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Glucose Testing: Understanding Glucose and Insulin Patterns

Dr. Ritamarie Loscalzo

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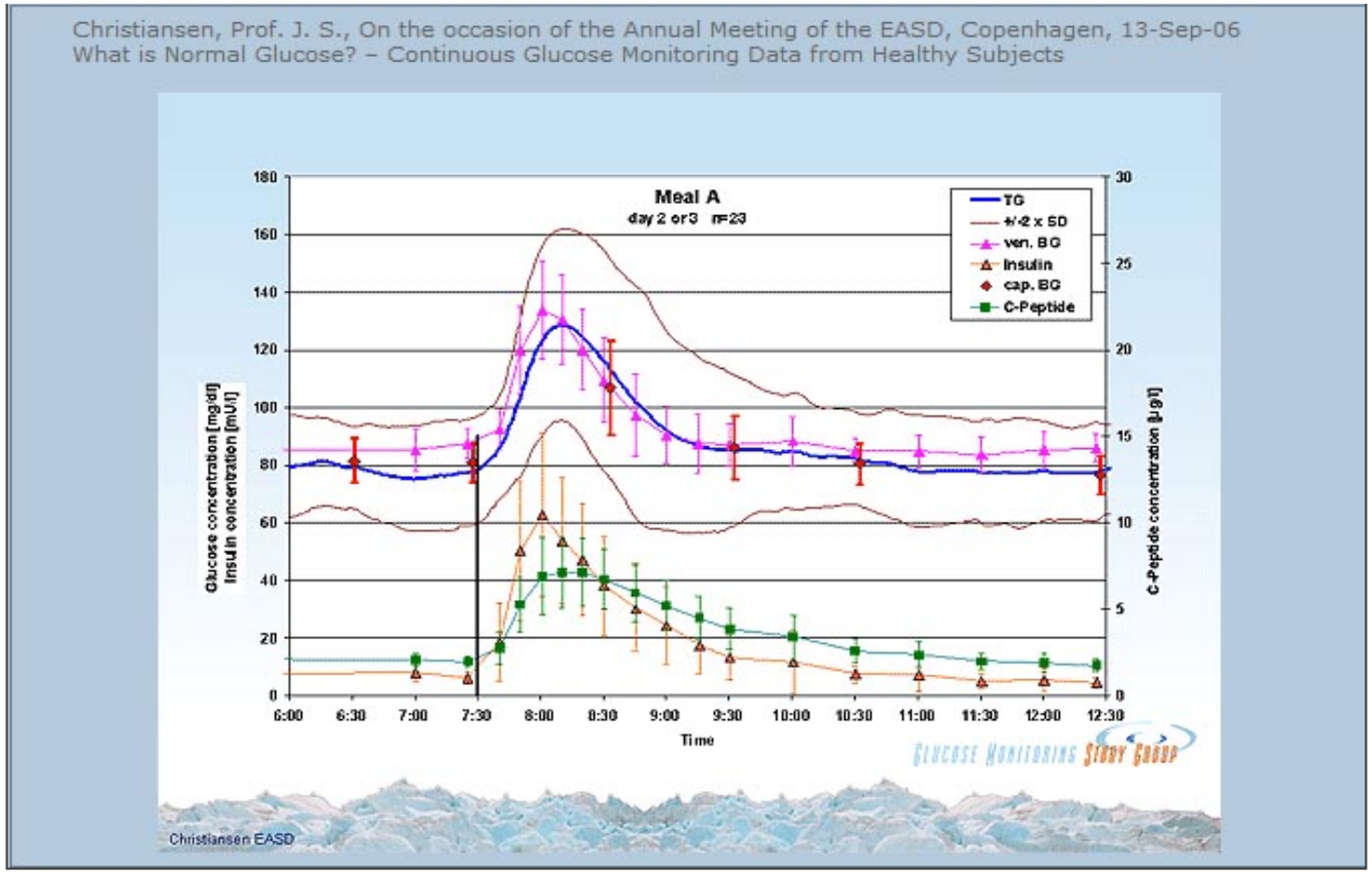
What is Normal Blood Sugar?



