0.4444

Slope B : 0.9048
95% CI : 0.5556 to 1.2222

Cusum test for linearity
No significant deviation from linearity (P>0.10)

```

Bias?

## Passing & Bablok Regression Analysis Output

### Summary statistics, regression equation, confidence intervals, and linearity test

```

Variable X : TIME1
Variable Y : TIME0

Select : AND(SUBJECT="CAREGIVER",SCENARIO="CURRENT",METHOD="TTO")

Sample size = 28

TIME1
Lowest value = 0.2250
Highest value = 1.0000
Arithmetic mean = 0.8571
Median = 1.0000
Standard deviation = 0.2052
Standard error of the mean = 0.0388

TIME0
Lowest value = 0.3750
Highest value = 1.0000
Arithmetic mean = 0.8813
Median = 1.0000
Standard deviation = 0.1867
Standard error of the mean = 0.0353

----- REGRESSION EQUATION -----
Y = 0.0952 + 0.9048 X

Intercept A : 0.0952
95% CI : -0.2222 to 0.4444

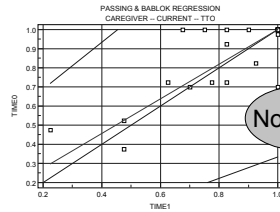
Slope B : 0.9048
95% CI : 0.5556 to 1.2222

Cusum test for linearity
No significant deviation from linearity (P>0.10)

```

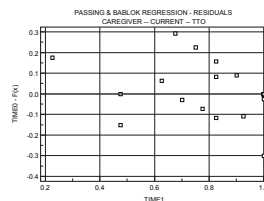
No Bias

### Scatterplot with regression line (and c.i.), and identity (x=y) line



No Bias?

### Residuals plot



## Deming Regression Analysis

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- Allows method comparison using the Deming regression model.<sup>4</sup>
  - Formal test for detecting constant and/or proportional bias.
- More accurately represents data in a clinical laboratory.
  - Takes measurement error for both methods into account unlike ordinary linear regression.
  - Result does not depend on the assignment of methods (or instruments) to X or Y.
- Mathematically more complex
  - Standard errors and confidence intervals estimated using the jackknife method.
  - Software available.

## Deming Regression Analysis

### Required Input

---

- Two (2) options for each method represented in the sample:
  - 1 measurement and its Coefficient of Variation ( $CV=sd/mean$ )
  - 2 repeated measurements

## Deming Regression Analysis

### 2 Hypotheses Tested

---

#### No Constant Bias (A=0)

- *Accepted* if the confidence interval for A contains 0.
- If *rejected*, conclude A is different from 0 and both methods differ at least by a constant amount.

#### No Proportional Bias (B=1)

- *Accepted* if the confidence interval for B contains 1.
- If *rejected*, conclude B is different from 1 and there is at least a proportional difference between the two methods.

$$Y = A + BX$$

## Deming Regression Analysis

### Possible Outcomes

---

Four (4) possible outcomes

1. No bias
2. Constant bias only
3. Proportional bias only
4. Both Constant and proportional bias

# Deming Regression Analysis Output

|                         |             |                              |                   |
|-------------------------|-------------|------------------------------|-------------------|
| Method X                | : bic15     |                              |                   |
| Method Y                | : peak      |                              |                   |
| <hr/>                   |             |                              |                   |
| Method                  | Mean        | Coefficient of Variation (%) |                   |
| X                       | 67.9583     | 32.60                        |                   |
| Y                       | 80.1208     | 29.50                        |                   |
| <hr/>                   |             |                              |                   |
| Sample size             | : 240       |                              |                   |
| Variance ratio          | : 0.8786    |                              |                   |
| — REGRESSION EQUATION — |             |                              |                   |
| Y = 7.5196 + 1.0683 X   |             |                              |                   |
| Parameter               | Coefficient | SE                           | 95% CI            |
| Intercept               | 7.5196      | 3.1476                       | 1.3191 to 13.7201 |
| Slope                   | 1.0683      | 0.0442                       | 0.9812 to 1.1554  |

Bias?

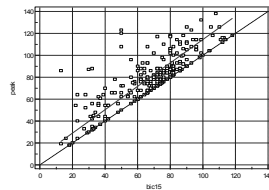
# Deming Regression Analysis Output

**Summary statistics, regression equation, and confidence intervals**

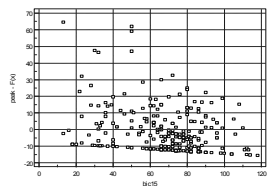
|                         |             |                              |                   |
|-------------------------|-------------|------------------------------|-------------------|
| Method X                | : bic15     |                              |                   |
| Method Y                | : peak      |                              |                   |
| <hr/>                   |             |                              |                   |
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| Parameter               | Coefficient | SE                           | 95% CI            |
| Intercept               | 7.5196      | 3.1476                       | 1.3191 to 13.7201 |
| Slope                   | 1.0683      | 0.0442                       | 0.9812 to 1.1554  |

Constant Bias

**Scatterplot with regression line and identity (x=y) line**



**Residuals plot**



## %A1C Study

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1. Passing & Bablok Regression
2. Deming Regression

## Passing & Bablok Regression Analysis %A1C Study

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```
Variable X : HITACHI
Variable Y : LX20PRO

Sample size = 25

HITACHI
Lowest value = 6.1000
Highest value = 11.8000
Arithmetic mean = 8.0920
Median = 7.6000
Standard deviation = 1.4384
Standard error of the mean = 0.2877

LX20PRO
Lowest value = 5.8000
Highest value = 10.9000
Arithmetic mean = 7.4920
Median = 7.2000
Standard deviation = 1.4480
Standard error of the mean = 0.2896

--- REGRESSION EQUATION ---

Y = -0.5000 + 1.0000 X

Intercept A : -0.5000
95% CI : -2.0200 to 0.8091

Slope B : 1.0000
95% CI : 0.8182 to 1.2000

Cusum test for linearity
No significant deviation from linearity (P>0.10)
```

