BEYOND GLYCEMIC INDEX: NEW FOOD INSULIN INDEX

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RELEVANCE OF INSULIN SECRETION

- Prevention and management of weight gain

- Hyperlipidemia

- Non-insulin dependent diabetes mellitus (NIDDM)

- Long-term exposure to high insulin concentrations may be associated with increased risk of cancer

WHAT IS FOOD INSULIN INDEX (FII)?

Directly quantifies the postprandial insulin response to an isoenergetic portion of a test food in comparison to a reference food

Allows testing of foods with no or low carbohydrate content

FII has been shown to predict the relative insulin demand evoked by mixed meals

FOOD INSULIN INDEX (FII)

- Measures blood insulin response to a food compared to a reference food glucose (*FII=100*)

- Measures incremental insulin area under the curve (AUC) over two hours in response to consumption of a 1000 kJ portion of the test food divided by the AUC after ingestion of a 1000 kJ portion of the reference food

How is FII Different from Glycemic Index?

FOOD INSULIN INDEX

- Measures postprandial increase in **insulin** secretion of a whole **food**

- Dependent on **carbohydrate, quantity and quality of protein and fat and their interactions**

GLYCEMIC INDEX

- Measures effect of **carbohydrate**-containing foods on postprandial increase in **blood-glucose** levels

- GI is not always proportional to the insulin response

METHODS

- APPROXIMATELY 100 FOODS AND 16 CEREALS WERE ANALYZED USING GLUCOSE AS THE REFERENCE FOOD
- 407 FOODS, 147 MARGARINES, 58 OILS, 111 CEREALS WERE IMPUTED USING VARIOUS ALGORITHMS
- 166 FOODS AND 89 CEREALS WERE RECIPE-DERIVED
- 44 FOODS WERE ASSUMED TO BE 0

FOODS SENT TO UNIVERSITY OF SYDNEY

MUFFIN MIXES

READY-MADE SWEET ROLL

- SunMaid honey raisin bran muffin mix
- Duncan Hines blueberry muffin mix
- Krusteaz fat-free blueberry muffin mix
- Entenmann cinnamon buns

Cake Mix

- Betty Crocker golden cake w/ Betty Crocker choc frosting

Pancake Mix

- Aunt Jemima pancake mix

Cookies

- Chips Ahoy regular chocolate chip
- Chips Ahoy reduced fat chocolate chip
- Archway fat-free oatmeal raisin

Chips

- Cape Cod reduced fat potato chips

Candy Bars

- Snickers candy bars
- Hershey candy bars

U.S. Analyzed Cereals

CEREALS

- Cheerios
- Shredded Wheat
- Corn Flakes
- Quaker 100% Natural
- Cracklin Oat Bran
- Lucky Charms
- Frosted Flakes
- Great Grains
- Honey Bunches of Oats
- Wheaties

Matching U.S. Foods Purchased in Sydney

Dairy

- Cream cheese
- Low fat cheddar cheese
- Low fat processed cheese
- Low fat cottage cheese
- Low fat ice cream
- Sherbet
- 1% milk
- Butter

Fruits or fruit drinks

- Peaches canned in juice
- Peaches canned in syrup
- Orange juice
- Prunes
- Punch

Cereals

- Kashi 7 grain puffs
- Rice Bubbles

Meat, fish, mixed dishes

- Tacos
- Lasagna
- Roast chicken
- Shrimp
- Tofu
- Tuna in oil
- Bacon

Miscellaneous items

- Olive oil
- Navy beans
- Raspberry jam
- Pretzels
- Walnuts
- Corn tortillas
- Jatz crackers (similar to Ritz)

Recipe-derived FII Values

- Used analyzed foods as ingredients
- Used ingredients that were imputed from analyzed foods.