What is a Normal Blood Sugar?

Normal blood sugars after a high carbohydrate breakfast eaten at 7:30 AM. The blue line is the average for the group. The brown lines show the range within which most readings fell (2 standard deviations). Bottom lines show Insulin and C-peptide levels at the same time.Graph is a screen shot from Dr. Christiansen's presentation cited below.

Continuous Glucose Profiles in Healthy Subjects under Everyday Life Conditions and after Different Meals

Normal Fasting Blood Sugar

A normal fasting blood sugar (which is also the blood sugar a normal person will see right before a meal) is:

83 mg/dl (4.6 mmol/L) or less.

Many normal people have fasting blood sugars in the mid and high 70 mg/dl (3.9 mmol/L) range.

Though most doctors will tell you any fasting blood sugar under 100 mg/dl (5.6 mmol/L) is "normal", there are several studies that suggest that testing with a fasting blood sugar in the mid 90 mg/dl (5 mmol/L) range often predicts diabetes that is diagnosed a decade later.

http://www.drritamarie.com/NormalBloodSugarGraph

Post-Meal Blood Sugar (Postprandial)

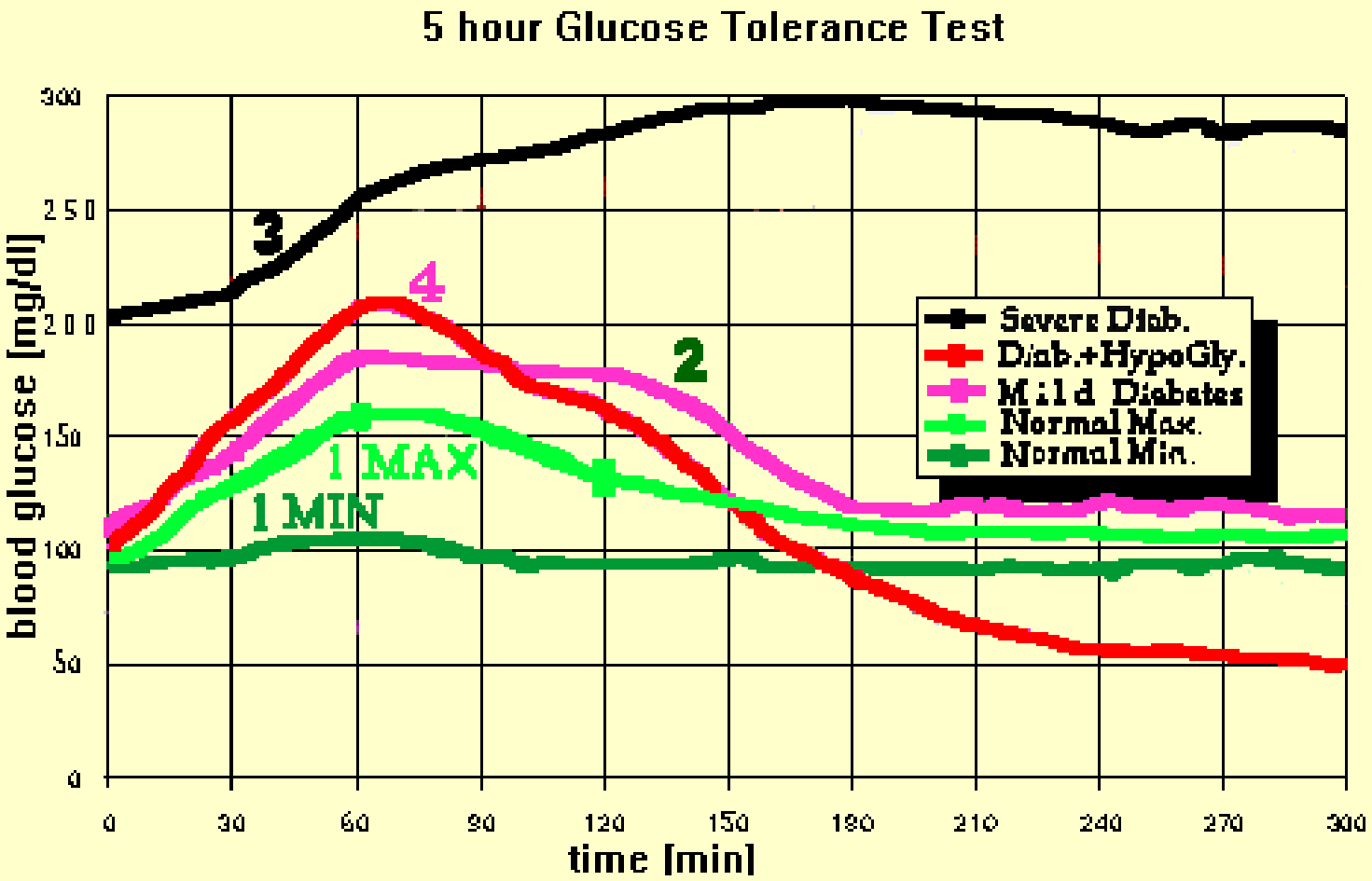
Independent of what they eat, the blood sugar of a truly normal person is:

Under 120 mg/dl (6.6 mmol/L) one or two hours after a meal.

Most normal people are **under 100 mg/dl (5.5 mmol/L) two hours after eating.**

http://www.drritamarie.com/NormalBloodSugarGraph

Response After 100 gram Glucose Solution



Normal Minimum Curve on Glucose Tolerance Test (GTT)

1a. Normal Minimum curve according to Seale Harris

Time [hours]	0	0.5	1	2	3	4	5	6
bG_{min} [mg/dl]	80	90	105	90	80	80	80	80

A "Normal-Min" curve means your pancreas is still in very good shape. Insulin release is strong and sufficient to keep glucose from rising. Keep your pancreas healthy by not stimulating much release of insulin, ie, eat low carbohydrate meals.

“Normal” Maximum Curve - GTT

1b. Normal Maximum curve according to Seale Harris

Time [hours]	0	0.5	1	2	3	4	5	6
bG_{max} [mg/dl]	120	135	160	130	110	100	110	105

The "Normal-Max" response means you are already well started on the road to diabetes. This

Pattern of Early Hypoglycemia

6. Pre-hypoglycemia (Source: Hypoglycemia, P. Airola)

Time [hours]	0	0.5	1	2	3	4	5	6
bG [mg/dl]	90	115	140	100	85	80	70	75

The curve is typical for a prestage of hypoglycemia. However, a range of mild symptoms may be present at this stage. A 3-hour GTT would not have been long enough to diagnose this type of hypoglycemia.

Mild Hypoglycemia

7. Mild hypoglycemia (Source: Hypoglycemia, P. Airola)

Time [hours]	0	0.5	1	2	3	4	5	6
bG [mg/dl]	80	120	80	60	80	75	80	80

This curve represents a mild form of hypoglycemia. Within the hour, the bG level drops to normal value. During the second hour, the value is far too low, this is typical in case of reactive hypoglycemia. Consequently, the curve rises until the normal value are reached. Because the bG level drops 40 mg% (mg/dl) within half an hour, severe symptoms may occur.

Severe Hypoglycemia

8. Severe hypoglycemia I (Source: Hypoglycemia, P. Airola)

Time [hours]	0	0.5	1	2	3	4	5	6
bG [mg/dl]	95	110	120	105	100	60	40	60

During the first 3 hours, the curve is fully normal. However, this curve depicts a form of hypoglycemia
that often occurs and causes severe symptoms. The fact that the curve drops more than 20 mg% (mg/dl)
below normal value indicates already that severe symptoms might well possible be present.