Bias?

# Passing & Bablok Regression Analysis %A1C Study

Summary statistics, regression equation, confidence intervals, and linearity test

```

Variable X : HITACHI
Variable Y : LX20PRO

Sample size = 25

HITACHI
Lowest value = 6.1000
Highest value = 11.8000
Arithmetic mean = 8.0920
Median = 7.6000
Standard deviation = 1.4384
Standard error of the mean = 0.2877

LX20PRO
Lowest value = 5.8000
Highest value = 10.9000
Arithmetic mean = 7.4920
Median = 7.2000
Standard deviation = 1.4480
Standard error of the mean = 0.2896

--- REGRESSION EQUATION ---
Y = -0.5000 + 1.0000 X

Intercept A : -0.5000
95% CI : -2.0200 to 0.8091

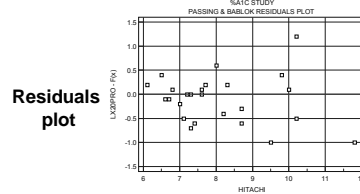
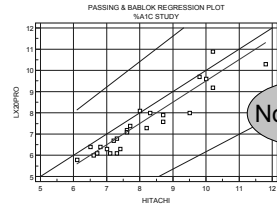
Slope B : 1.0000
95% CI : 0.8182 to 1.2000

Cusum test for linearity
No significant deviation from linearity (P>0.10)

```

No Bias

Scatterplot with regression line (and c.i.), and identity (x=y) line



# Deming Regression Analysis %A1C Study

```

Method X : HITACHI
Method Y : LX20PRO

Method Mean Coefficient of Variation (%)

X 8.0920 17.78
Y 7.4920 19.33

Sample size : 25
Variance ratio : 0.9870

--- REGRESSION EQUATION ---
Y = -0.6536 + 1.0066 X

Parameter Coefficient SE 95% CI
Intercept -0.6536 1.0080 -2.7341 to 1.4268
Slope 1.0066 0.1337 0.7306 to 1.2827

```

Bias?

