

The Use and Biology of Energy Drinks:

Current Knowledge and Critical Gaps

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ENERGY DRINKS AND METABOLISM

The Effects of Caffeine and Energy Drinks on Skeletal Muscle Metabolism

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CIHR

Caffeine in energy drinks

Beginning in 2009, APNM has published 1 paper on EDs and 1 on Taurine.!

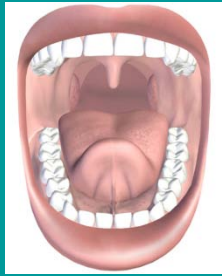
I will address caffeine with exercise and then in resting conditions but will focus on muscle

Will end with a few comments for taurine and also Vitamin B3

Serving 50 -200 mg

Physical 'energy' (power or endurance); mental 'energy' (alertness, reactions, mental errors), increased fat metabolism; weight loss; appetite suppression;

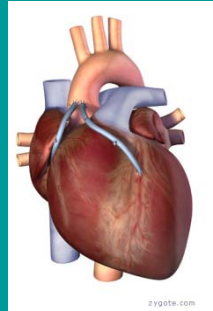
The Human



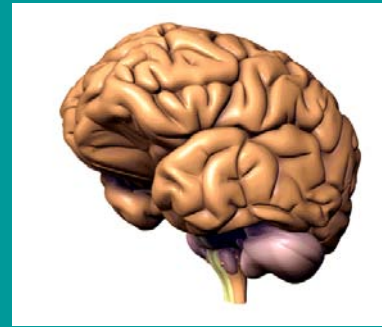
Mouth

MX absorption

Heart/Circulation



HR
BP
TPR



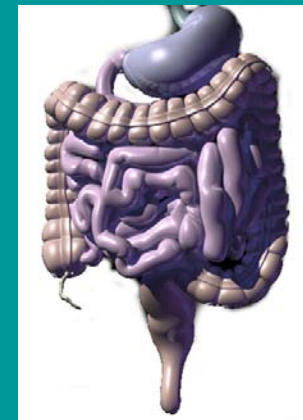
Brain

Dependence
Fatigue/arousal
Motor recruitment
SNS - epinephrine
- norepinephrine



Muscle

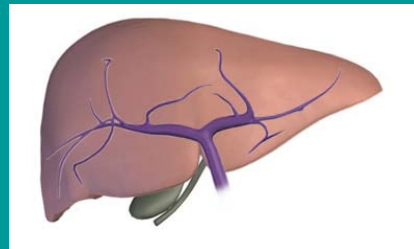
Contractility
Fat oxidation
Glycogen use
Insulin resistance