Example: apple butter   FII = 52

Derived from recipe using apple, a.j., and sugar as ingredients (all analyzed foods)

IMPUTED OR CALCULATED FII VALUES

FOODS

CALCULATION

Cereal grains, baked goods, sweets and snack foods, beverages, fruits, and dairy

Similar analyzed foods and a carb/1000 kj adjustment

$$\frac{\text{carb/1000 kj imputed food}}{\text{carb/1000 kj analyzed food}} \times \text{FII}$$

Breakfast cereals

Used analyzed cereals adjusting for carbohydrate/amount

Meats, fish, and poultry

Directly from similar analyzed foods

IMPUTED FII VEGETABLE VALUES

VEGETABLES

- NON STARCHY

- STARCHY

- PEAS and LIMA BEANS

CALCULATIONS

Recipe from avocado using an H_2O ratio

Recipe from potatoes or carrots using fiber ratios

Recipe from beans using an fiber ratio

FII PUBLICATIONS

Bao J, de Jong V, Atkinson F, Petocz P, Brand-Miller JC. Food insulin index: physiologic basis for predicting insulin demand evoked by composite meals. Am J Clin Nutr 2009;90:986-992.

Holt SH, Miller JC, & Petocz P. An insulin index of foods: the insulin demand generated by 1000-kJ portions of common foods. Am J Clin Nutr, 66:1264-67; 1997.
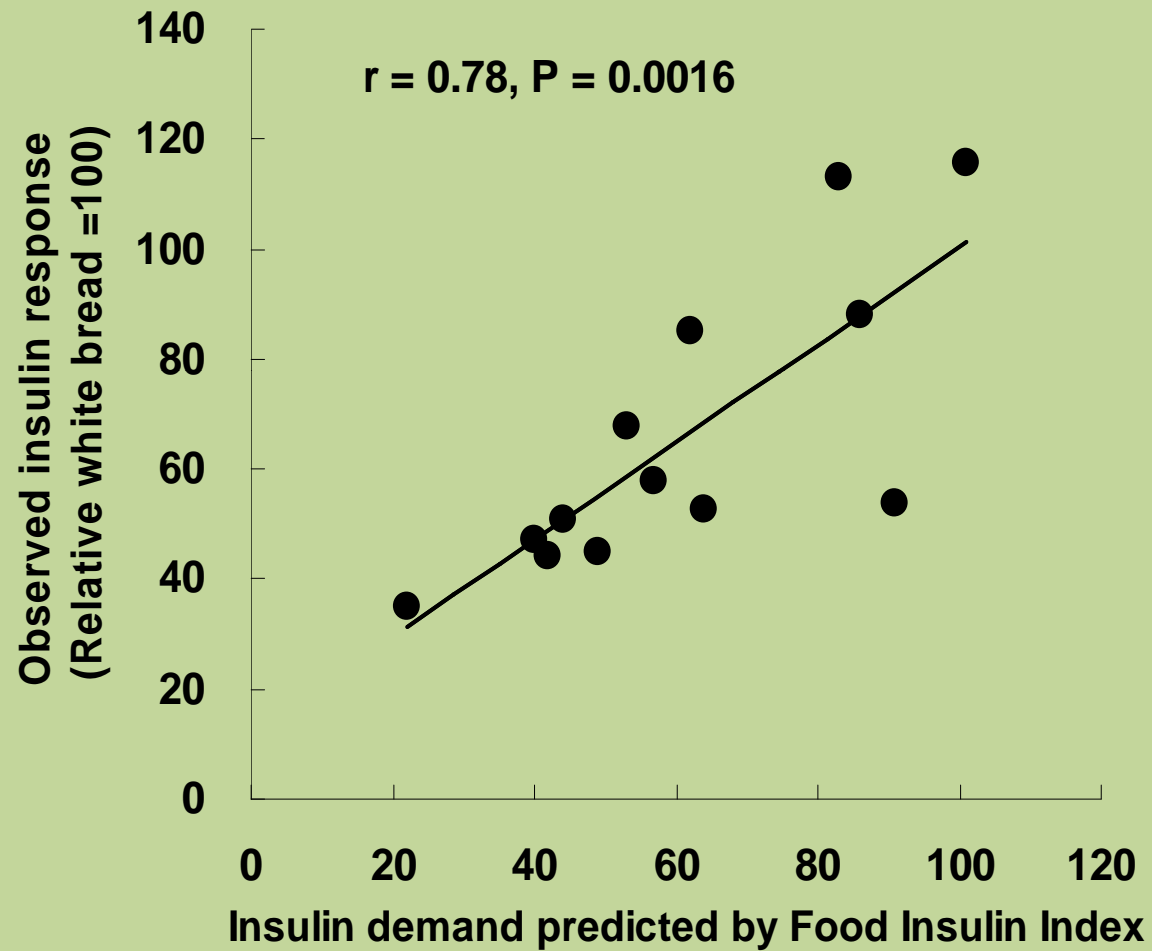
RESULTS of the mixed meal study:
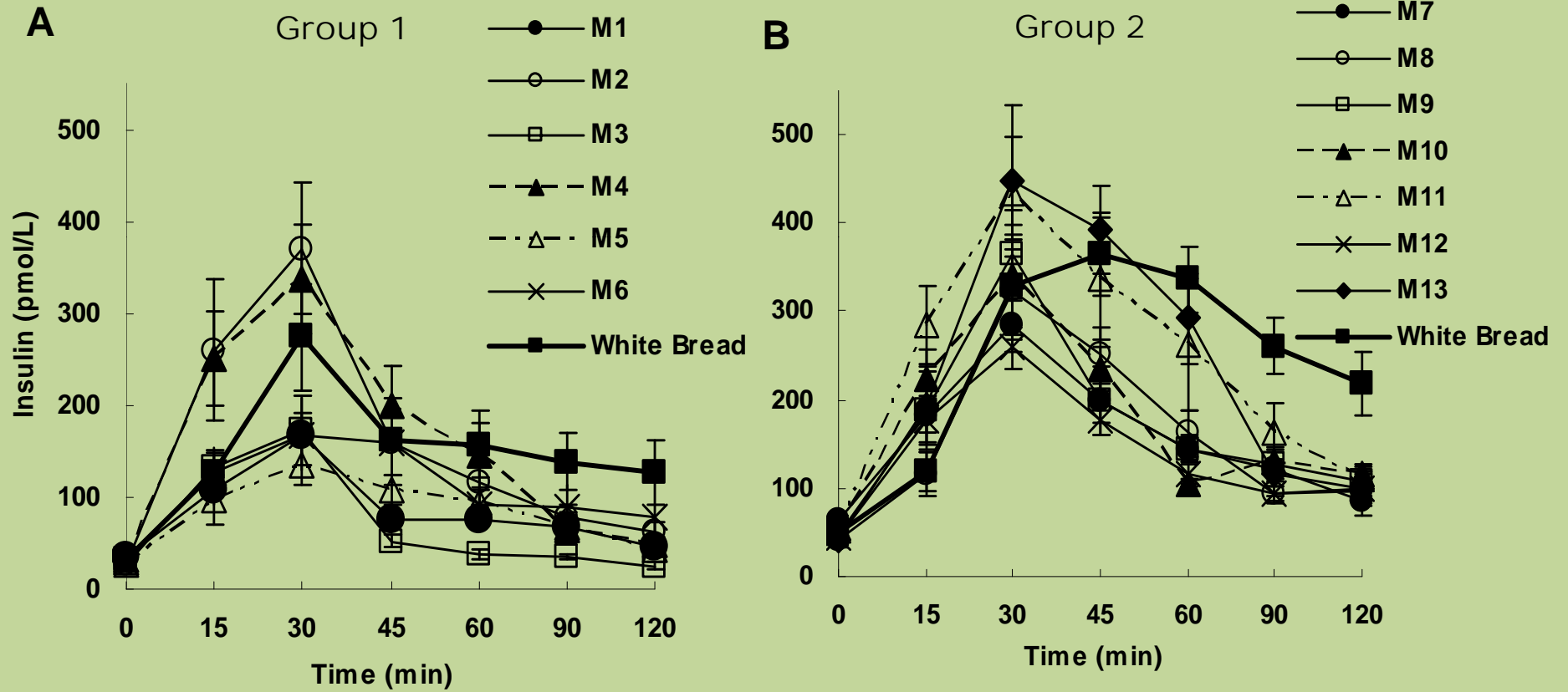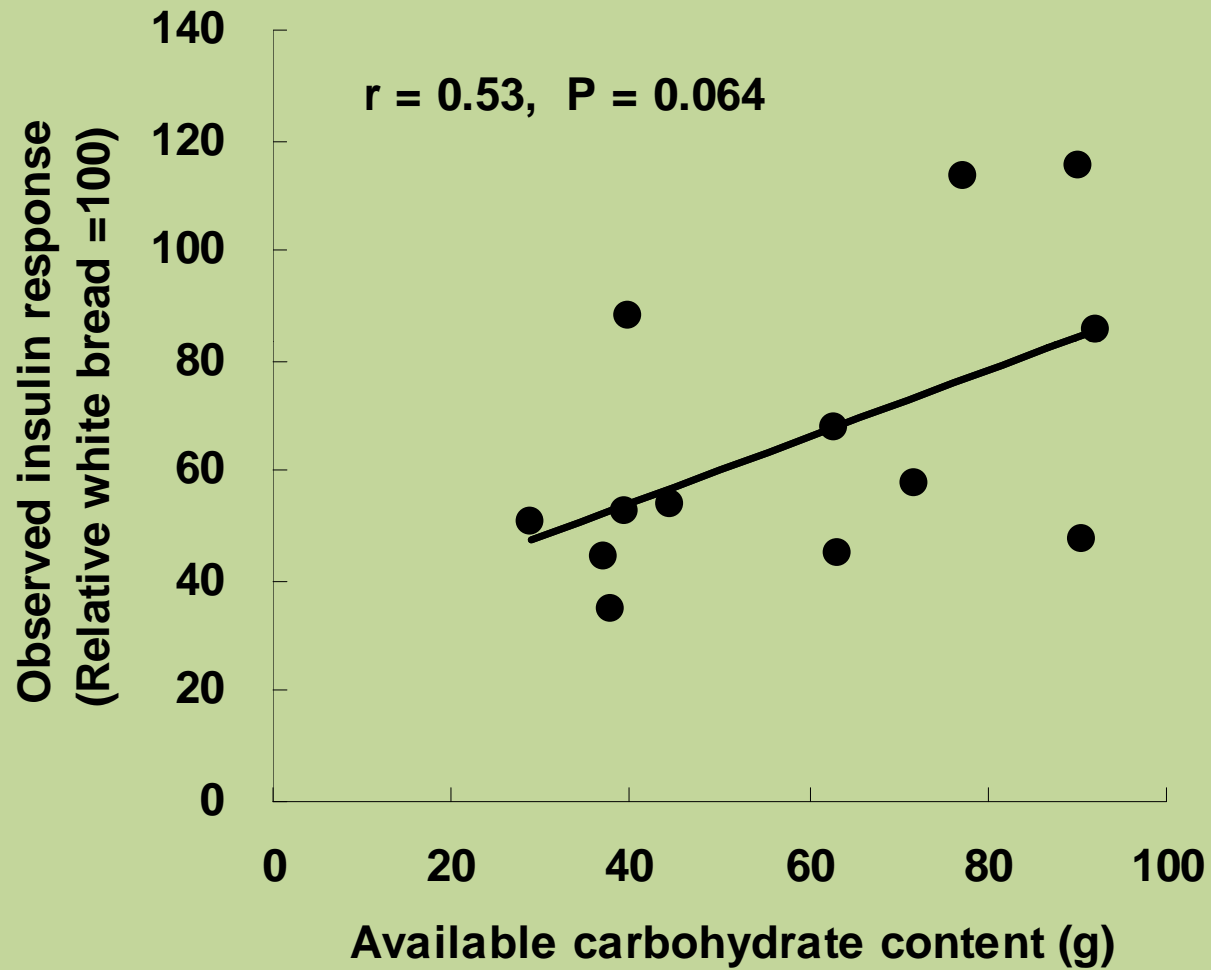