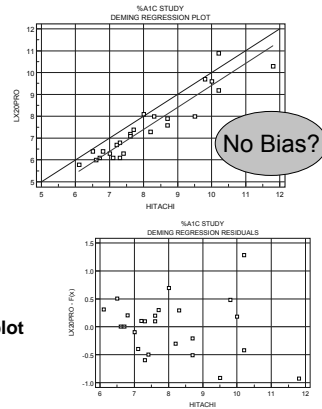
# Deming Regression Analysis %A1C Study

## Summary statistics, regression equation, and confidence intervals

|                        |             |                              |                   |
|------------------------|-------------|------------------------------|-------------------|
| Method X               | : HITACHI   |                              |                   |
| Method Y               | : LX20PRO   |                              |                   |
| Method                 | Mean        | Coefficient of Variation (%) |                   |
| X                      | 8.0920      | 17.78                        |                   |
| Y                      | 7.4920      | 19.33                        |                   |
| Sample size            | : 25        |                              |                   |
| Variance ratio         | : 0.9870    |                              |                   |
| REGRESSION EQUATION    |             |                              |                   |
| Y = -0.6536 + 1.0066 X |             |                              |                   |
| Parameter              | Coefficient | SE                           | 95% CI            |
| Intercept              | -0.6536     | 1.0080                       | -2.7341 to 1.4268 |
| Slope                  | 1.0066      | 0.1337                       | 0.7306 to 1.2827  |

No Bias

## Scatterplot with regression line and identity (x=y) line



Residuals plot

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# %A1C Study Summary

- Very strong correlation of 0.940 between the two measurements
- No obvious pattern revealed in Bland & Altman plot
- Mountain plot suggests a method-bias
  - Hitachi > LX20PRO 2031
- No "significant" measurement bias detected with model-based methods (P&B and Deming)
  - Regression plots suggest a constant bias
  - Larger sample size > 25 may be needed in order to detect bias

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## Shortened vs. Peak ePFT Study

## Shortened vs. Peak ePFT Study

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- The endoscopic pancreatic function test (ePFT) takes an hour to perform
  - Not very practical for routine use
- Four (4) Timed collections → 15, 30, 45, or 60 minutes after secretin
- Peak measurement =  $\max(15,30,45,60)$
- Determine which timed endoscopic collection(s) best predict the “peak” from the full hour-long test
- Seven (7) theoretical shortened tests proposed:
  - 4-single collections → 15, 30, 45 and 60
  - 3-maximum of dual collections →  $\max(15,30)$ ,  $\max(30,45)$  and  $\max(45,60)$

## Shortened vs. Peak ePFT Study

- Compare each theoretical shortened test measurement to the “peak” result
- Concentrations  $\geq 80$  mEq/L  $\rightarrow$  “normal”  
Concentrations  $< 80$  mEq/L  $\rightarrow$  “abnormal”

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## Shortened vs. Peak ePFT Study

Data

| Obs | peak | bic15 | bic30 | bic45 | bic60 | max1530 | max3045 | max4560 |
|-----|------|-------|-------|-------|-------|---------|---------|---------|
| 1   | 82   | 82    | 78    | 82    | 80    | 82      | 82      | 82      |
| 2   | 82   | 82    | 52    | 52    | 44    | 82      | 52      | 52      |
| 3   | 72   | 72    | 70    | 70    | 72    | 72      | 70      | 72      |
| 4   | 74   | 72    | 70    | 74    | 10    | 72      | 74      | 74      |
| 5   | 74   | 74    | 47    | 45    | 35    | 74      | 47      | 45      |
| 6   | 78   | 72    | 74    | 78    | 74    | 74      | 78      | 78      |
| 7   | 108  | 82    | 86    | 78    | 108   | 86      | 86      | 108     |
| 8   | 87   | 87    | 48    | 57    | 78    | 87      | 57      | 78      |
| 9   | 34   | 34    | 34    | 30    | 26    | 34      | 34      | 30      |
| 10  | 78   | 70    | 78    | 74    | 68    | 78      | 78      | 74      |
| .   | .    | .     | .     | .     | .     | .       | .       | .       |
| .   | .    | .     | .     | .     | .     | .       | .       | .       |
| 240 | 120  | 50    | 66    | 108   | 120   | 66      | 108     | 120     |