Gut

CHO absorption
incretins

Exercise



Liver

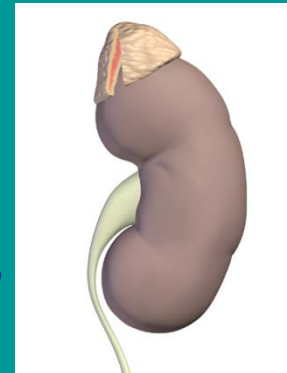
Glucose management
MX clearance

Adrenal

Epinephrine

Kidney/ Sweat Glands

Fluid loss

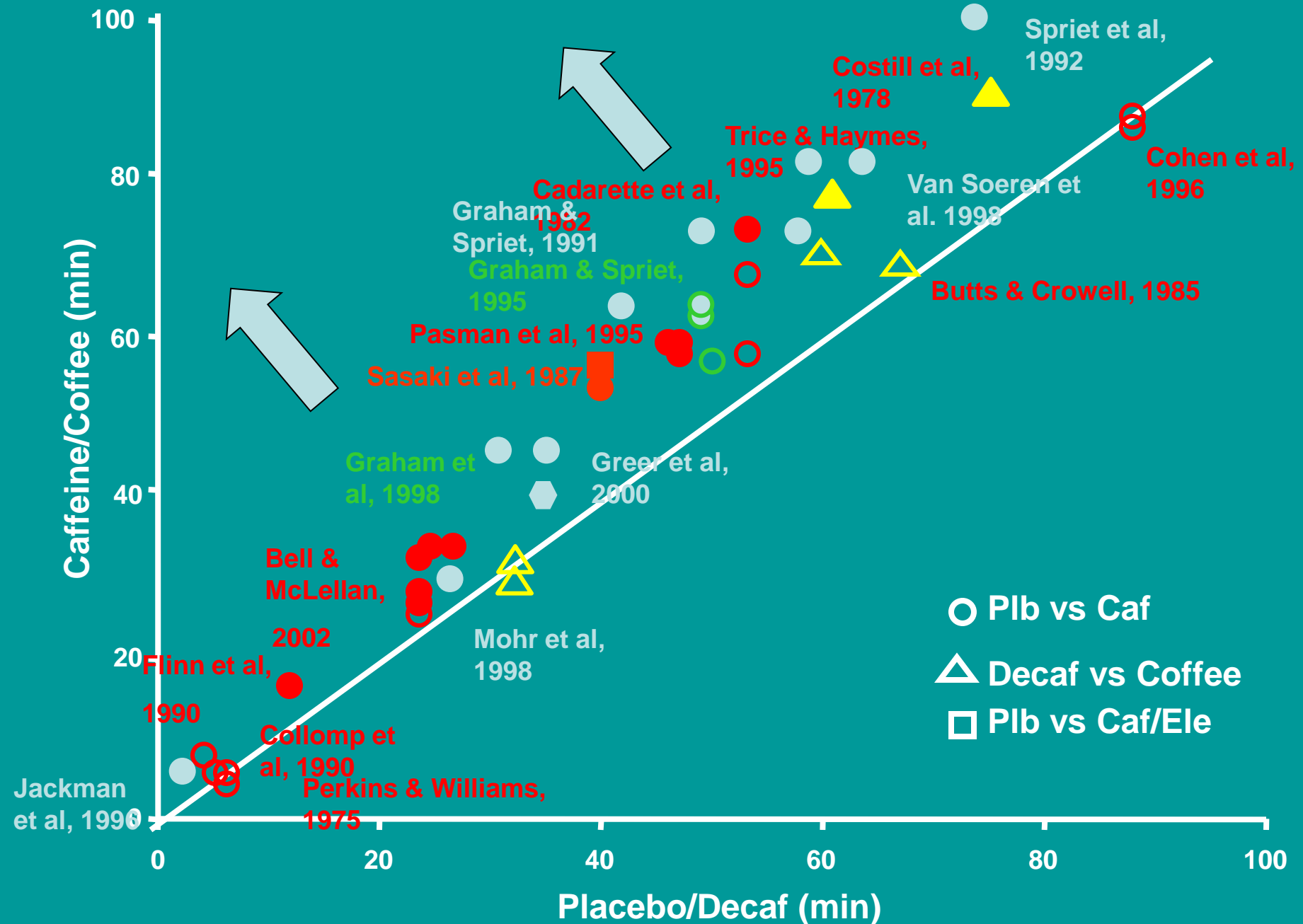


Adipose

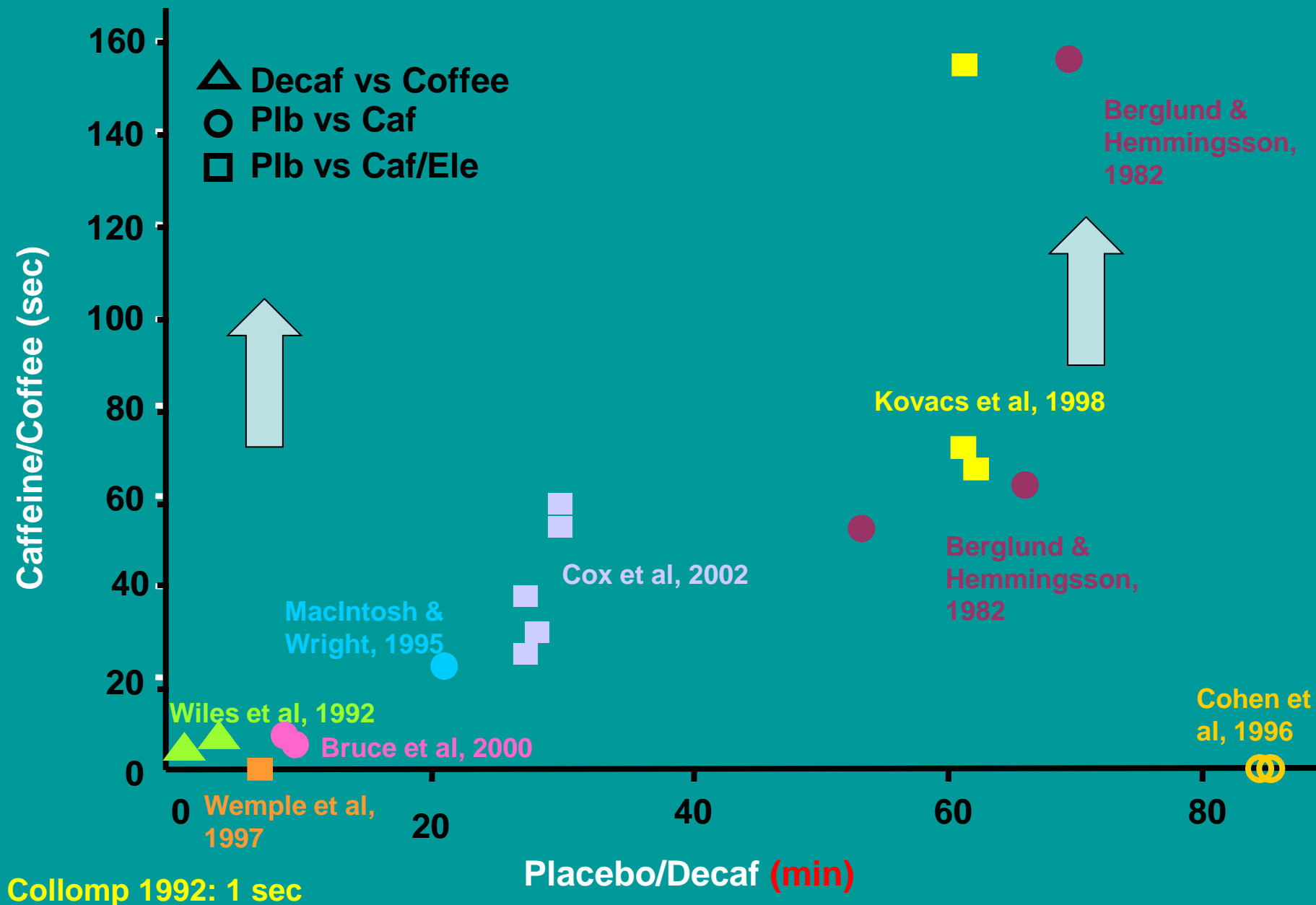
FFA mobilization



Effects of Caffeine on Endurance Times



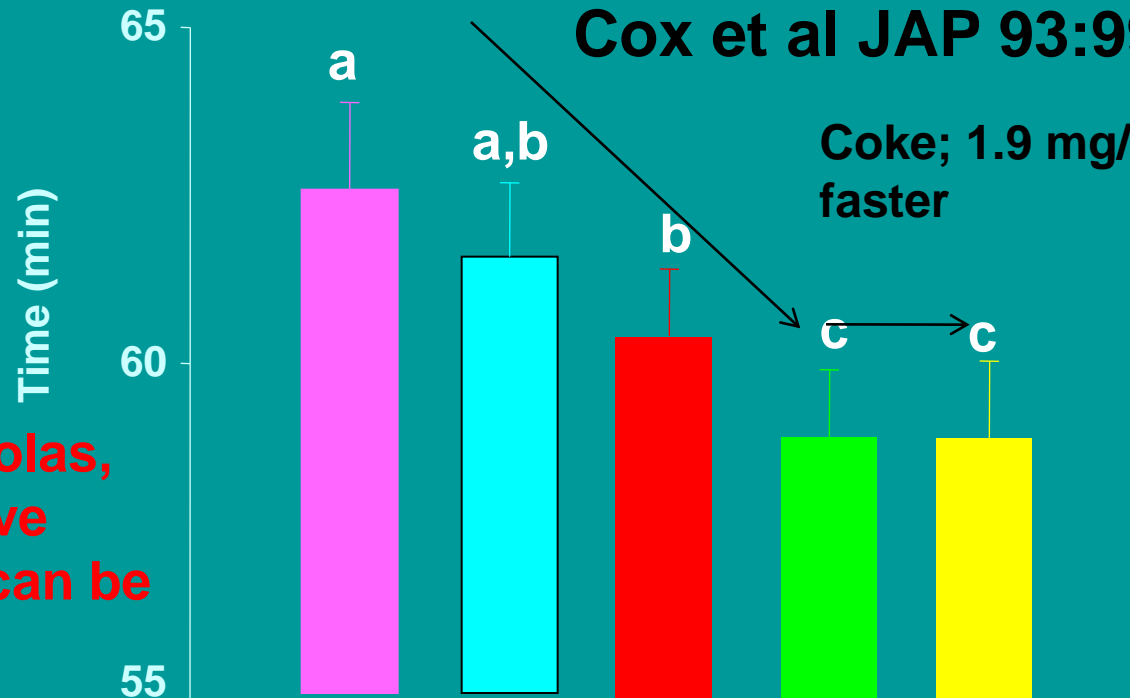
Effects of Caffeine on Performance



Sport drinks and Performance

Kovacs et al., *JAP* 82: 709-715, 1998

Ivy et al. 2009; **RB** 2.4
mg/kg; 64.5 min – 61.5 min



Cox et al *JAP* 93:990-999, 2002.

Coke; 1.9 mg/kg; 2.7%
faster

Sport drinks, colas,
EDs are effective
Caffeine dose can be
quite low

Avg power (W)

W
292
(10)

CES
295
(9)

+150
299
(10)

+225
308
(9)

+320
309
(10)

mg/l

if there is a dose
response it is
small

Caffeine dose (mg/kg)

0

0

2.1

3.2

4.5

What do we see in the blood?

- Increased FFA, epinephrine and lactate
- Little to no change in glucose and insulin
- **Does this reflect the metabolism of the active muscle?**

Does Caffeine increase fat oxidation and spare glycogen?

- Graham et al J Physiol 529:837-847, 2000.
- Direct Fick of leg plus biopsies
- No** difference in glycogen
- No** difference in glucose uptake
- No** difference in lactate release
- No** difference in muscle lactate
- No** difference in FFA uptake

Caffeine, exercise and stable isotopes

- Raguso et al. Metab 45:1153-1160, 1996.
Theo- **no** diff in RER or Ra or Rd for glycerol or FFA and **no** diff Ra for glucose but less Rd
- Roy et al Eur JAP 85:280-286, 2001.
- **No** diff RER; **no** diff in Ra or Rd for Glucose
- These are whole body measures
- **How could caffeine result in fat/weight loss?**