Bao J et al. Am J Clin Nutr 2009;90:986-992.

RESULTS: Correlations

Highest versus Lowest FII Values

- **Highest analyzed FII**

  Jelly Beans (120)

  Pancakes (112)

  Honeydew Melon (95)

  Potatoes (90)

  Breakfast Cereals (*70*-113)

- **Lowest analyzed FII**

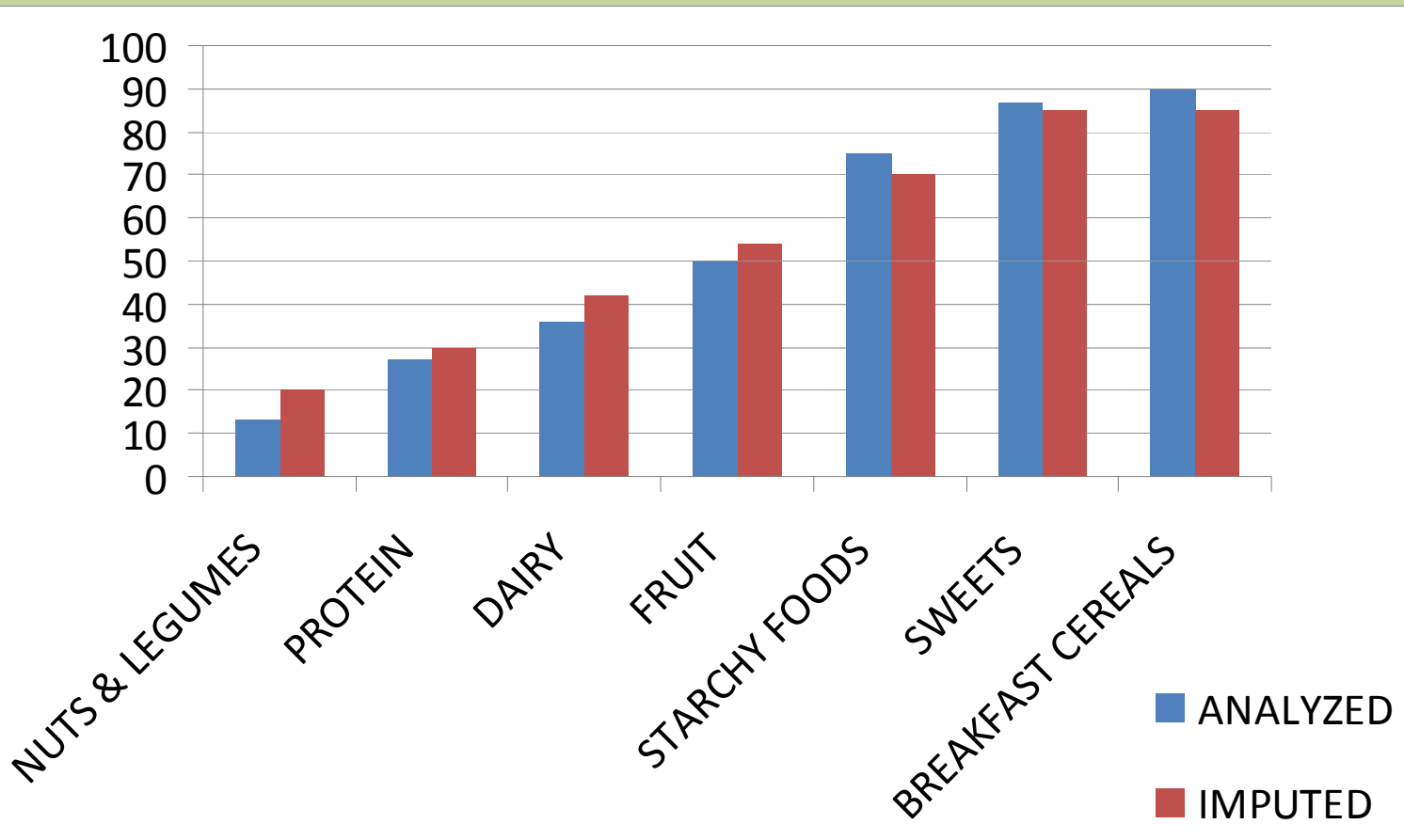 **Olive Oil (3)**

  Avocado (5)

  Walnuts (6)

  Tuna (16)

  Chicken (20)

MEAN ANALYZED VS MEAN IMPUTED FII DATA

LIMITATIONS

- **Although imputed FII data are similar to analyzed data, algorithms used for imputing FII have not been validated.**

- **FII variability within some food groups complicates the assignment of imputed values. For example, analyzed FII for dairy foods range from 18 for cream cheese to 86 for fruited yogurt.**

CONCLUSION

- **Most vegetables produce negligible insulin response, as measured by FII.**

- ***Even fats, and protein sources produce largely variable insulin responses, as measured by FII.***

- **Imputed FII values track closely to analyzed values.**

- **Refined cereals, sweets, and potatoes produce the greatest insulin response, as measured by FII.**

DERIVED INSULIN LOAD

Insulin Load, Glucose = (calories*FII)/100

- the individual average insulinogenic load (IL) during the past year was estimated from FFQs by multiplying the FII of each food by its energy content and the consumption frequency and summing over all reported food items.

DIETARY INSULIN INDEX, DII

The average dietary DII was calculated by dividing the average Insulin Load, IL, by the total daily energy intake.

