

# Blood Monitoring Challenges

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# Glucose Meter Evolution



# Sample Issues

# Glucose Samples (BGM)

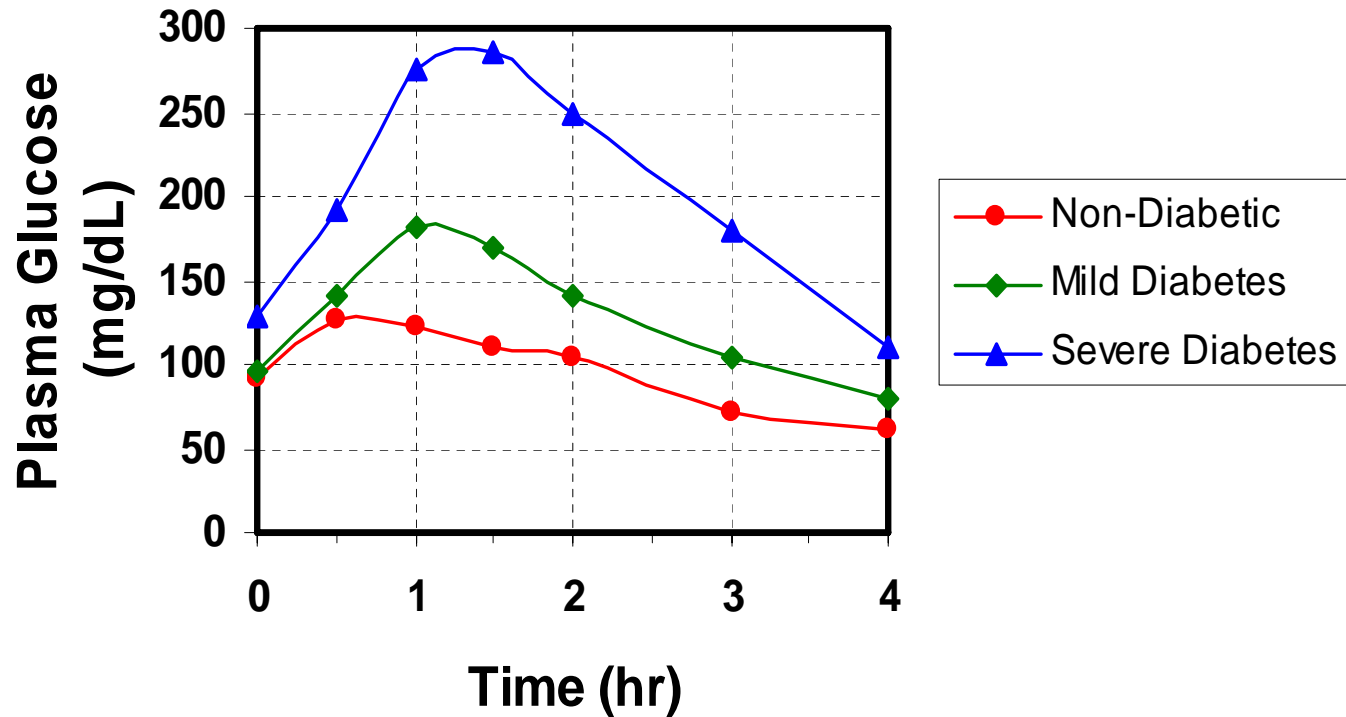
- Capillary Blood (FS)
- Venous Blood
- Arterial Blood
- Alternative Site Samples
- Plasma or Serum
- Interstitial Fluid (ISF)
- Urine
- Other ?