240 ePFT results

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## Shortened vs. Peak ePFT Study

### Deming Regression Analysis

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- Use actual bicarbonate results
- Look for best shortened test considering possible constant and/or proportional bias

## Shortened vs. Peak ePFT Study

### Deming Regression Analysis

---

**MedCalc  
Results**

| Method X : bic15            |             | Method Y : peak              |                   |
|-----------------------------|-------------|------------------------------|-------------------|
| Method                      | Mean        | Coefficient of Variation (%) |                   |
| X                           | 67.9583     | 32.40                        |                   |
| Y                           | 80.1208     | 29.50                        |                   |
| Sample size : 240           |             |                              |                   |
| Variance ratio : 0.8786     |             |                              |                   |
| --- REGRESSION EQUATION --- |             |                              |                   |
| Y = 7.5196 + 1.0683 X       |             |                              |                   |
| Parameter                   | Coefficient | SE                           | 95% CI            |
| Intercept                   | 7.5196      | 3.1476                       | 1.3191 to 13.7201 |
| Slope                       | 1.0683      | 0.0442                       | 0.9812 to 1.1554  |

| Method X : bic30            |             | Method Y : peak              |                   |
|-----------------------------|-------------|------------------------------|-------------------|
| Method                      | Mean        | Coefficient of Variation (%) |                   |
| X                           | 71.6625     | 33.00                        |                   |
| Y                           | 80.1208     | 29.50                        |                   |
| Sample size : 240           |             |                              |                   |
| Variance ratio : 1.0011     |             |                              |                   |
| --- REGRESSION EQUATION --- |             |                              |                   |
| Y = 8.4069 + 1.0007 X       |             |                              |                   |
| Parameter                   | Coefficient | SE                           | 95% CI            |
| Intercept                   | 8.4069      | 2.1738                       | 4.1245 to 12.6892 |
| Slope                       | 1.0007      | 0.0291                       | 0.9434 to 1.0580  |

| Method X : bic45            |             | Method Y : peak              |                    |
|-----------------------------|-------------|------------------------------|--------------------|
| Method                      | Mean        | Coefficient of Variation (%) |                    |
| X                           | 70.9875     | 37.00                        |                    |
| Y                           | 80.1208     | 29.50                        |                    |
| Sample size : 240           |             |                              |                    |
| Variance ratio : 1.2349     |             |                              |                    |
| --- REGRESSION EQUATION --- |             |                              |                    |
| Y = 16.1166 + 0.9016 X      |             |                              |                    |
| Parameter                   | Coefficient | SE                           | 95% CI             |
| Intercept                   | 16.1166     | 2.5048                       | 11.1824 to 21.0508 |
| Slope                       | 0.9016      | 0.0291                       | 0.8442 to 0.9590   |

| Method X : bic60            |             | Method Y : peak              |                    |
|-----------------------------|-------------|------------------------------|--------------------|
| Method                      | Mean        | Coefficient of Variation (%) |                    |
| X                           | 68.7542     | 40.40                        |                    |
| Y                           | 80.1208     | 29.50                        |                    |
| Sample size : 240           |             |                              |                    |
| Variance ratio : 1.3811     |             |                              |                    |
| --- REGRESSION EQUATION --- |             |                              |                    |
| Y = 21.4960 + 0.8527 X      |             |                              |                    |
| Parameter                   | Coefficient | SE                           | 95% CI             |
| Intercept                   | 21.4960     | 2.5810                       | 16.4116 to 26.5805 |
| Slope                       | 0.8527      | 0.0313                       | 0.7910 to 0.9144   |

