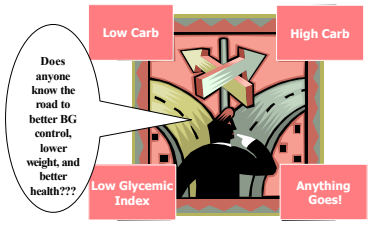
Slide 1

The Crux of the Glycemic Index in Diabetes Management

Janine Freeman, RD,LD,CDE

Slide 2



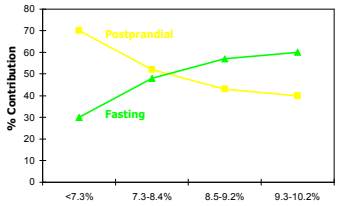
Slide 3

Emphasis on Postprandial Hyperglycemia

- Contribution to overall glycemic control
  - Establishment of 2-hr pp PG goals
    ADA: <180 mg/dl AACE: <140 mg/dl
- Evidence that pp hyperglycemia increases risk for CV disease

Slide 4

Contribution of Postprandial BG to A1C



Monnier, L Diabetes Care 26, 2003

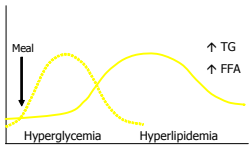
Slide 5

Emphasis on Postprandial Hyperglycemia

- Contribution to overall glycemic control
  - Establishment of 2-hr pp PG goals
    ADA: <180 mg/dl AACE: <140 mg/dl
- Evidence that pp hyperglycemia increases risk for CV disease

Slide 6

Postprandial Glycemia and Lipidemia Following a Mixed Meal



Adapted from Heine RJ, et al. Diabetic Medicine 2004;21: 208-213

Slide 7

What Determines Postprandial Hyperglycemia?

- Postprandial BG response determined by:
  - Rate of appearance of glucose into the bloodstream
    - Hepatic glucose output
    - Food intake
  - Disappearance from circulation
    - Insulin

Slide 8

Postprandial Hyperglycemia in Type 2 and IGT

- Loss of first phase insulin secretion
- Decreased suppression of hepatic glucose production
- Decreased glucose uptake
  - Insulin resistant tissue

Slide 9

Pharmacological Management of PP Hyperglycemia

- Rapid-acting insulin analogues
- Short-acting oral agents
- Exenatide (Byetta)
  - Suppresses glucagon
  - Regulates gastric emptying
  - Stimulates insulin secretion
  - Decreases food intake
- Pramlintide (Symlin)
  - Suppresses glucagon
  - Slows gastric emptying
  - Decreases food intake

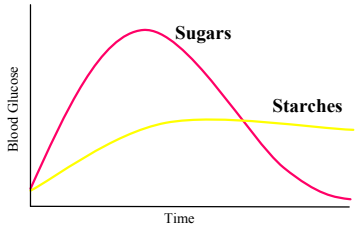
Slide 10

Dietary Effects on Postprandial Blood Glucose

- Carbohydrate - greatest effect on BG
- Fat – little effect
  - slows glucose absorption
- Protein – little effect
  - stimulates insulin release

Slide 11

Traditionally Held View of PP Effect of CHOs



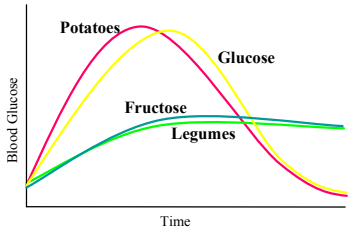
Slide 12

Sugar Vs Starch

- 1983 - First published study:
  Bantle, et al
  - Compared meals containing equal amounts of CHO, protein and fat, but from sugars and starches
  - No significant difference in glycemic responses or insulin needs
- Numerous other studies followed

Slide 13

Actual Glycemic Response Curves



Slide 14

Sugar Vs Starch

- Peters, et al: Substituted a piece of chocolate cake for a baked potato in a meal (equal carbohydrate and calories)
  - No differences in glucose response to the two meals

Slide 15

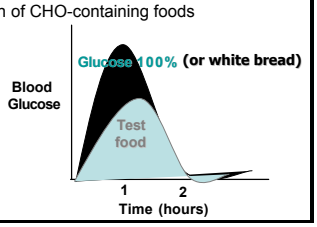
Glycemic Index (GI)

- Numeric classification developed 1981 by Jenkins and colleagues
  - Potential use in diabetes/IGT
- Area of debate
  - Impact and importance of type or source of CHO on pp BG