RESULTS FROM COHORT STUDIES

MEN

- Median IL was 840

- Median DII was 41.7

WOMEN

- Median IL was 677

- Median DII was 42.7

TOP 8 FOODS CONTRIBUTING TO IL

MEN

Cold Cereal (6.1%)

Potatoes (5.7%)

Dark Bread (4.4%)

Skimmed Milk (3.2%)

Bananas (3.2%)

English Muffin (3.1%)

White Bread (2.9%)

Orange Juice (2.8%)

WOMEN

Mashed Potatoes (6.2%)

Skimmed Milk (5.7%)

Cold Cereal (5.3%)

Dark Bread (4.6%)

Beef (3.6%)

Yogurt (3.3%)

White Bread (3.1%)

English Muffin (2.7%)

TOP 4 FFQ ITEMS explaining the inter-individual variation of insulin load

MEN	**WOMEN**
49%	45%
LIQUOR	LIQUOR
COLD CEREAL	WINE
BEER	YOGURT
WINE	COLD CEREAL

COHORT STUDY RESULTS

In multivariate adjusted regression models, dietary II and IL were not significantly associated with plasma C-peptide.

Participants in the highest quintile of both II and IL had 26% higher triacylglycerol concentrations than participants in the lowest quintile (p_{trend} <0.0001).

The positive association between II and IL and plasma triacylglycerol was strongest in obese (BMI ≥30 kg/m^2) participants (difference highest versus lowest quintile in II = 72%, p_{trend}=0.01).

An inverse association between DII and HDL cholesterol was observed among obese participants (difference = -22%, p_{trend}=0.01 for II).

DII and IL were not associated with LDL cholesterol, CRP or IL-6.

CONCLUSION

DII and IL were not associated with markers of glycemic control, at least in the fasting state, but may be physiologically relevant to plasma lipids, especially in the obese.