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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Caffeine in energy drinks

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

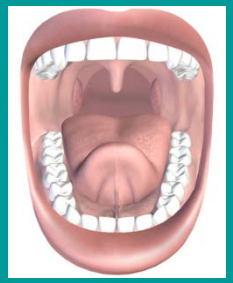
I will address caffeine with exercise and then in resting conditions but will focus on muscle

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



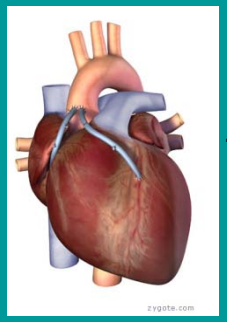
Mouth

MX absorption

Brain

Dependence
Fatigue/arousal
Motor recruitment
SNS - epinephrine
- norepinephrine

Heart/Circulation

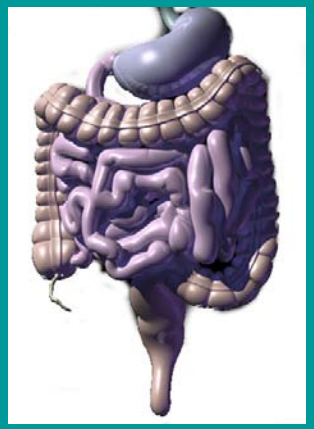


HR
BP
TPR

Muscle

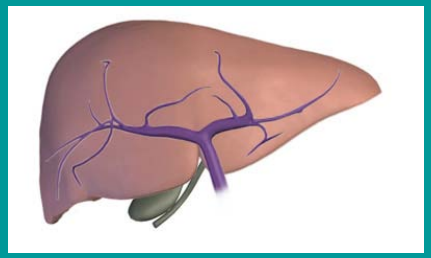
Contractility
Fat oxidation
Glycogen use
Insulin resistance