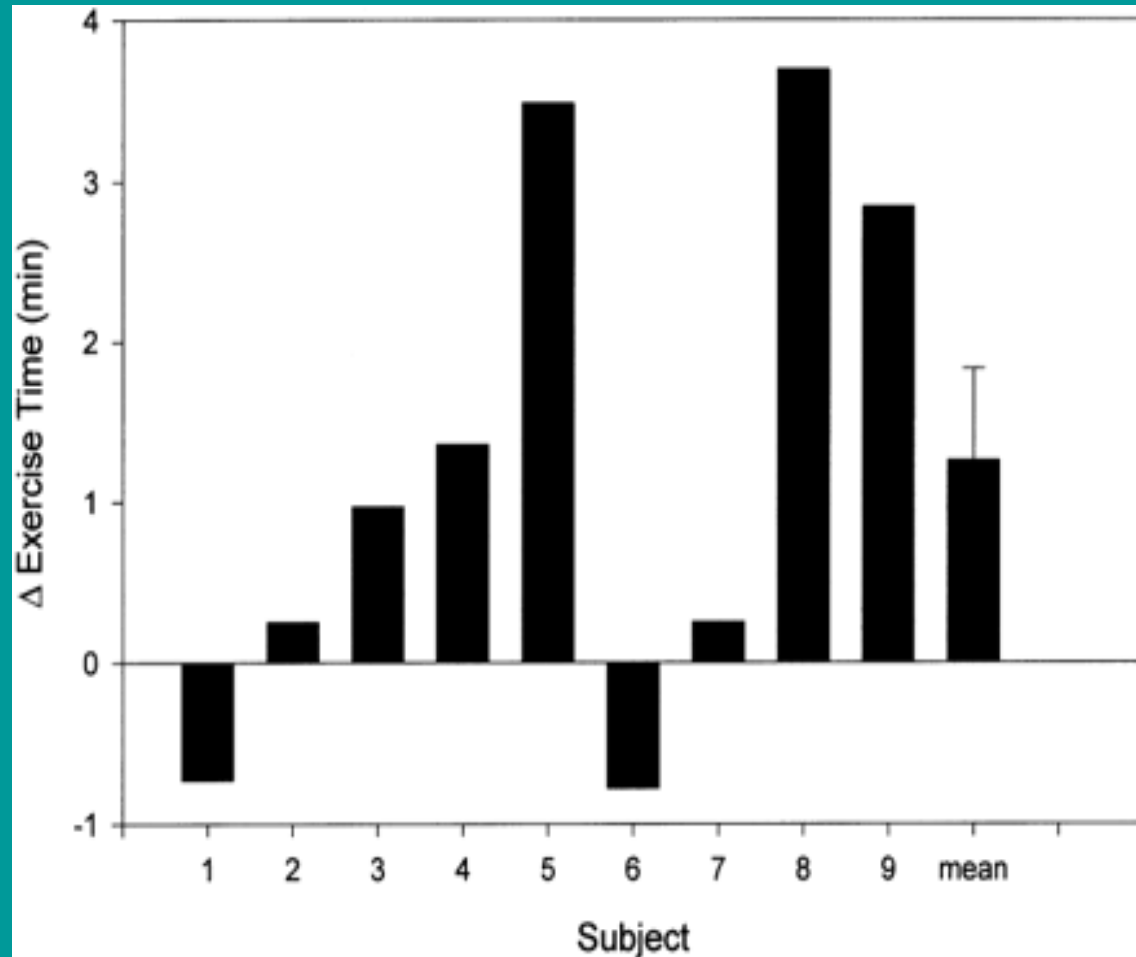
It is a rare study that reports a **decrease** in RER/RQ i.e. **increase** in fat oxidation

- Original support by Costill et al was convincing and based on RQ and muscle TG's
- Close examination of the data (Graham CJAP 26:S103-119, 2001) shows that quantitatively the TG data **can not be correct**. It is difficult to measure IM TG and they are energy dense.

Tetraplegic patients

Electric stimulation of muscles

So overall, to the relief of football and hockey players, one does not need a brain!



No role of CNS
No change in epi
Metabolism not limiting
So????

So what is critical?

Muscle can work harder or longer- but no change in 'maximum' output (**Note: training/health benefit**)

Effect is seen in wide range of circumstances (**sec to hours**)

If there is ONE mechanism, then it must be a fundamental aspect

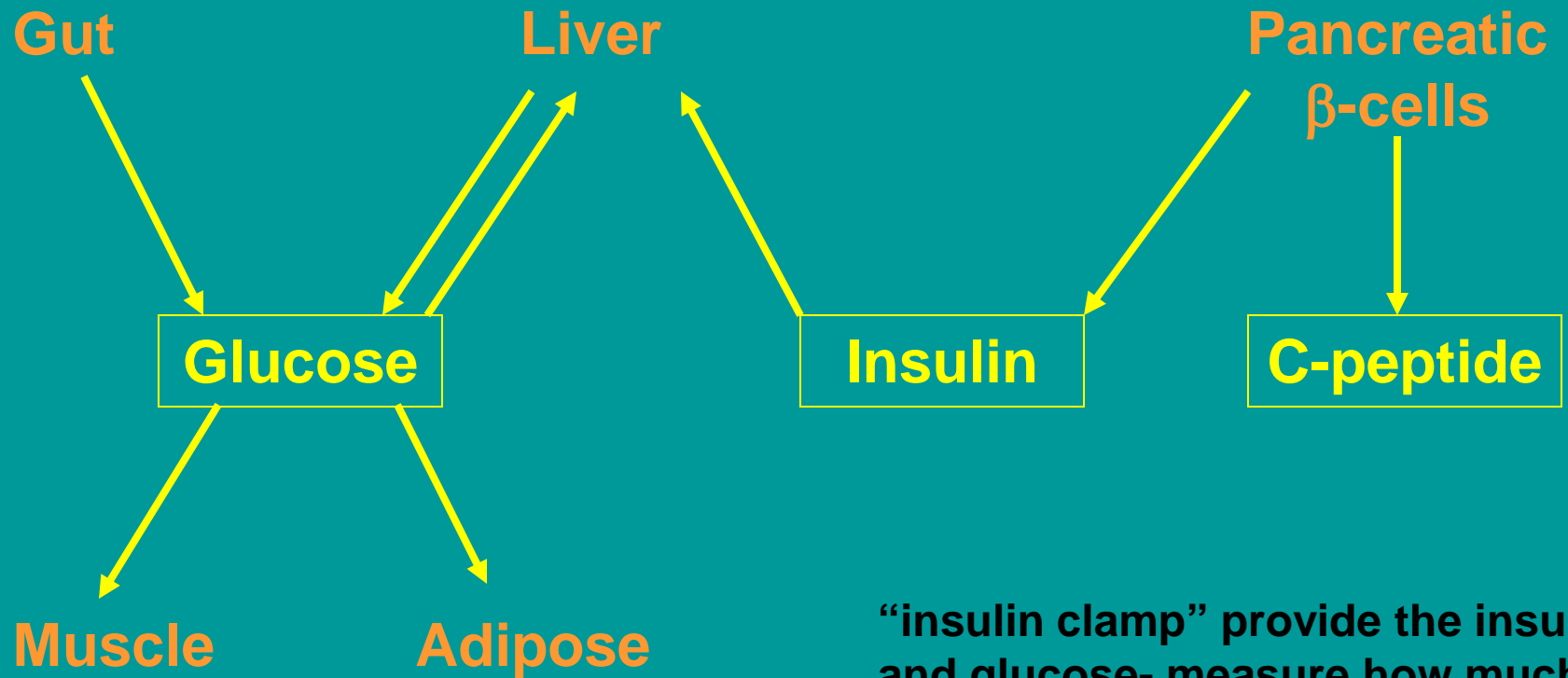
CHO/Fat metabolism do not appear to be altered