Slide 16

Glycemic Index (GI)

- Measure of the change in BG following ingestion of CHO-containing foods



Slide 17

GI Definition

- the incremental area under the BG response curve of a 50-g available CHO portion of a test food expressed as a percentage of the response to the same amount of CHO from a standard food taken by the same subject

Slide 18

GI Testing

After 10-12 hr fast:

- Subjects consume 50 grams reference food
  - Capillary BG tested over 2 hrs
- Subjects consume 50 grams (available CHO) test food
  - Capillary BG tested over 2 hrs
- Values are compared

Slide 19

Tables of GI Values

- International table of glycemic index and glycemic load values: 2002
  - Foster-Powell, Holt, Brand-Miller. *Am J Clin Nutr* 2002;76:5-56.
  - www.glycemicindex.com (University of Sydney, Australia)

Slide 20

GI Table

Food Item	GI Glucose =100	GI Bread = 100	Subjects	Avail-able Carb	GL per serving
Sweet corn (N. Zealand)	37	53	Healthy, 9	30	11
Sweet corn (Australia)	48	69	Healthy, 6	30	14
Sweet corn (Canada)	59	84	Healthy, 5	33	20
Sweet corn (USA)	60	85	Type 2, 5 IGT, 6	33	20
Mean of 6 Studies	53	78	-	32	17

Slide 21

GI Food Examples*

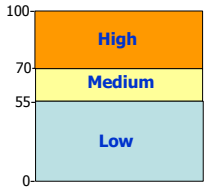
High GI (>70)	Low GI (<55)
White bread, plain bagel, pancakes	Wheat bread, rye bread, brown rice, barley
Corn flakes, Rice Krispies, Cheerios, Grapenuts	All Bran cereal, muesli, nuts
Baked potatoes, carrots	Lentils, beans, peas, cold boiled potatoes, yams
Watermelon, dried dates	Apples, grapes, pears, strawberries, bananas
Jelly beans, Gatorade	Yogurt, milk, ice cream, chocolate bars

* Using glucose as reference food

Data from Foster-Powell, et al. International table of GI and GL. Am J Clin Nutr 2002

Slide 22

Categorization of GI Foods*

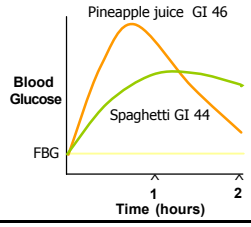


*Using glucose as reference food.

Slide 23

Comparison of Glycemic Response with Similar GIs

The faster or greater BG rise does not always represent the highest GI



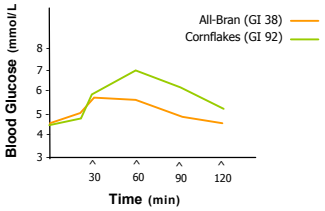
Slide 24

What Does the GI of a Food Reflect?

- Assumption: GI reflects rate of digestion and absorption (entry of glucose into the systemic circulation)
- Food can have low GI due to having either:
  - Low rate of appearance of glucose
  - High rate of disappearance of glucose

Slide 25

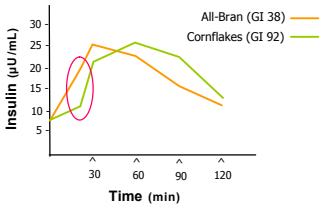
Glycemic Response to Breakfast Cereals



Schenk S, et al. Am J Clin Nutr, 2003

Slide 26

Insulin Response to Breakfast Cereals



Slide 27

High GI Foods and Hyperinsulinemia

Hypothesized:

- High GI foods contribute to:
  - Hyperinsulinemia
    - Protein also stimulates insulin secretion, despite lowering GI value
  - Insulin resistance
    - Studies do not support
  - Weight gain

Slide 28

Factors that Influence Glycemic Response to Food

- Amount of carbohydrate
- Type of carbohydrate
- Ripeness of food
- Physical form
- Variety/type
- Cooking and food processing

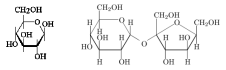
Slide 29

Amount of Carbohydrate

Slide 30

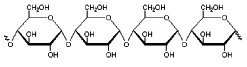
Type of Carbohydrate

Sugars
(Mono or disaccharides)



1 or 2 sugar molecules

Starches
(Polysaccharides)