# Testing Concerns

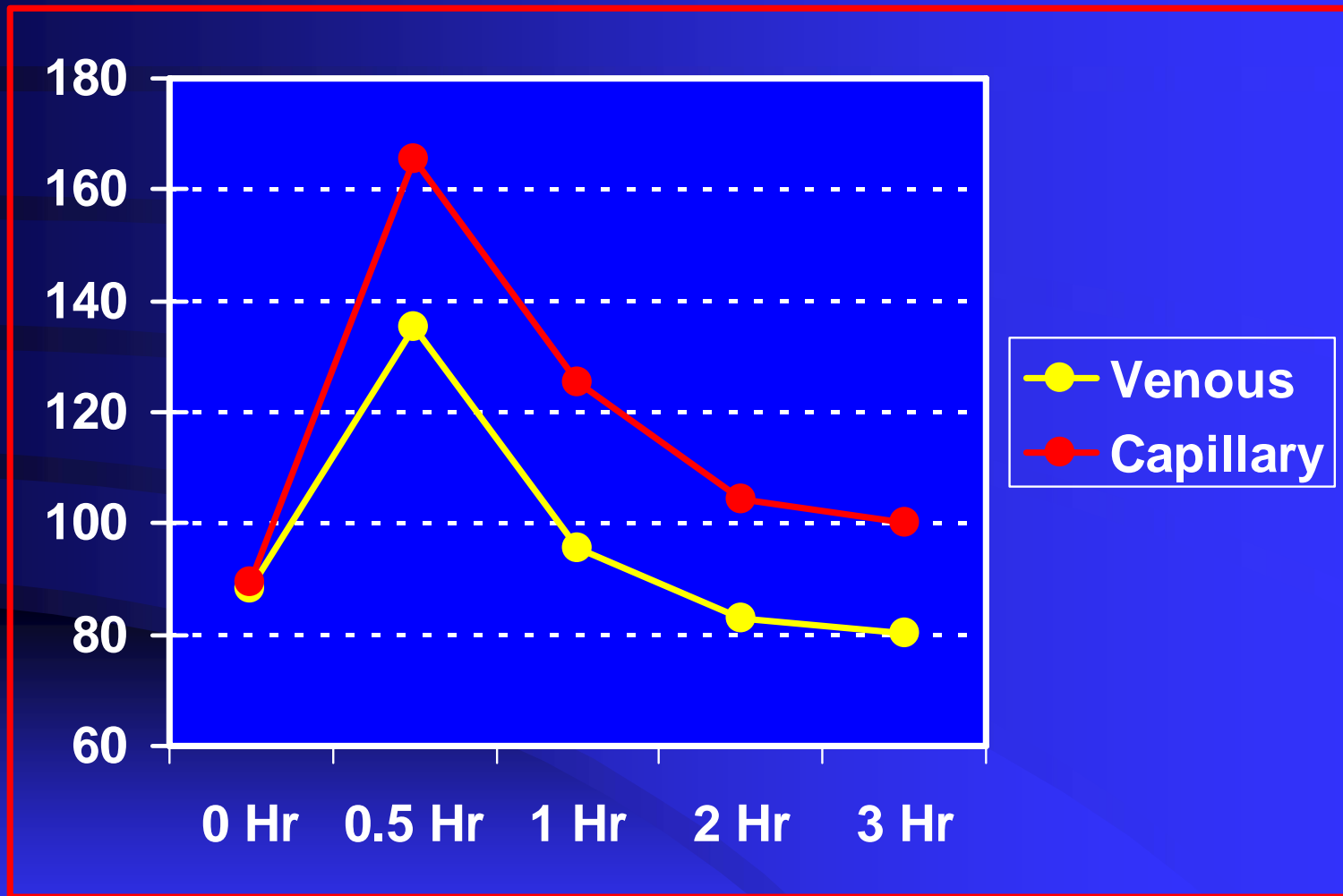
- Sample Volume
- Hematocrit
- Altitude
- Oxygen
- Glycolysis
- Evaporation
- Clotting
- ISF (milking)
- Mis-Coding
- Hypotension
- Medications
- Icodextrin (Extraneal)
- Intragam P
- Maltose
- Fluoride anticoagulant
- Vitamin C (Ascorbate)