Blood flow not altered

CNS not essential

Ca²⁺

At rest: Caffeine plus CHO results in high blood glucose.
WHY?



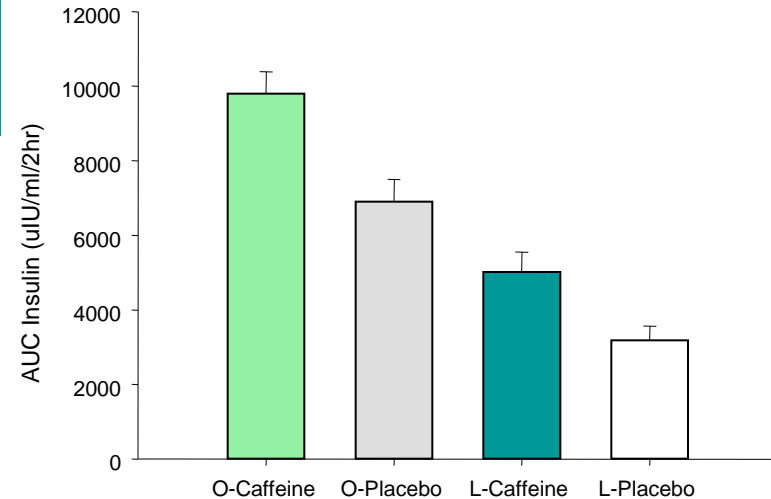
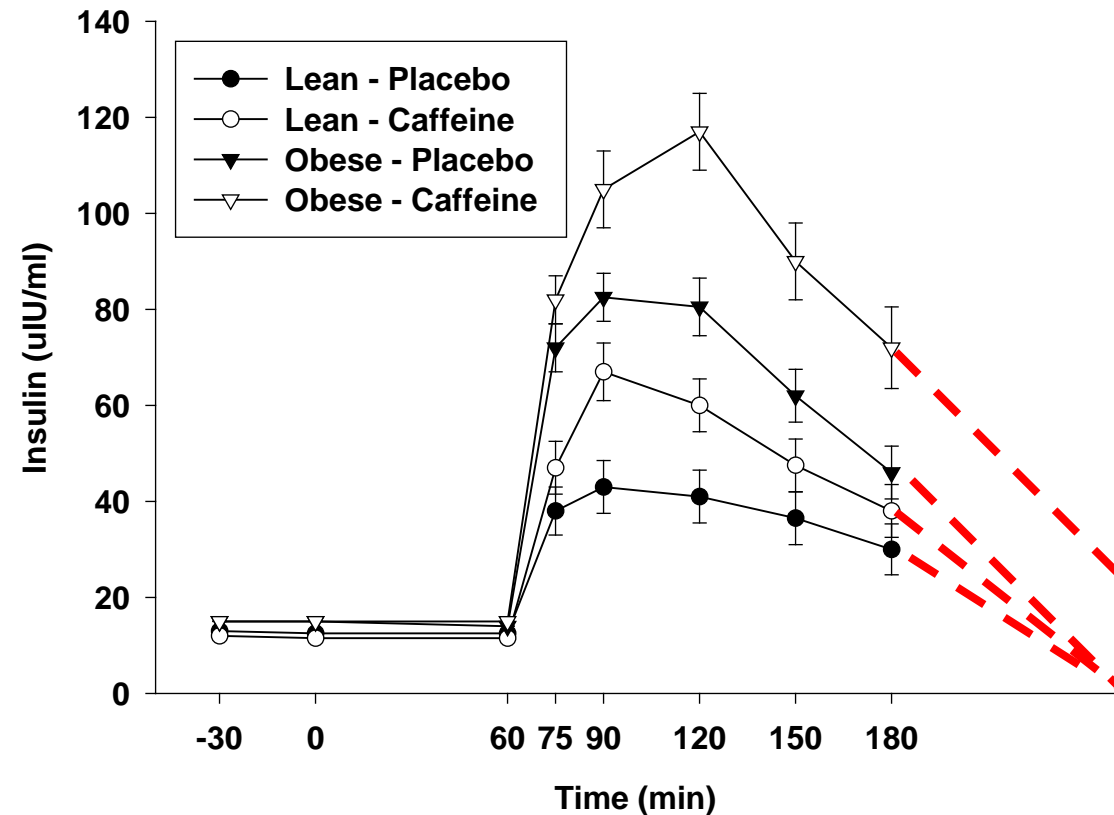
“insulin clamp” provide the insulin and glucose- measure how much glucose is ‘used’ for a given insulin