# Shortened vs. Peak ePFT Study

## Deming Regression Analysis

### MedCalc Results

```

Method X : max1530
Method Y : peak

Method Mean Coefficient of Variation (%)

X 74.8542 30.00
Y 80.1208 29.50

Sample size : 240
Variance ratio : 0.9027

--- REGRESSION EQUATION ---
Y = 1.2890 + 1.0531 X
Parameter Coefficient SE 95% CI

Intercept 1.2890 1.7113 -2.0822 to 4.6601
Slope 1.0531 0.0244 1.0051 to 1.1012

```

```

Method X : max4560
Method Y : peak

Method Mean Coefficient of Variation (%)

X 75.4167 33.60
Y 80.1208 29.50

Sample size : 240
Variance ratio : 1.1494

--- REGRESSION EQUATION ---
Y = 9.6490 + 0.9344 X
Parameter Coefficient SE 95% CI

Intercept 9.6490 1.2877 7.1123 to 12.1856
Slope 0.9344 0.0144 0.9061 to 0.9628

```

```

Method X : max3045
Method Y : peak

Method Mean Coefficient of Variation (%)

X 76.0792 31.50
Y 80.1208 29.50

Sample size : 240
Variance ratio : 1.0281

--- REGRESSION EQUATION ---
Y = 5.1074 + 0.9860 X
Parameter Coefficient SE 95% CI

Intercept 5.1074 1.3349 2.4777 to 7.7371
Slope 0.9860 0.0164 0.9536 to 1.0184

```

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# Shortened vs. Peak ePFT Study