Some Foods Don't Raise Glucose, But Do Increase Insulin

- Dairy produces high insulin responses, despite low GI
- Insulin response to milk not just due to lactose in the milk sugar
- Amino acids leucine, valine, lysine, and isoleucine are insulinogenic -- highest in whey
- Protein-rich foods and foods rich in fat and refined carbohydrate elicited insulin responses that were higher than their glycemic responses
- Protein-rich foods or the addition of protein to a carbohydrate-rich meal can stimulate a modest rise in insulin secretion without increasing blood glucose

Glycemia and insulinemia in healthy subjects after lactose-equivalent meals of milk and other food proteins: the role of plasma amino acids and incretins *Mikael Nilsson, Marianne Stenberg, Anders H Frid, Jens J Holst and Inger ME Björck*
Applied Nutrition and Food Chemistry, Lund University, PO Box 124, 221 00 Lund, Sweden
http://www.drritamarie.com/AJCNPlasmaAminoAcid

TABLE 4
Areas under the 120-min plasma glucose and insulin response curves (AUCs), ratio of insulin AUC to glucose AUC, the insulin AUC per g carbohydrate and per g serving weight, and mean glucose and insulin scores[1]

Food	Glucose AUC	Insulin AUC	Insulin AUC: glucose AUC	Insulin AUC per g carbohydrate	Insulin AUC per g serving weight	Glucose score	Insulin score
	mol · min/L	*pmol · min/L*		*pmol · min · L^{-1} · g^{-1}*	*pmol · min · L^{-1} · g^{-1}*	%	%
Breakfast cereals							
White bread	156 ± 21	13 557 ± 1756	108 ± 19	295 ± 38	144 ± 19	100 ± 0	100 ± 0
All-Bran	59 ± 9	4299 ± 612	87 ± 15	99 ± 14	25 ± 3	40 ± 7	32 ± 4
Porridge	80 ± 9	5093 ± 493	74 ± 11	139 ± 13	13 ± 1	60 ± 12	40 ± 4
Muesli	65 ± 12	6034 ± 813	118 ± 18	163 ± 22	34 ± 5	43 ± 7	46 ± 5
Special K	106 ± 14	8038 ± 635	95 ± 14	195 ± 15	47 ± 4	70 ± 9	66 ± 5
Honeysmacks	91 ± 10	9102 ± 1506	108 ± 12	189 ± 31	53 ± 9	60 ± 7	67 ± 6
Sustain	93 ± 8	8938 ± 757	102 ± 9	209 ± 18	53 ± 4	66 ± 6	71 ± 6
Cornflakes	110 ± 11	8768 ± 623	88 ± 5	189 ± 13	52 ± 4	76 ± 11	75 ± 8
Group mean	—	7183 ± 357	92 ± 5	169 ± 8	39 ± 2	59 ± 3	57 ± 3
Carbohydrate-rich foods							
White bread	120 ± 13	12 882 ± 1901	112 ± 15	281 ± 41	137 ± 20	100 ± 0	100 ± 0
White pasta	50 ± 11	4456 ± 453	156 ± 48	91 ± 9	22 ± 2	46 ± 10	40 ± 5
Brown pasta	74 ± 7	4535 ± 574	67 ± 10	93 ± 12	21 ± 3	68 ± 10	40 ± 5
Grain bread	68 ± 9	6659 ± 837	106 ± 12	166 ± 21	62 ± 8	60 ± 12	56 ± 6
Brown rice	113 ± 13	6240 ± 616	58 ± 5	117 ± 11	42 ± 4	104 ± 18	62 ± 11
French fries	70 ± 11	7643 ± 713	146 ± 29	209 ± 19	82 ± 8	71 ± 16	74 ± 12
White rice	129 ± 16	8143 ± 683	69 ± 5	145 ± 12	40 ± 3	110 ± 15	79 ± 12
Whole-meal bread	106 ± 14	11 203 ± 1420	122 ± 20	247 ± 31	111 ± 14	97 ± 17	96 ± 12
Potatoes	148 ± 24	13 930 ± 1467	120 ± 19	284 ± 30	38 ± 4	141 ± 35	121 ± 11
Group mean	—	8410 ± 461	106 ± 8	182 ± 10	62 ± 5	88 ± 6	74 ± 8
Protein-rich foods							
White bread	121 ± 19	17 438 ± 3154	177 ± 35	387 ± 63	185 ± 33	100 ± 0	100 ± 0
Eggs	36 ± 11	4744 ± 1017	135 ± 92	9340 ± 1845	30 ± 6	42 ± 16	31 ± 6
Cheese	42 ± 10	5994 ± 1590	268 ± 153	64 257 ± 15 013	106 ± 27	55 ± 18	45 ± 13
Beef	18 ± 6	7910 ± 2193	1583 ± 939	—	50 ± 14	21 ± 8	51 ± 16
Lentils	63 ± 17	9268 ± 2174	307 ± 103	325 ± 68	37 ± 9	62 ± 22	58 ± 12
Fish	29 ± 14	9350 ± 2055	775 ± 502	—	28 ± 6	28 ± 13	59 ± 18
Baked beans	110 ± 14	20 106 ± 3776	183 ± 44	504 ± 87	57 ± 11	114 ± 18	120 ± 19
Group mean	—	9983 ± 1032	585 ± 61	18 607 ± 5456	53 ± 6	54 ± 7	61 ± 7
Fruit							
White bread	171 ± 19	15 563 ± 1632	105 ± 18	339 ± 36	166 ± 17	100 ± 0	100 ± 0
Apples	83 ± 7	8919 ± 910	118 ± 18	152 ± 15	20 ± 2	50 ± 6	59 ± 4
Oranges	66 ± 11	9345 ± 1074	166 ± 23	185 ± 21	15 ± 2	39 ± 7	60 ± 3