Exercise



Gut

CHO absorption
incretins



Adipose

FFA mobilization

Liver

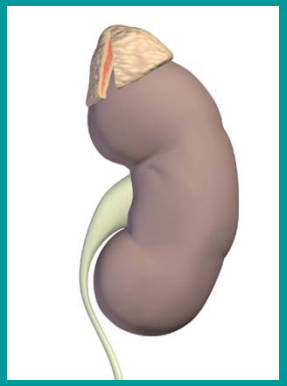
Glucose management
MX clearance

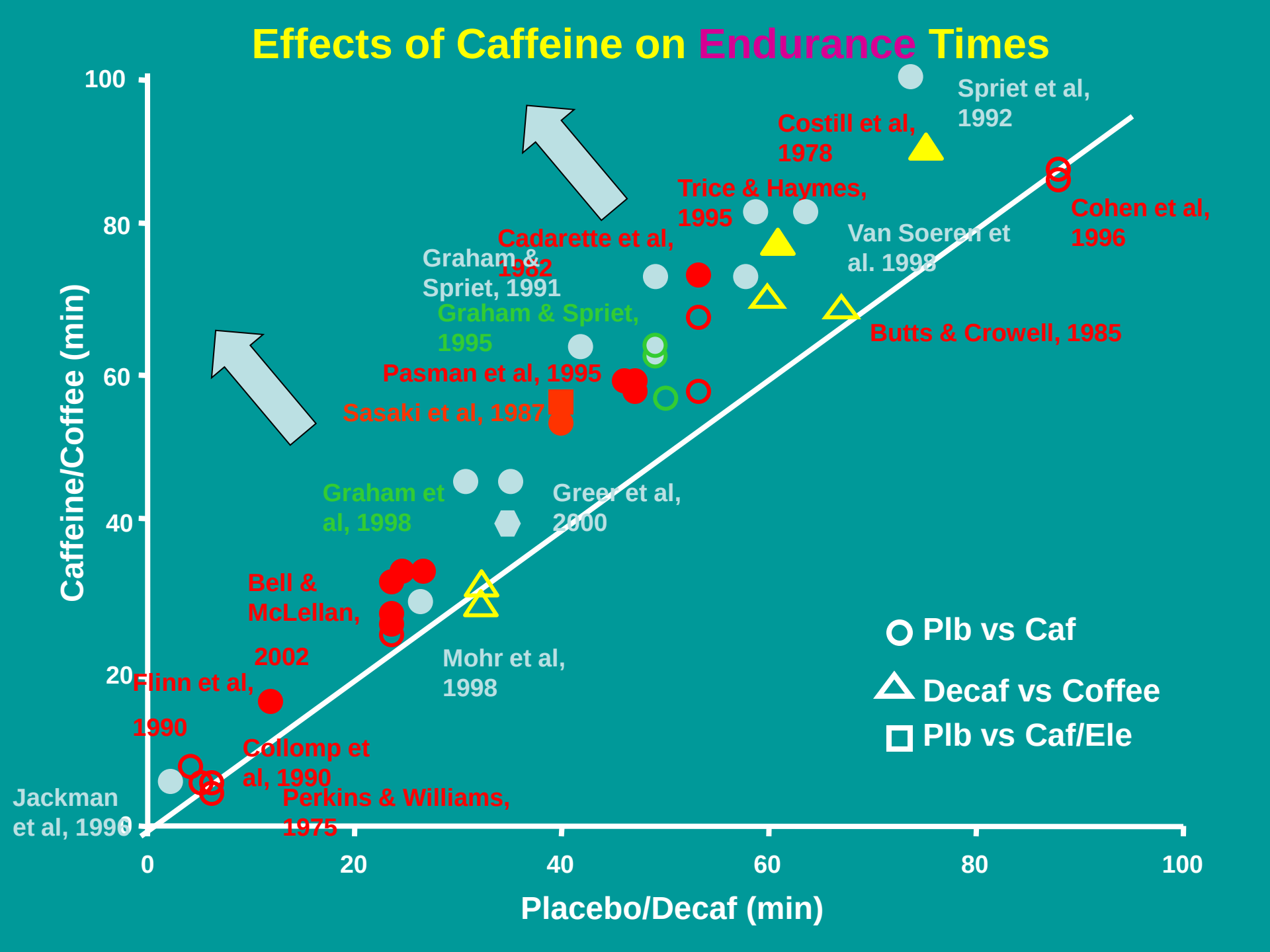
Adrenal

Epinephrine

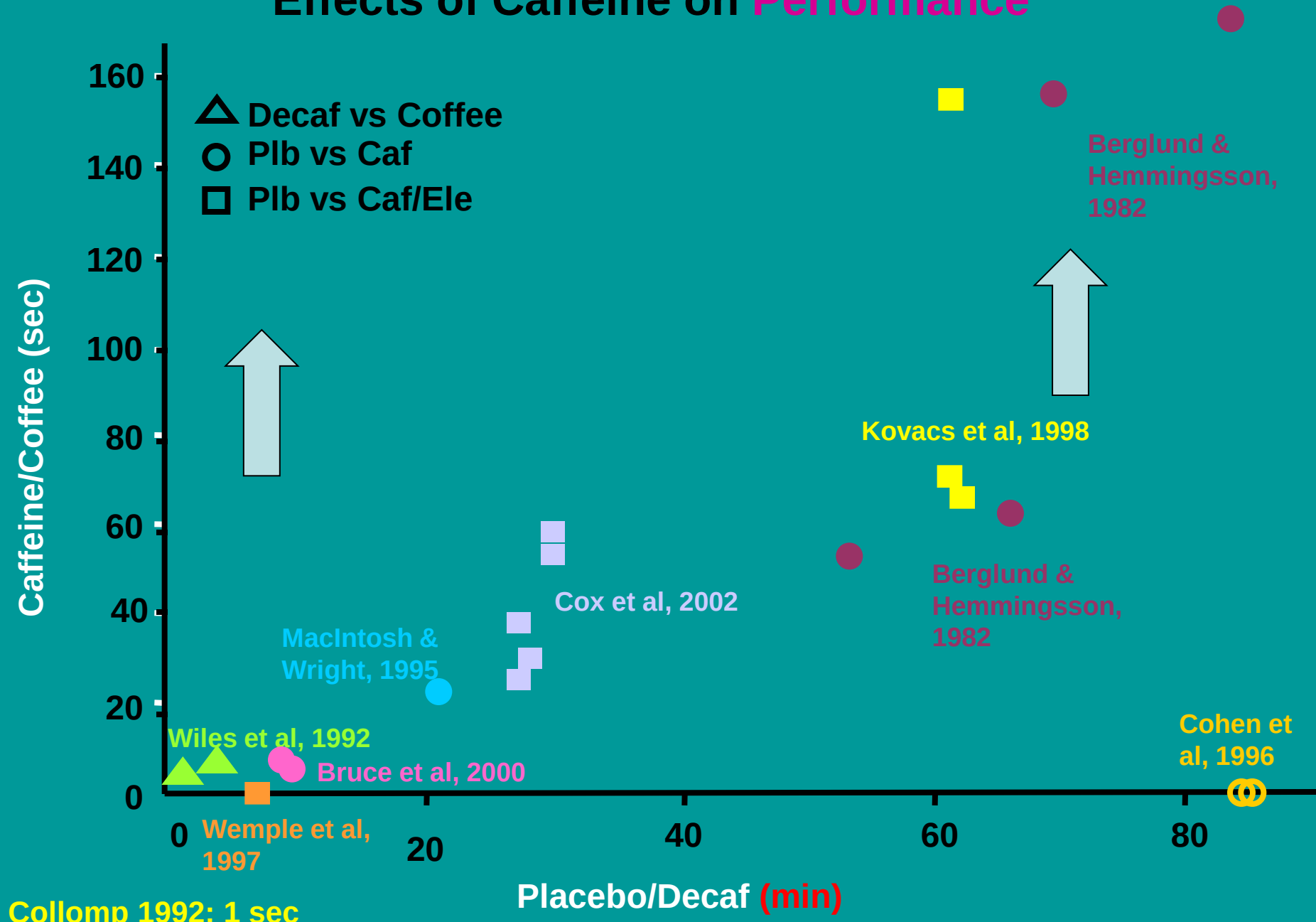
Kidney/ Sweat Glands

Fluid loss




Effects of Caffeine on Endurance Times
Caffeine/Coffee (min)
Placebo/Decaf (min)
0
20
40
60
80
100
Spriet et al, 1992
Costill et al, 1978
Trice & Haymes, 1995
Cohen et al, 1996
Van Soeren et al. 1998
Cadarette et al, 1982
Graham & Spriet, 1991
Graham & Spriet, 1995
Butts & Crowell, 1985
Pasman et al, 1995
Sasaki et al, 1987
Graham et al, 1998
Greer et al, 2000
Bell & McLellan, 2002
Mohr et al, 1998
Flinn et al, 1990
Collomp et al, 1990
Jackman et al, 1990
Perkins & Williams, 1975
Plb vs Caf
Decaf vs Coffee
Plb vs Caf/Ele