Oral glucose tolerance test: give set amount of glucose orally and measure blood glucose and insulin

Caffeine plus CHO results in high blood glucose.

WHY?

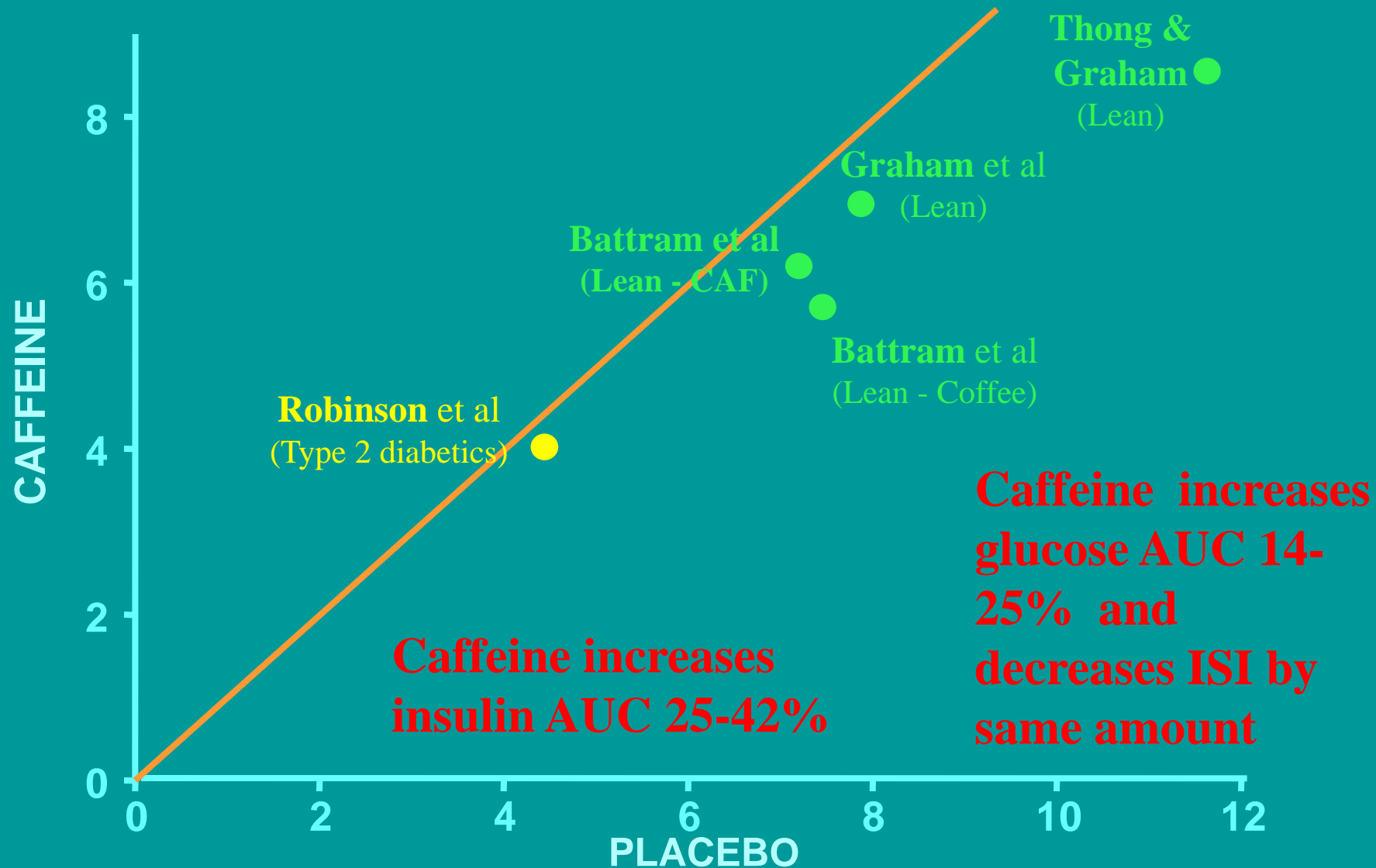
The high glucose not
due to low insulin!



The subjects are
resistant to the insulin!