Effects of Food on Glucose and Insulin Chart

Low GI foods (GI= 1-39) Moderate GI foods (GI= 40-59)

Food	Portion size	Calories	Carbohydrate (gM)	Glycemic Index	Insulin Index**
Breakfast cereals					
Oatmeal	3/4 cup	240	36.5	60	40
Cornflakes		240	46.3	76	75
Special K		240	41.2	70	66
All Bran		240	43.1	42	32
Muesli		240	36.9	60	40
Grains/pasta					
Brown rice	1/2 cup	240	58	76	62
White rice	1/2 cup	240	56	110	79
White pasta	1 cup	240	39.7	46	40
Brown pasta	1 cup	240	37.2	68	40

An insulinindexof foods:the insulindemandgenerated by 1000-kJ portions of common foods, Susanne HA Holt, Janette C Brand Miller, and Peter Petocz Am J Clin Nutr l997;66:l264â€”76. http://www.drritamarie.com/AJCNInsulinIndexOfFoods

Effects of Fat and Protein on Blood Glucose and Insulin

- ✓ Milk proteins have insulinotropic (insulin raising) properties; the whey fraction contains the predominating insulin secretagogue.
- ✓ Protein-rich foods or protein added to a carbohydrate-rich meal can stimulate insulin secretion without increasing blood glucose.
- ✓ A large amount of fat added to a carbohydrate-rich meal increases insulin secretion even though plasma glucose responses are reduced.**
- ✓ Hyperinsulinemia (too much insulin)—when induced experimentally over a 48–72 hour period may induce insulin resistance in healthy subjects.