# Glucose Variation with Time

## Plasma Glucose Tolerance Response

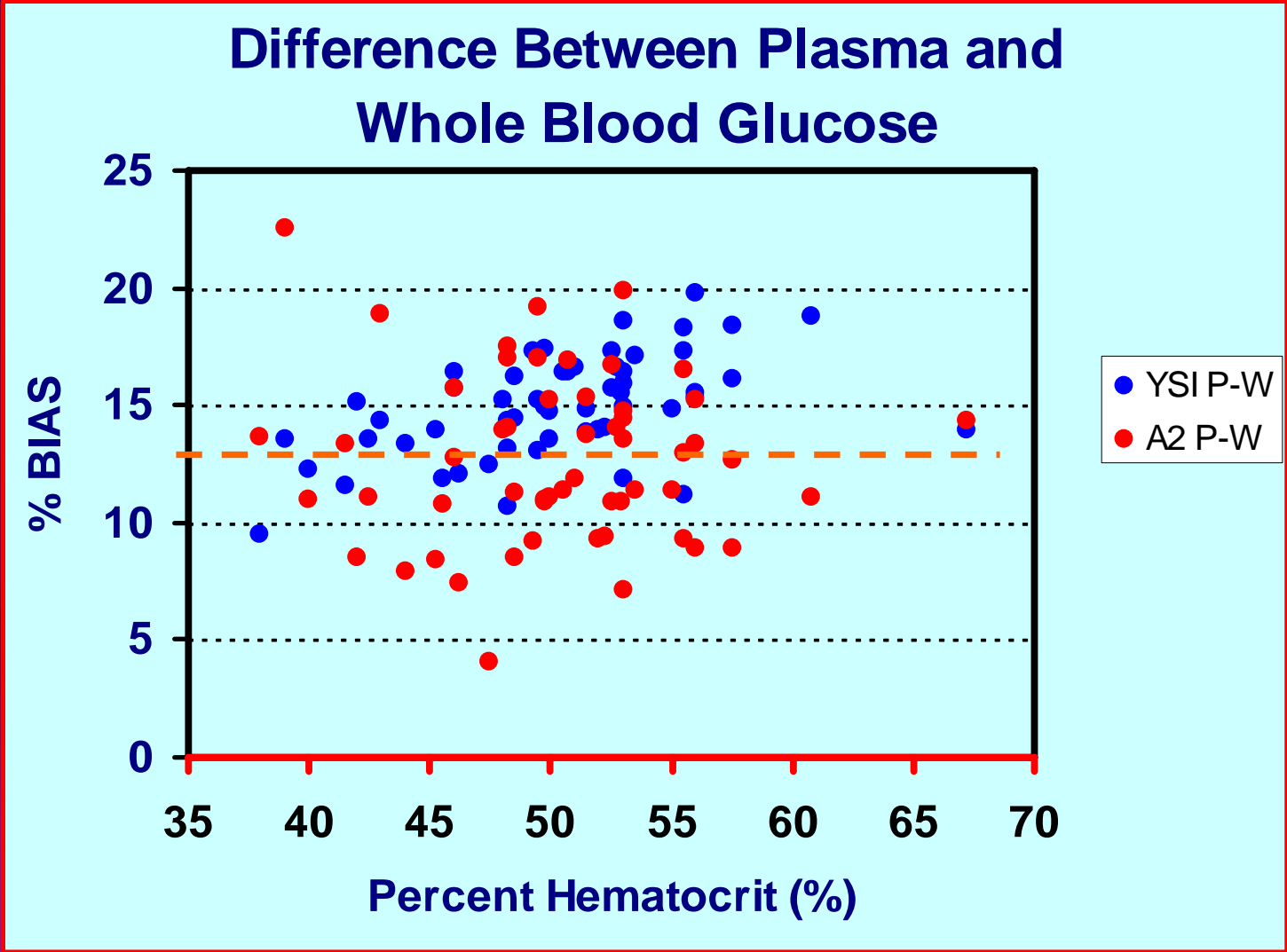


# Capillary vs Venous Glucose



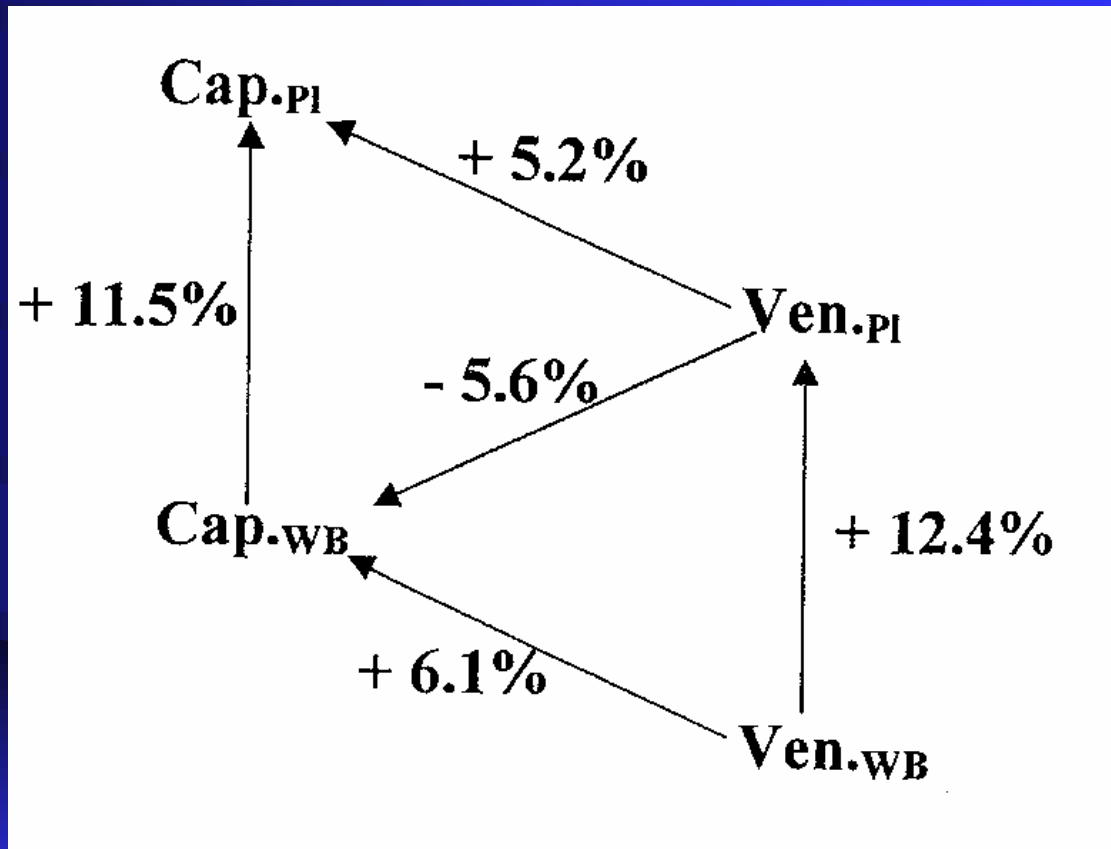
Melnik & Potter. AJMT 1982; 48:543-545.

# Plasma vs Whole Blood





# Capillary and Venous Differences



Davidson & Parker. *Clinical Diabetes Mellitus: A Problem Oriented Approach*. 2000, p. 461.

# Sample Oxygen Levels

Blood Sample	Mean pO <sub>2</sub> (mm Hg)	pO <sub>2</sub> Range (mm Hg)
Arterial	95	75 to 120
Capillary	75	60 to 90
Venous	50	30 to 70
Venous - Aged	15 to 20	5 to 30
O <sub>2</sub> Therapy	Variable	>100 to > 600