Insulin Levels for an OGTT on Lean &
Obese Subjects

Insulin Sensitivity Index* for Various Studies During Placebo and Caffeine Trials

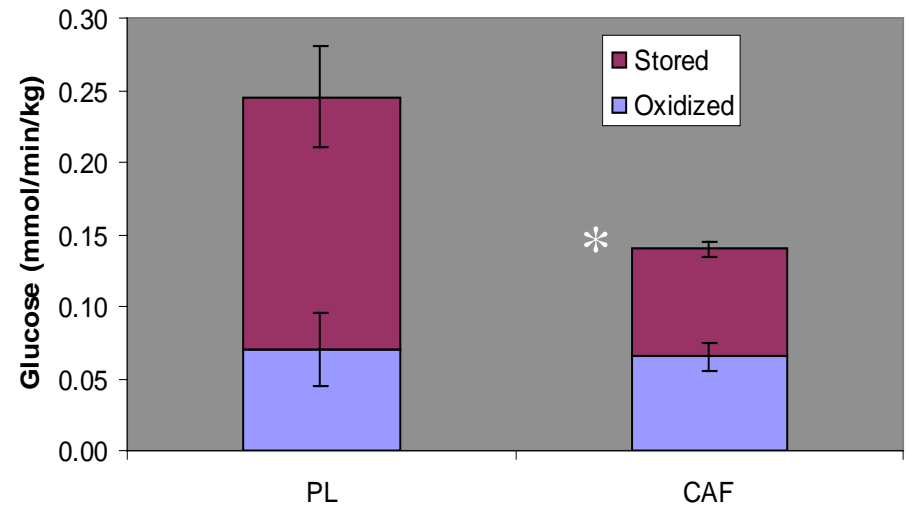
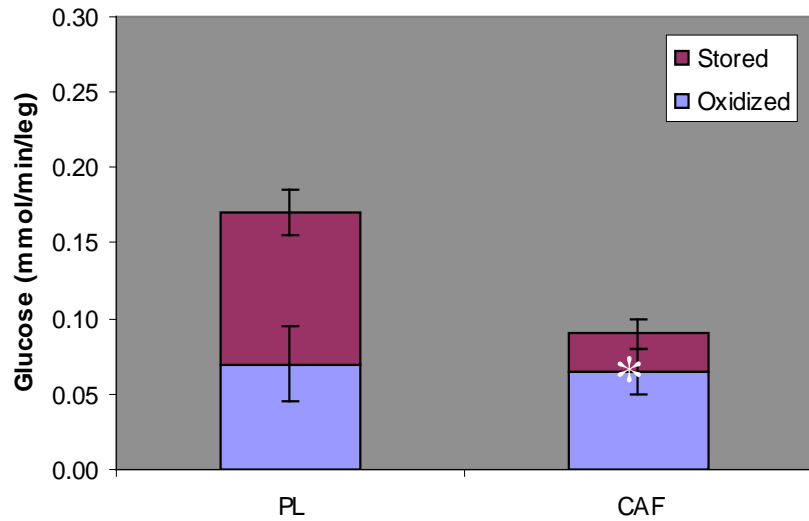


* Index calculation reference: Matsuda & De Fronzo. *Diabetes Care* 22:1462, 1999.

Resting leg

'Clamp Studies'