## Deming Regression Analysis

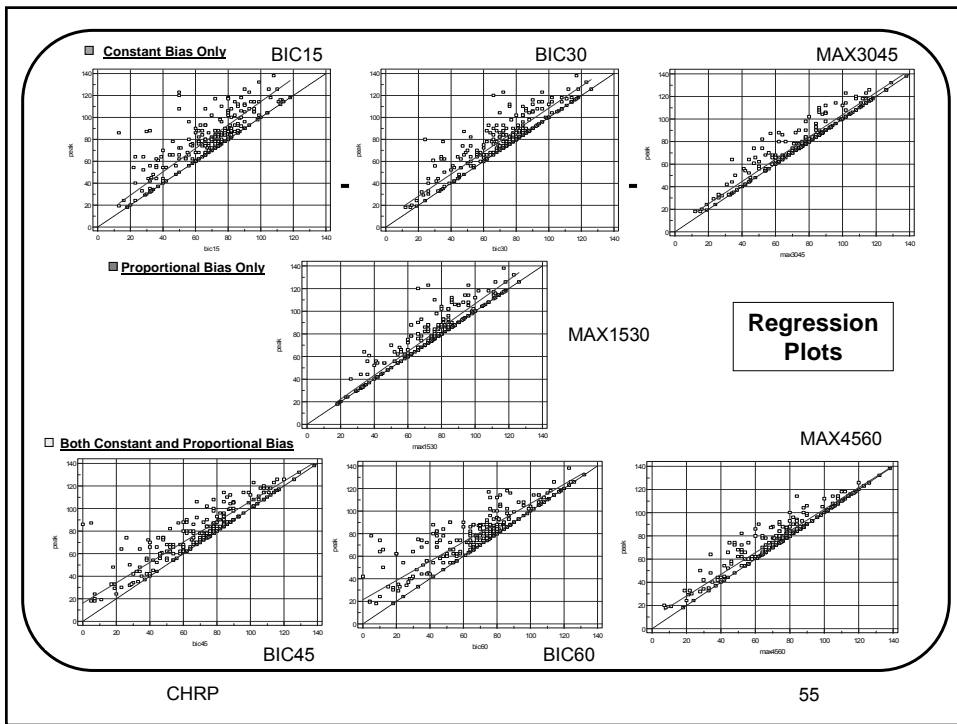
### Comparison of Results

| Comparison       | Intercept<br>(Indicator of Constant Bias) |                   | Slope<br>(Indicator of Proportional Bias) |                 |
|------------------|-------------------------------------------|-------------------|-------------------------------------------|-----------------|
|                  | Coefficient                               | 95% CI            | Coefficient                               | 95% CI          |
| BIC15 vs. Peak   | 7.5196                                    | 1.3191 - 13.7201  | 1.0683                                    | 0.9812 - 1.1554 |
| BIC30 vs. Peak   | 8.4069                                    | 4.1245 - 12.6892  | 1.0007                                    | 0.9434 - 1.0580 |
| BIC45 vs. Peak   | 16.1166                                   | 11.1824 - 21.0508 | 0.9016                                    | 0.8442 - 0.9590 |
| BIC60 vs. Peak   | 21.4960                                   | 16.4116 - 26.5805 | 0.8527                                    | 0.7910 - 0.9144 |
| MAX1530 vs. Peak | 1.2890                                    | -2.0822 - 4.6601  | 1.0531                                    | 1.0051 - 1.1012 |
| MAX3045 vs. Peak | 5.1074                                    | 2.4777 - 7.7371   | 0.9860                                    | 0.9536 - 1.0184 |
| MAX4560 vs. Peak | 9.6490                                    | 7.1123 - 12.1856  | 0.9344                                    | 0.9061 - 0.9628 |

- Significant constant bias only.
- Significant proportional bias only.
- Significant constant and proportional bias.

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## Shortened vs. Peak ePFT Study

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- Given the Deming regression analysis results, which shortened test would you select as an alternative to Peak?
- What all would you consider about the type(s) of bias exhibited by an individual test?

## Shortened vs. Peak ePFT Study

### Choosing an Alternative

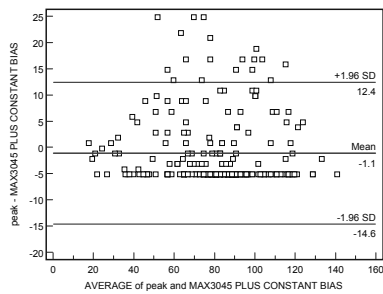
---

- All 7 alternatives resulted in some sort of bias
- Choose among alternatives with single source of bias
  - MAX3045 – best of the three (3) constant bias only alternatives
  - MAX1530 – proportional bias only
- MAX3045
  - Approximately 5 points lower than peak with a range of 2.5 to 7.7 points.
- MAX1530
  - Approximately 5% lower than peak with a range of 1-10%.
- Select MAX3045 alternative
  - Constant bias is probably the preferred method for explaining deviation from peak

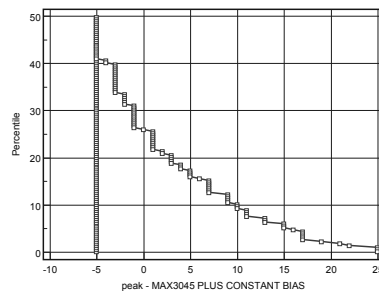
# Shortened vs. Peak ePFT Study

MAX3045\*\* vs. PEAK

Bland & Altman Plot



Mountain Plot



$$\text{MAX3045}^{**} = \text{MAX3045} + 5.1$$

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## General Considerations

- Consider nature of measurements.
  - Interval/ratio, nominal, ordinal, etc.
- If you are investigating whether or not another method/technique is a viable replacement, consider using a method comparison tool.
  - A statistically significant correlation coefficient may not tell the full story.
- Consider using both graphical and model-based tools.
- Should these approaches be considered when the correlation coefficient is not significant?

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## References

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3. Passing H, Bablok W (1983) A new biometrical procedure for testing the equality of measurements from two different analytical methods. Part I. *J. Clin. Chem. Clin. Biochem.*, 21:709-720
4. Combleet PJ, Gochman N (1979) Incorrect least-squares regression coefficients in method-comparison analysis. *Clinical Chemistry*, 25:432-438.