# Alternative Site Testing

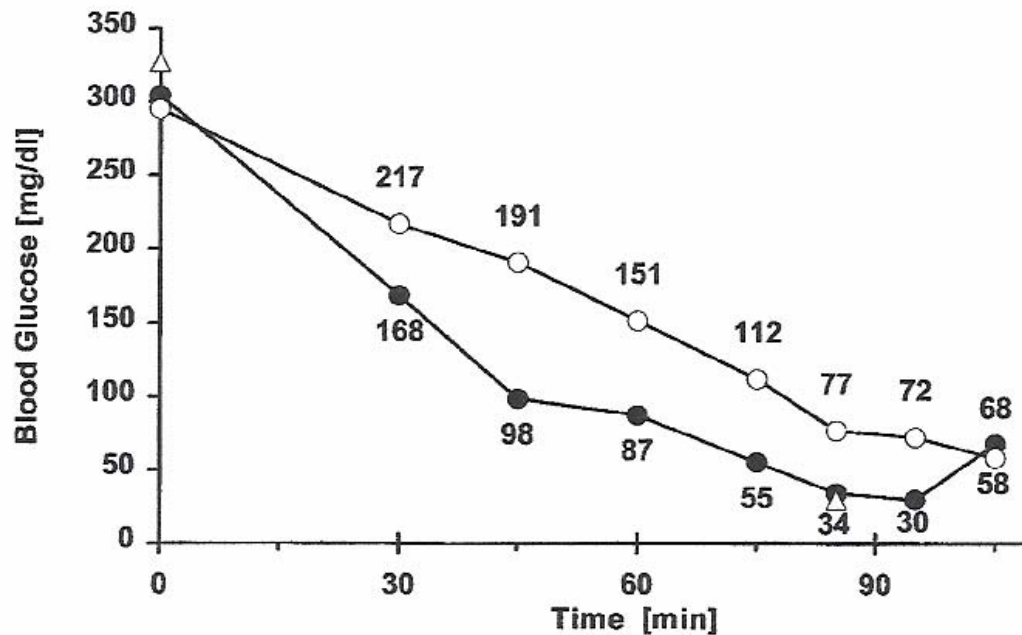
# Blood Flow and Nerve Density

- Blood Flow
  - » Fingers =  $33 \pm 10$  mL / g • min at 19-22 °C
  - » Forearm = 4-6 mL / g • min at 19-22 °C
  - » Abdomen = 4-6 mL / g • min at 19-22 °C
- Relative nerve tissue density
  - » Fingers: Highly enervated (pain issues)
  - » Forearm: 20-25% of finger nerve levels
  - » Palm: 75% of finger nerve density

# Alternative Sampling Sites

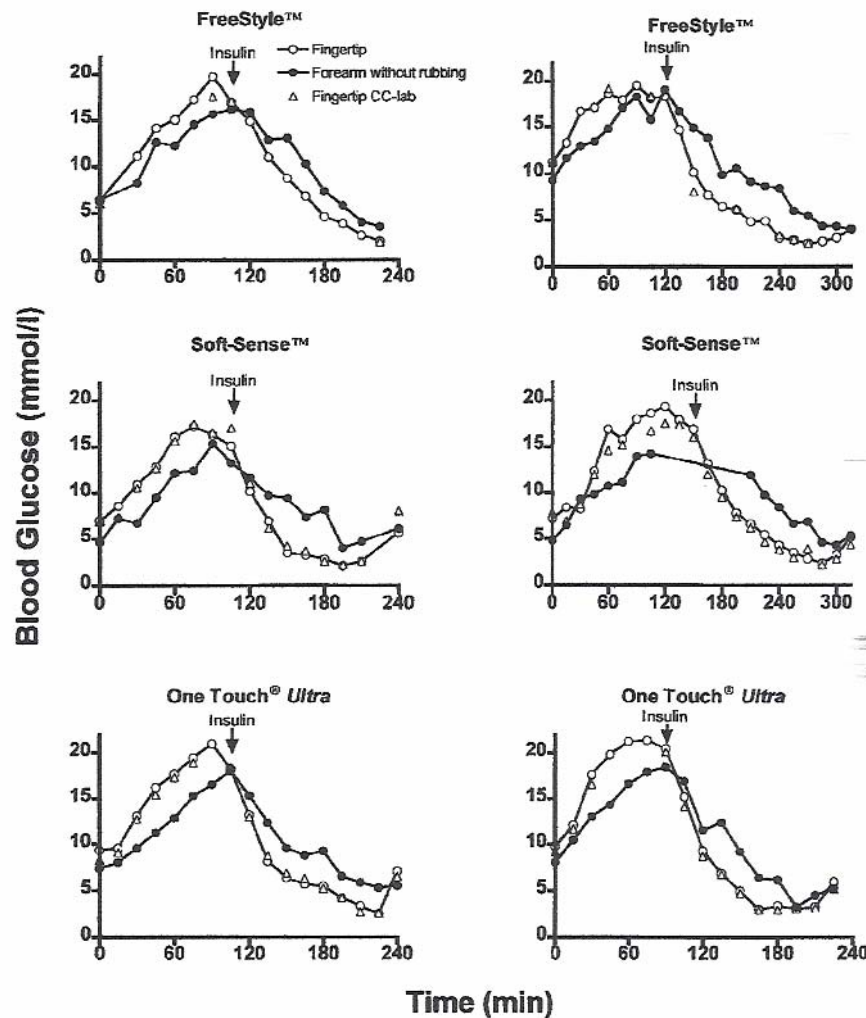
- Forearm
- Palm
- Abdomen
- Thigh
- Ear lobe (Not convenient)
- Foot (Not recommended)