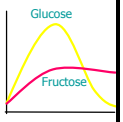


Long chains of glucose molecules

Slide 31

Effect of Type of Sugar on Glycemic Response

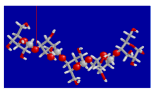
- Higher glycemic effect
  - Glucose
- Lower glycemic effect
  - Fructose, sucrose, lactose
    - Fructose stored in liver as glycogen and slowly converted to glucose if at all
    - Sucrose and lactose are ½ glucose and ½ fructose (or galactose)

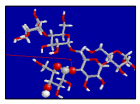


Slide 32

Effect of Type of Starch on Glycemic Response

- Amylose (10-20%) (straight chains)
  - More slowly digested and absorbed
- Amylopectin (80-90%) (branched chains)
  - Faster breakdown





Slide 33

Type of Starch

- Resistant starch
  - i.e. legumes (starchy beans and peas)
  - Incompletely digested and absorbed
  - Lower glycemic response

Slide 34

Food Processing

- Processing grains increases GI
- Chemically modifying starch can decrease GI
- Heat and moisture affect starch granules

Slide 35

Food Preparation

- Amount of heat used
  - Cooking splits starch granules, making them available for digestion by enzymes
- Amount of water
- Time of cooking
- Cooling, storage

Slide 36

Physical Form of Food

- Mashed potato vs whole potato
  - Changes GI by 25%
- Juice vs whole fruit

Slide 37

Ripeness of Fruit

- Glycemic response can change as the fruit ripens

Under ripe (green at tips)	GI 42
Ripe (all yellow)	GI 54
Over ripe (brown spots)	GI 64

Source: Jenkins, Wolever

Slide 38

Variety or Type of Food

- Type of rice
  - Amylose vs amylopectin (higher)
  - Long grain vs arborio vs basmati
- Type of pasta
  - Linguini vs macaroni
- Country of origin

Slide 39

"And Now the Bad News: Potatoes"

- "When you eat a potato and that starch hits the saliva in your mouth, its tightly bundled molecules immediately get turned into sugars, which make a beeline for the blood."

-Time Magazine, 1/21 2002

Slide 40

GI of Potatoes in U.S.

POTATO	GI
Boiled red potato (hot)	89
Instant mashed	88
Baked russet	76
French fries	64
Boiled red potato (cold)	56

JADA April 2005, Volume 105, Number 4

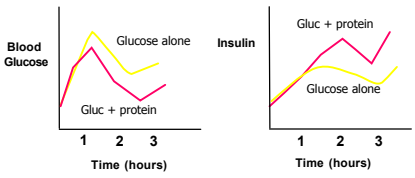
Slide 41

Other Food Components

- Fat and protein
  - Glucose is more slowly absorbed in high fat foods
  - Protein stimulates insulin secretion

Slide 42

Effect of Protein on Glucose and Insulin in Type 2 DM



Slide 43

Other Factors Affecting Glycemic Response

- Coingestion of protein and fat in meals (mixed meals)
  - Flint A (2004)- Randomized, cross-over meal test
    - No association between predicted GI (from tables) and measured GI
    - GI of meals was best predicted by fat and protein content, or with energy content than with CHO alone

Slide 44

Other Factors Affecting Glycemic Response

- Prior food intake
- Premeal glucose level
- Degree of insulin resistance

Slide 45

Other Food Components

- Acidity
  - Can lower GI
- Addition of sugars
  - Fructose
  - Sucrose

Slide 46

Glycemic Load (GL)

- Proposed as a measure of the overall glycemic impact of the diet
  - Takes into account the amount of CHO in an ordinary serving

Slide 47

Glycemic Load

GL = GI x gms CHO/serving ÷ 100

Slide 48

Glycemic Load

Food	CHO per svg	GI	GL
Carrots ½ cup	8 g	92	7
Snicker's 2 oz	35 g	68	23

Carrots: GI (92) x 8 g CHO ÷ 100 = 7

Snickers: GI (68) x 35g CHO ÷ 100 =23

Slide 49

Issues Regarding GI

- GI takes into account only type of CHO, not the CHO in a typical serving
- GI of any particular food is highly variable

Slide 50

Variance of GI

CARROTS	GI	Subjects
Romania (raw)	16	Type 2, n=30
Australia (peeled, boiled)	32 ± 5	Healthy, n=8
Australia (peeled, boiled)	49 ± 2	Healthy, n=7
Canada (not specified)	92 ± 20	Healthy, n=5
Mean of 4 studies	47 ± 16	

Slide 51

Variance of GI

RICE (boiled, white)	GI	Subjects
France	43	Type 2, n=14
Italy	102	Healthy, n=14
Canada	72	Healthy, n=7
Canada	56	Type 2, n=6
Mean of 12 studies	64 ± 7	