Exercised leg

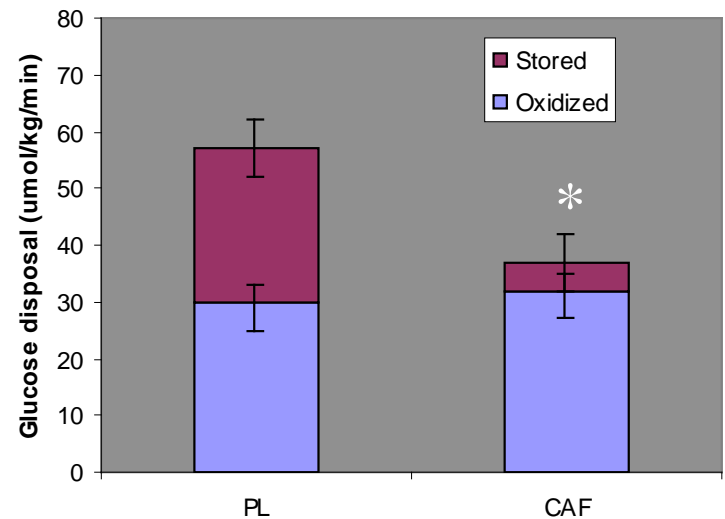


caffeine decreased insulin-mediated but **not** exercise-mediated glucose uptake

Muscle is the major tissue storing CHO postprandially

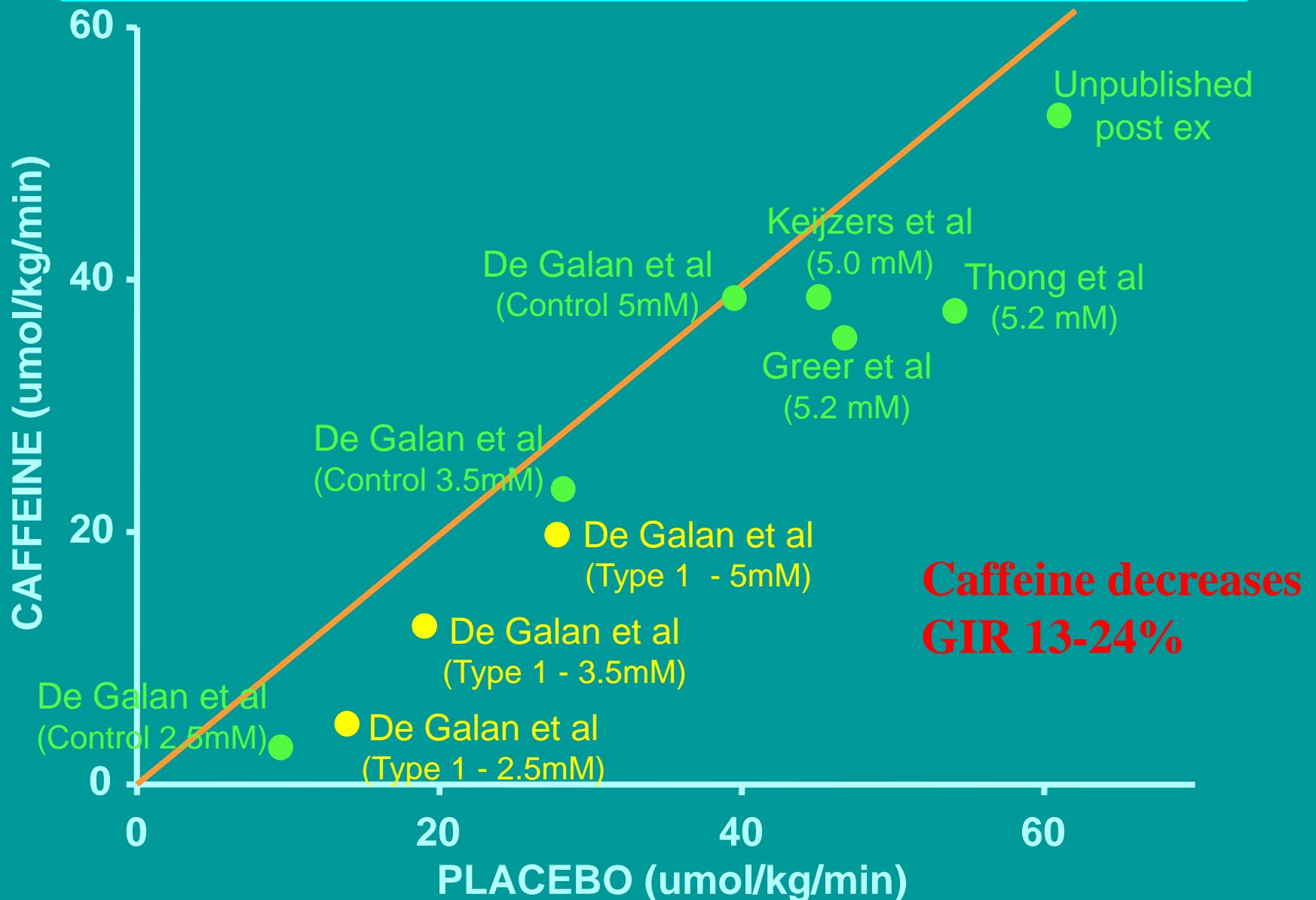
Less glucose taken up for a given insulin and of this amount, less is stored, but oxidation is not effected!

Whole Body (post 1-leg exercise)



Thong et al. *Diabetes*
51:583, 2002.

Infusion Rates for Various Clamp Studies During Placebo and Caffeine Trials



Subjects and conditions

- **CAFFEINE/COFFEE**
- Men/women; young/mature; lean/obese; type 2 diabetic
- Low and high GI cereal
- First and second meal
- With/without ingestion of fat
- **Pregnant women** –GDM
- **Tetraplegics**

B vitamins?

Most health benefits of vitamins etc. are for deficiencies and are found with **systemic long term supplementation**

B vitamins are water soluble – readily excreted

B3/Niacin/nicotinic acid: can inhibit adipose tissue mobilization of FFA

Therapeutic doses (100 mg- 1g/d) nicotinic acid, GPR109A receptor binding and cAMP/inhibition of lipolysis

Typical serving 10-40 mg

Stellingwerff et al Am J Physiol Endocrinol Metab 284: E589–E596, 2003
20 mg/kg bm (70 kg person = 1400 mg) one hour before exercise)~65% VO₂max
fasted [FFA] decreased from ~0.5 mM to ~0.2 mM
stayed very low during exercise (<0.1 mM); CHO oxidation increased 15%

Terry speculation: no effects on muscle metabolism at this low dose

Taurine?

Putative roles: osmotic reg; Ca²⁺ handling; antioxidant;

Typical serving 10-2000 mg

studies: few; descriptive; performance and/or crude measures of short term oxidative stress

Does it get into circulation? Yes.

Where does it go?

Blood and muscle biopsy measures:

Muscle concentration: 40-50 mmol/kg dw (25-35% of TAA 170-180 mmol/kg dw)

plasma concentration: 10-40 umol/l (1-% of Total AA 1050 umol/l)

Femoral A-V : 1-2 umol/l (rest and exercise)

Terry speculation: no effects and/or very transient effects with muscle and some health claims would likely need chronic treatments

conclusions

- We know little about muscle metabolism and energy drinks
- Based on studies of each ingredient, EDs **likely increase** physical endurance
- EDs **likely do not** alter fat or CHO metabolism
- EDs **likely** result in periods of insulin resistance in muscle

GAPS/important questions:

- 1- what are the metabolic responses and what are the **'active'** ingredients?
- 2- Who responds? **Age, sex, medical conditions?**
- 3- What are the acute vs chronic effects of these responses? **Endurance/performance vs wt loss, insulin resistance**
- 4- are any responses **beneficial?**
(training)
- 5- are any responses **negative? (insulin resistance)**

- **Whole Body and Tissue-Specific Effects of Energy Drinks on Metabolism: Beyond Skeletal Muscle**
- *Jane Shearer* — University of Calgary