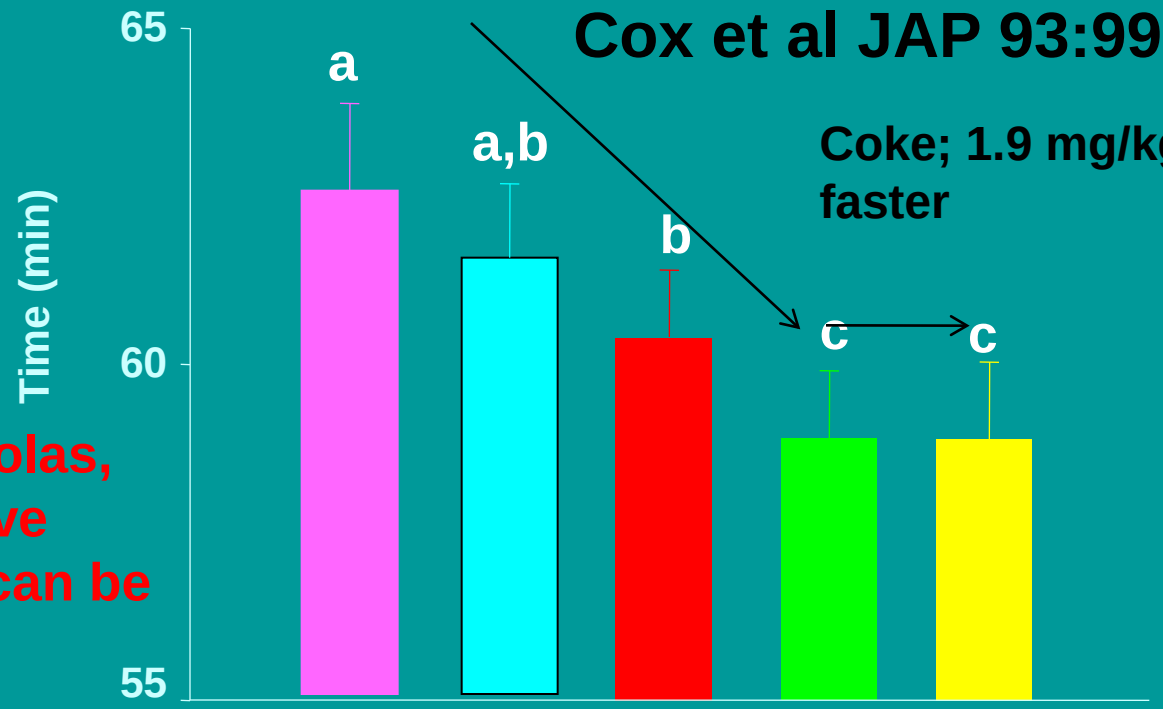
Effects of Caffeine on Performance



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

	W	CES	+150	+225	+320	mg/l
Avg power (W)	292 (10)	295 (9)	299 (10)	308 (9)	309 (10)	
Caffeine dose (mg/kg)	0	0	2.1	3.2	4.5	

if there is a dose response it is small

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?**

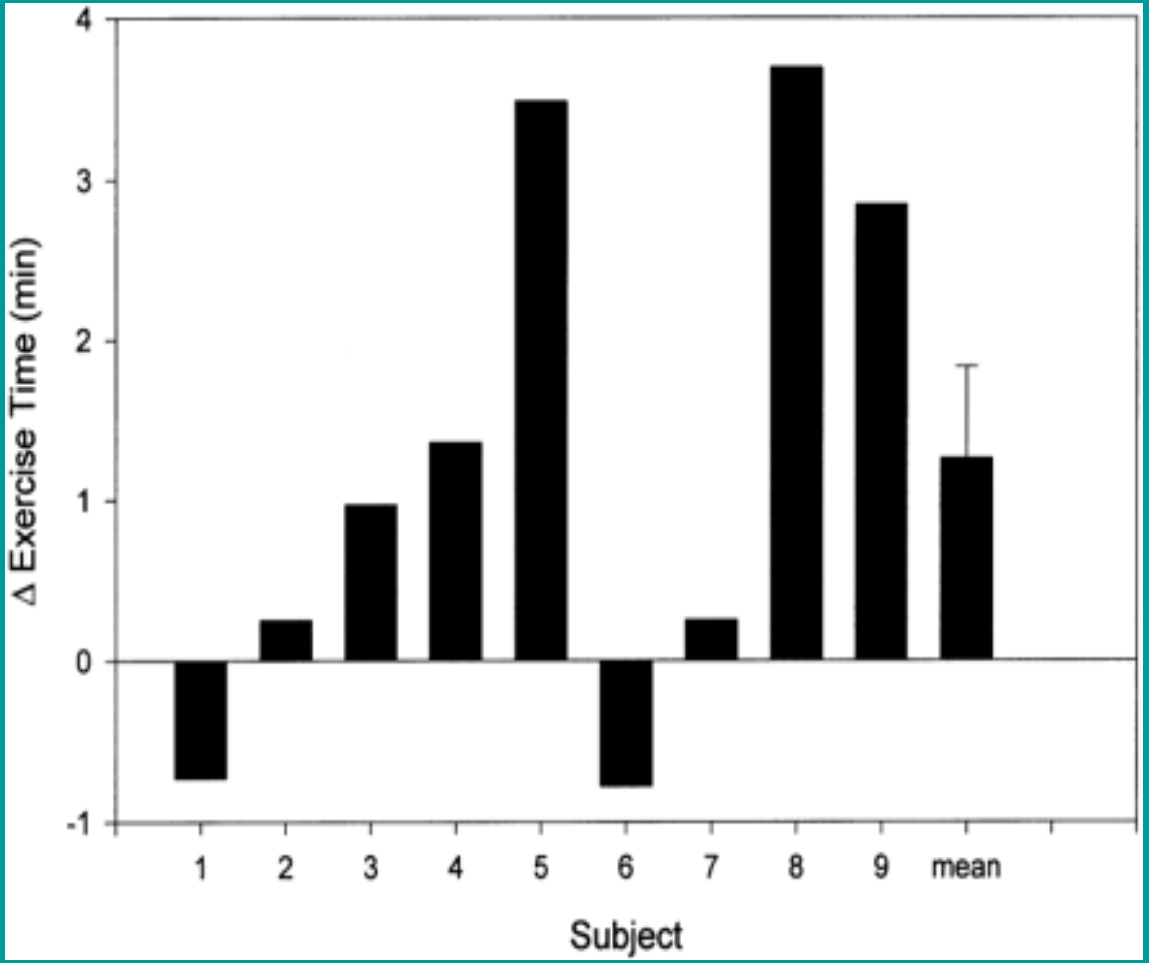
It is a rare study that reports a **decrease** in RER/RQ i.e. **increase in fat oxidation**

- 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????