# AST Wake Up Call



**Figure 1**—Effect of a fast blood glucose decrease ( $3 \text{ mg} \cdot \text{dl}^{-1} \cdot \text{min}$ ) on capillary blood glucose values at the fingertip (●) and at the forearm (○) using the FreeStyle system in a type 1 diabetic patient. Control blood glucose values from the fingertip measured at the laboratory are indicated (△).

Jungheim J and Koschinsky T. *Diabetes Care* 2001; 24(7): 1303-04.



**Figure 1**—Representative study BG profiles from the forearm and the fingertip of six patients with diabetes. Changes in BG were induced with 75 g oral glucose ( $t = 0$ ) and by intravenous insulin injection. BG was analyzed using three different BG monitors as well as a clinical chemistry laboratory (CC-lab) method.

# AST Impact Factors

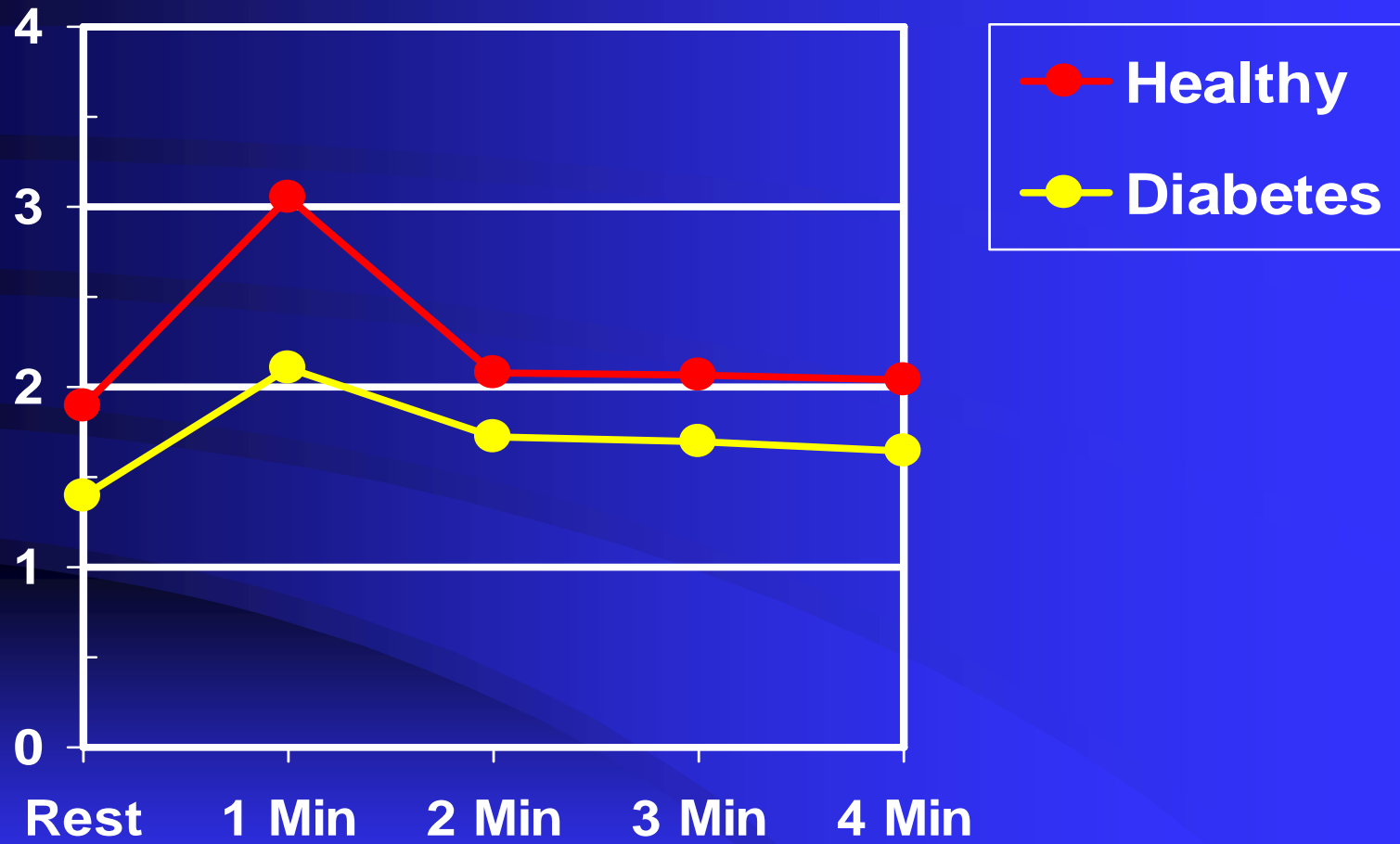
- Meals or snacks
- Insulin doses (Fast acting)
- Oral medications
- Exercise
- Hypoglycemia unawareness
- Operating dangerous equipment
- Advanced neuropathy (?)



# Number of Punctures Required to Obtain a Sample

<b>DEX<sup>®</sup></b>	<b>Finger #1</b>	<b>Finger #2</b>	<b>Palm</b>	<b>Forearm</b>	<b>Thigh</b>	<b>Abdomen</b>