Slide 52

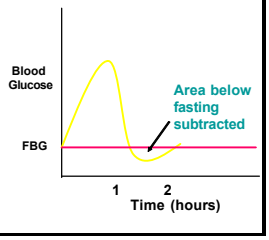
Issues Regarding GI

- Confusion due to use of two reference foods (glucose and white bread)
- Lack of standardization for testing GI of foods
  - Determination of "available" carbohydrate
  - Venous vs capillary whole blood
  - Use of incremental area under the curve

Slide 53

Incremental Area Under the Curve

- Some experts favor use of total area under the curve
- Glycemic response between two calculations varies markedly



Slide 54

Issues Regarding GI

- 2-hour time frame
  - Individuals with diabetes require >2 hours for BG to return to premeal concentrations
  - Maximizes difference between high and low GI foods

Slide 55

Effect of Pizza on Post-meal Hyperglycemia

- *Diabetes Care* 1993: Significant hyperglycemia 4-9 hrs after eating pizza
- *Diabetes Technology & Therapeutics* 2005: Insulin adjusted over 8-hr period after pizza meal

GI = 51 (low)

Slide 56

Issues Regarding GI

- Only measures response to individual food
  - Sum the GI of component foods
- GI does not predict BG response in individuals with diabetes as well as in healthy persons

Slide 57

Issue Regarding GL

- May include “significant unspecified error”
- Glycemic load can be reduced by
  - reducing the diet GI
  - reducing carbohydrate intake
    - Not associated with reduced A1C

Slide 58

Studies on GI (or GL)

Slide 59

Determining Effectiveness of GI

- Conclusions challenging due to:
  - Variation in study design
  - Subject characteristics
  - Diet composition

Slide 60

Estimation of GI in Epidemiological Studies

- Use of food frequency questionnaires
  - Usual food intake
- Assigning GI values
  - Use mean GI in table or create own mean
  - Influence of processing, ripeness, cooking, storage, variety not considered
- Use of GI data tables

Slide 61

Sample Calculation of GI of Meal (Epidemiological studies)

Sample	GI	Carbs	Mean GI	Cumulative GL
1 slice rye bread	50	15	50	8
1 slice rye bread	50	15	50	16
3 ounces turkey	-	-	50	16
1 med. apple	38	24	46	25
1 c. skim milk	32	12	43	29

Slide 62

Determination of Meal/Diet GI
(Short-term studies)*

- GI of total daily diet
  - CHO (g) of each food x GI of each food
  - Sum divided by total daily CHO intake

*Food and Agriculture Organization/World Health Organization, 1998

Slide 63

Sample Calculation of Meal GI
(short-term studies)

Food	Available CHO (g)	Food GI	Meal GI*
Bread	25	71	41
Skim milk	6	32	5
Orange juice	12	46	13
Total	**43**		**59**

*(Available CHO x food GI) ÷ total meal CHO

Slide 64

Studies on Effect of GI on Glycemic Control

- EURODIAB IDDM Study
  - 2080 type 1 outpatients
  - GI of self-selected diets positively related to A1C levels
    - Highest quartile of GI: 11% higher A1Cs

Buyken, AE, et al. Am J clin Nutr 2001;73:574-81.

Slide 65

Studies on Effect of GI on Glycemic Control

- Brand-Miller, et al (2002). Review of 14 studies of high vs low GI diets
  - Low GI foods reduced A1C by 0.43% points over high GI diets (7.4% reduction in A1C)
    - Limitations: small number of subjects, short duration, questionable dietary compliance

Brand-Miller, et al. Diabetes Care 26: 2003

Slide 66

Studies on Effect of MNT on Glycemic Control

Type 1s

Study	MNT Approach	A1C
DAFNE	Mealtime insulin/CHO counting (IIT)	↓1% unit
Dusseldorf	Mealtime insulin/CHO counting	↓1.5% units

Franz MJ. Diabetes Care 26:2466, 2003

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Studies on Effect of MNT on Glycemic Control

Type 2s

Study	MNT Approach	A1C
UKPDS	Reduced energy intake	↓2% units
Type 2 NPGs	Variety of approaches	↓1-2% units
Rickheim, et al	Carb counting	↓~2% units
Goldhaber-Fiebert, et al	Portion control, healthier food substitutes, walking	↓~1.8% units