Mohr et al JAP 85:979-985, 1998

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

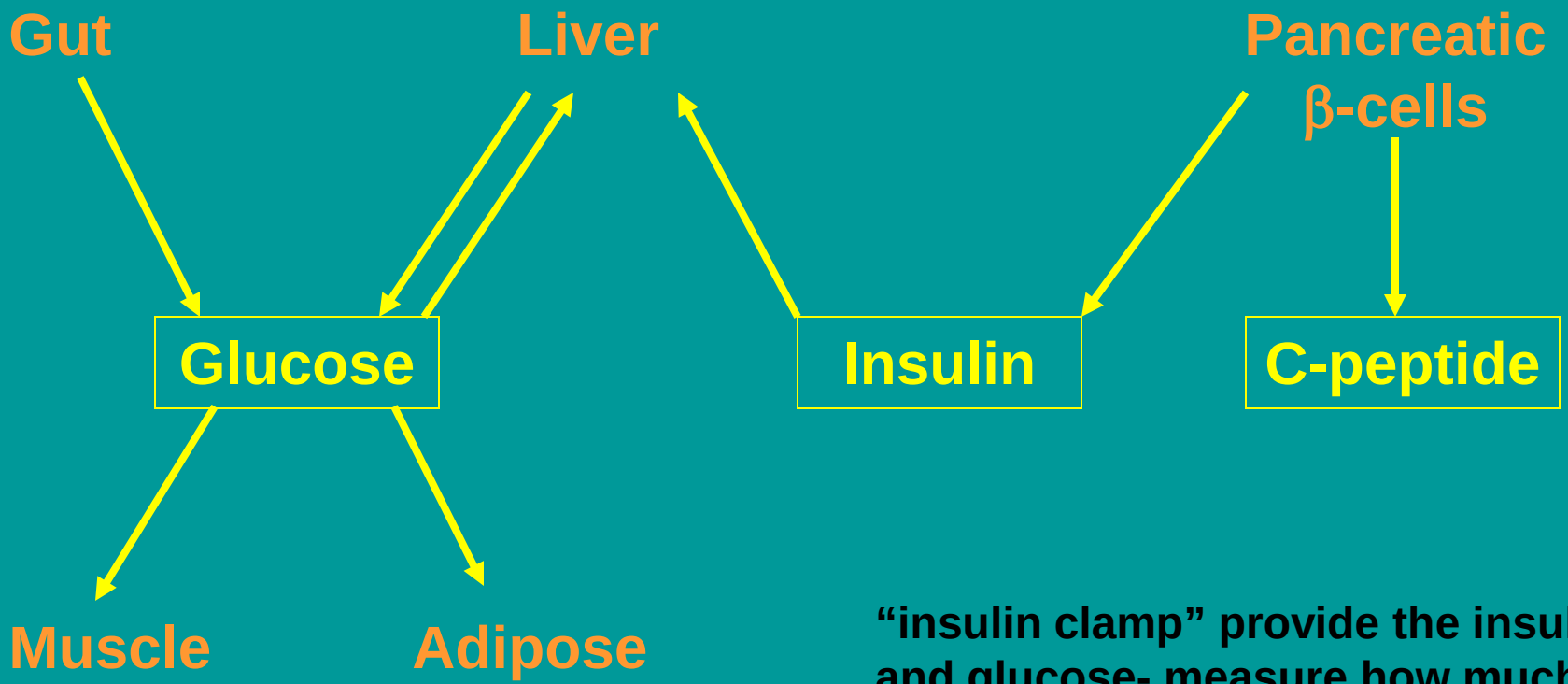
Blood flow not altered

CNS not essential

Ca^{2+}

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

WHY?