<b>Mean</b>	<b>1.12</b>	<b>1.25</b>	<b>1.42</b>	<b>1.40</b>	<b>1.67</b>	<b>1.65</b>
<b>SD</b>	<b>0.32</b>	<b>0.60</b>	<b>0.83</b>	<b>0.59</b>	<b>1.17</b>	<b>0.84</b>
<b>N</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>
<b>Elite XL</b>						
<b>Mean</b>	<b>1.10</b>	<b>1.17</b>	<b>1.13</b>	<b>1.45</b>	<b>1.17</b>	<b>1.72</b>
<b>SD</b>	<b>0.40</b>	<b>0.67</b>	<b>0.34</b>	<b>0.70</b>	<b>0.42</b>	<b>1.08</b>
<b>N</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>	<b>60</b>

# Forearm Blood Flow (Children)



Pichler et al. *Diabetes Care* 2004; 27(8):1942-46.

# BGM Testing Issues

- Sample volume (filled sensor)
- Fingertstick vs Venous blood
- Plasma vs Whole Blood Glucose
- Glycolysis and Evaporation
- Medications (Interference & Cross reactivity)
- ISF dilution (AST)
- User errors
- Technique issues

# Test System Issues

- Ease of use and ease of learning/teaching
- Human factors / Ergonomics
- Sample size and test time
- Manufacturing ease / complexity
- Lot-to-lot variability
- Durability and stability (meter & strips)
- Calibration (Reference method & materials)
- Dry reagent surface chemistry challenges
- Cost of goods & testing
- Value of testing – Outcomes studies