Franz MJ. Diabetes Care 26:2466, 2003

Slide 68

Comparison of Outcomes

Low GI Diets	Other Nutrition Interventions
↓ A1C 0.4% units (7.4% decrease)	↓ A1C ~1.5% units (20% decrease)

Franz MJ. Diabetes Care 26:2466, 2003

Slide 69

Studies on Effect of GI on CV Risk Factors

Hypothesis: High GI foods increase risk factors for CV disease

Study	Results	Comments
Opperman, et al Meta-analysis of 16 studies, 2004	No effect of low GI diets on TG or HDL ↓ LDL & Tchol in type 2s Epidemiological studies – no effect on TG, LDL, HDL,Tchol	Longer studies needed with larger number of subjects
Kelly S, et al Review of 15 studies, 2004	Limited and weak evidence of slightly ↓ Tchol with low GI diets No effect on LDL, HDL, TG	Short-term, poor quality, or small sample size

Slide 70

Studies on Effect of GI on Weight Gain

Hypothesis: High GI foods increase food intake and cause weight gain

- Raben (2002) – review of 31 short-term studies- low vs high GI
  - ~50% less hunger, decreased food intake Overall, no difference between low & high GI re food intake or wt loss
- Pawlak, et al (2002)
  - Single meal studies shown relationship between GI and hunger/food intake

Slide 71

Studies on Effect of GI on Weight Gain

- Sloth,et al – 10-week parallel, randomized study N=45
  - No difference in body weight decrease between low GI and high GI diet

Evidence for the hypothesis remains to be verified in longer-term intervention trials.

AM J Clin Nutr 2004;80:337-47

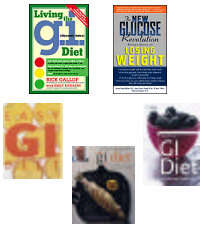
Slide 72

GI Diets – The Next Popular Weight Loss Trend?

Slide 73

Popular Books on GI

- Are GI diet books replacing low carb diet books???
- 31,000 GI diet books at Amazon.com



Slide 74

Popular GI Diet

- High GI foods raise insulin levels to point where your body won't burn up fat stores
  - Red, Yellow, Green light foods
    - Red light: High GI and high fat foods
    - Yellow light: Raise insulin levels – no weight loss
    - Green light: low GI, low saturated fat

Slide 75

Example of Food Lists

Red Light foods	Green Light foods
Baked beans with pork	Baked beans, low-fat
Refried beans	Black beans, lentils
Refined breads/cereals	Whole grain breads/cereals
Eggs	Egg substitutes
Butter	Soft margarine
Coconut oil	Olive oil
Melons, Dates, prunes	Apples, blueberries, grapes

Slide 76

The New Trend – Lower GI Foods

- Addition of low GI ingredients
  - Polyols (sugar alcohols)
  - Fructose
  - Fat
  - Different types of starch
  - Acidic fruits, vinegar
  - Whole grains, seeds, nuts
- Level of processing

Slide 77

GI Symbol for Foods Used in Australia

- Foods tested in vivo include on label:
  - GI Symbol
  - GI value
  - "High, medium, or low GI"

Slide 78

New Atkins Product Labeling

- **"Net Atkins Count"** replaces "Net Carbs"
- 3 Categories:
  - Low AGR (can eat regularly)
  - Medium AGR (eat in moderation)
  - High AGR (eat sparingly)

Slide 79

GI Seal of Approval – U.S.

- Conducts in vivo clinical studies for foods, nutraceuticals, pharmaceuticals

Slide 80

"Low Glycemic" Pet Food of the Year Award

Pet food "must be Low Glycemic, and formulated without meat-byproducts, or ingredients known to be harmful to animals. Further, the food must be nutritious and palatable, with a focus on longevity."

Slide 81

Low GI Food Products

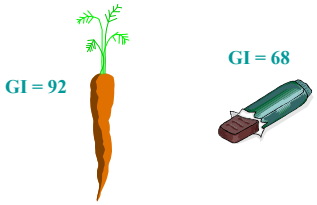
- Savvy Fair frozen gourmet meals
  - GIs less than 55
  - Olive oil, hazelnuts, Asiago cheese, pine nuts
- Kraft Balance Bars
  - GI 25-35
  - Label: "Energy that Lasts"

Slide 82

Is the GI a Useful Tool in Patient Education?

Slide 83

Does the GI Give the Right Message?