***Glycemia and insulinemia in healthy subjects after lactose-equivalent meals of milk and other food proteins: the role of plasma amino acids and incretins** Mikael Nilsson, Marianne Stenberg, Anders H Frid, Jens J Holst and Inger ME Björck Applied Nutrition and Food Chemistry, Lund University, PO Box 124, 221 00 Lund, Sweden http://www.drritamarie.com/AJCNPlasmaAminoAcid

****The effect of coingestion of fat on the glucose, insulin, and gastric inhibitory polypeptide responses to carbohydrate and protein.** Greg Collier BSc(Hons) and Kerin O'Dea PhD, sensitivity. Am J Clin Nutr 1983:37:941-944. http://www.drritamarie.com/AJCNJune1983v37no6

Conclusion: Effects of Milk on Insulin

- ✓ It can be concluded that food proteins differ in their capacity to stimulate insulin release, possibly by differently affecting the early release of incretin hormones and insulinotropic amino acids. Milk proteins have insulinotropic properties; the whey fraction contains the predominating insulin secretagogue.

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Other Lab Markers for Insulin Resistance

- ✓ **Fasting glucose:** ideal 80 - 95
- ✓ **Triglycerides:** ideal 50 - 100
- ✓ **HDL:** > 65
- ✓ **Insulin:** ideal 2 - 5
- ✓ **Cholesterol:** ideal < 200

Follow-up if glucose above the optimal range:

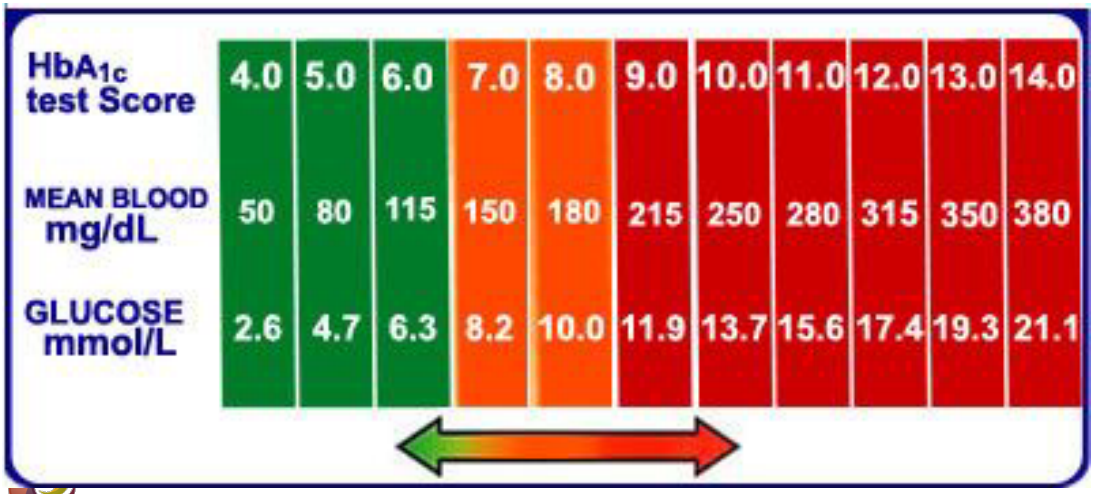
- ✓ Hemoglobin A1C

A truly normal A1c is between 4.6% and 5.4%

A1cs are not as good a measure of actual blood sugar control in individuals as they are for groups. An A1c of 5.1% maps to an average blood sugar of 100 mg/dl (5.6 mmol/L) or less when group statistics are analyzed, but normal variations in how our red blood cells work make the A1cs of truly normal individuals fall into a wider range.

Some people's A1cs are always a bit higher than their measured blood sugars would predict. Some are always lower. NOTE: If you are anemic your A1c will read *much lower* than your actual blood sugars and the resulting A1c is not a useful gauge of your actual blood sugar control.

Heart attack risk rises in a straight line fashion as A1c rises from 4.6%. You can learn more about the relationship of heart disease and blood sugar test results on this page: A1c and Post-Meal Blood Sugars Predict Heart Attack.



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