Slide 84

Use of GI Around the World

- Clinical applications
  - GI incorporated into food exchange systems in:
    Australia
    Canada
    Europe
    South Africa

Slide 85

Use of GI - Australia

Food Category	Low GI (55 or less)	Interm. GI (56-69)	High GI (70 & over)
Bread	wholemeal	pita, white, rye, crumpet	baguette, Wonderwhite
Cereals	All-Bran, porridge	Special K, Weetbix	Cornflakes, Rice Bubbles
Grains	fettucini, macaroni	basmati rice, couscous	water cracker, rice pasta
Starchy Veg.	lentils, lima beans	new potato, corn, sweet potato	instant potatoes, Pontiac potato
Fruit	apple, orange, pear, grapes	banana, apricots	watermelon, lychee

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Use of GI - Australia

High GI Plan	Lower GI Plan
Breakfast	**Breakfast**
Cornflakes	***Porridge***
Low fat milk	Low fat milk
½ muffin	***Barley toast***
Egg	Egg
Lunch	**Lunch**
White roll	***Whole grain roll***
Reduced fat cheese	Reduced fat cheese
Salad	Salad
Watermelon	***Apple***

Slide 87

Use of GI - Canada

- Canadian Diabetes Association
  - More fruits, and low-fat milk with meals
  - Use low and medium GI starch choices
  - Try barley, bulgar, couscous, or lentils
  - Consult with a dietitian to help choose low GI foods

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List of High GI Starchy Foods

Low GI (≤55)	Med. GI (56-69)	High GI (>70)
Breads: 100% whole wheat	**Breads**: whole wheat, rye, pita	**Breads**: white bread, rolls, bagels
Cereal: All-Bran, oatmeal, oat Bran	**Cereal**: Grapenuts, quick oats	**Cereal**: flake cereals, Rice Krispies, Cheerios
Grains: barley, bulgar, pasta, noodles, par-boiled rice	**Grains**: barley, bulgar, pasta, noodles	**Grains**: short grain rice
Other: Sweet potato, yam. legumes	**Other**: new potato, corn, popcorn, Stoned Wheat Thins	**Other**: Baked russets, French fries, rice cakes, soda crax

Canadian Diabetes Association website: www.diabetes.ca

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Patient Education

- Lengthy table of GI values of foods??
  - Confusion
  - Misinformation
  - Promotion of good/bad food concept

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Patient Education

- Individualized meal plan
  - Nutrition therapy approach documented to have greatest impact on metabolic outcomes
  - Suggestions for healthy foods that may have less effect on pp BG
    - Fruits, vegetables, legumes, whole grains, less processed foods
    - Use GI concept as adjunct to "fine-tune" glycemic control

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Individual Glycemic Response to Foods

- Have patients determine if some foods have higher glycemic effect
  - Check postmeal response to foods with equal carbs when premeal BG is near normal
  - Checking 2-4 hrs may be necessary

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Example of Individual Test of Glycemic Response

• Usual Breakfast	• Test Breakfast
½ cup oatmeal (15 g CHO)	2 pancakes (15 g CHO)
½ cup orange juice	½ cup orange juice
1 cup skim milk	1 cup skim milk

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Statements on GI

American Institute for Cancer Research (AICR)	• Cautions the public not to make dietary changes based solely on this interesting, but still unproven, concept
Food & Nutrition Board of the Institute of Medicine (IOM)	• Not all studies of low GI or GL diets have shown beneficial effects, but none have shown negative effects.

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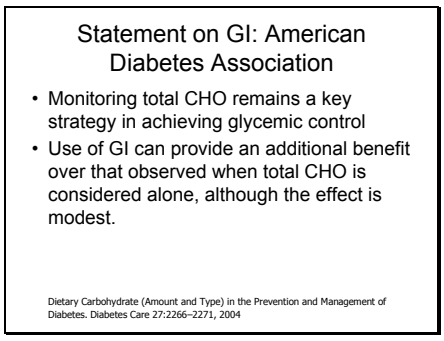

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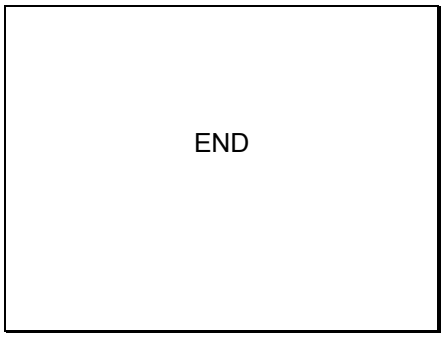

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Dr. Scott Angle, Dean and Director