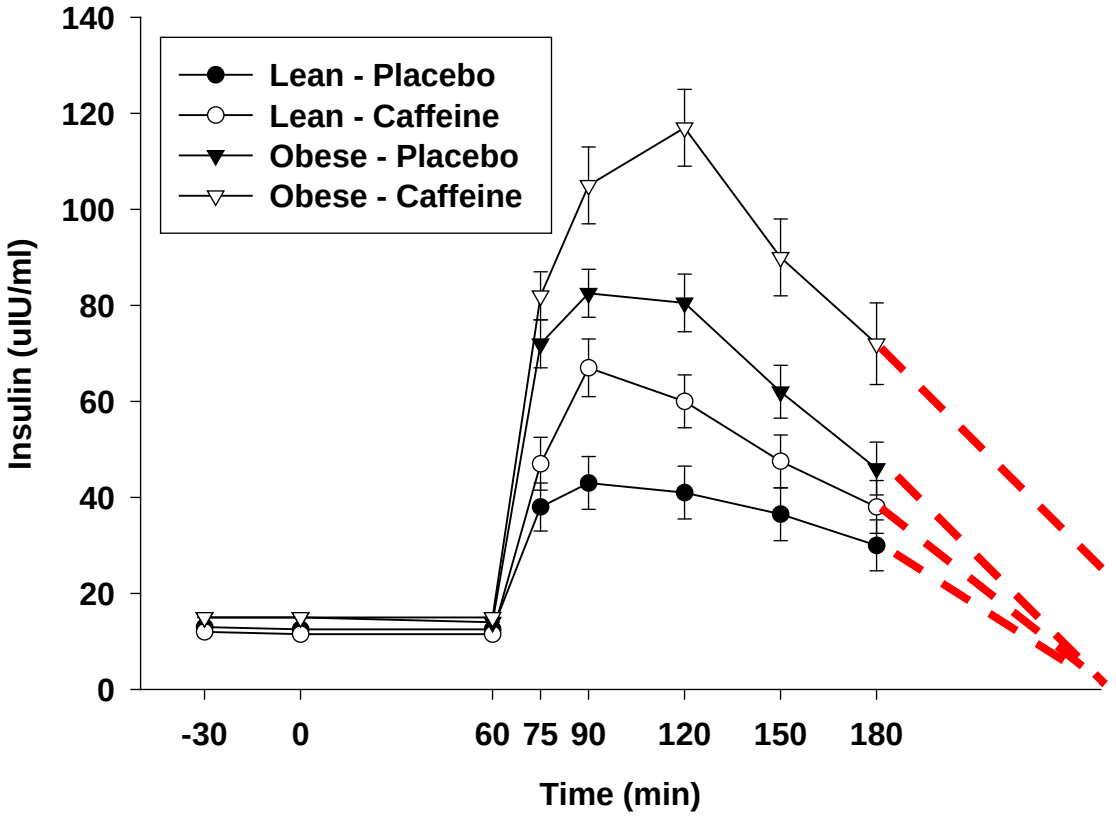
"insulin clamp" provide the insulin and glucose- measure how much glucose is 'used' for a given insulin

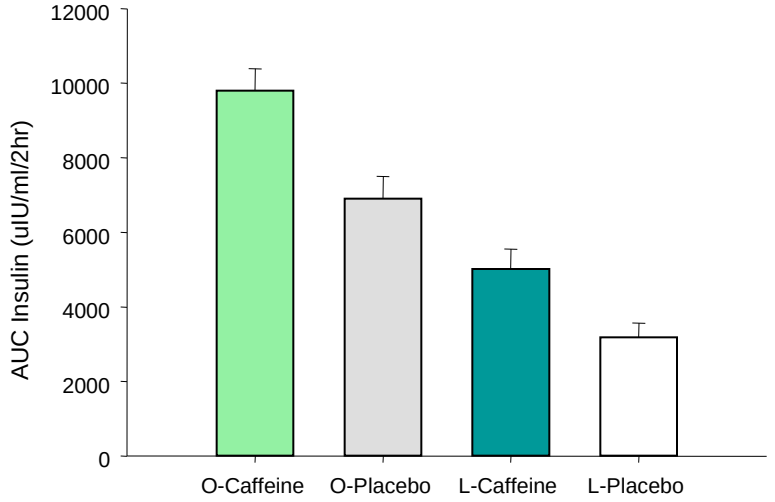
Oral glucose tolerance test: give set amount of glucose orally and measure blood glucose and insulin

Caffeine plus CHO results in high blood glucose.

WHY?

The high glucose not due to low insulin!

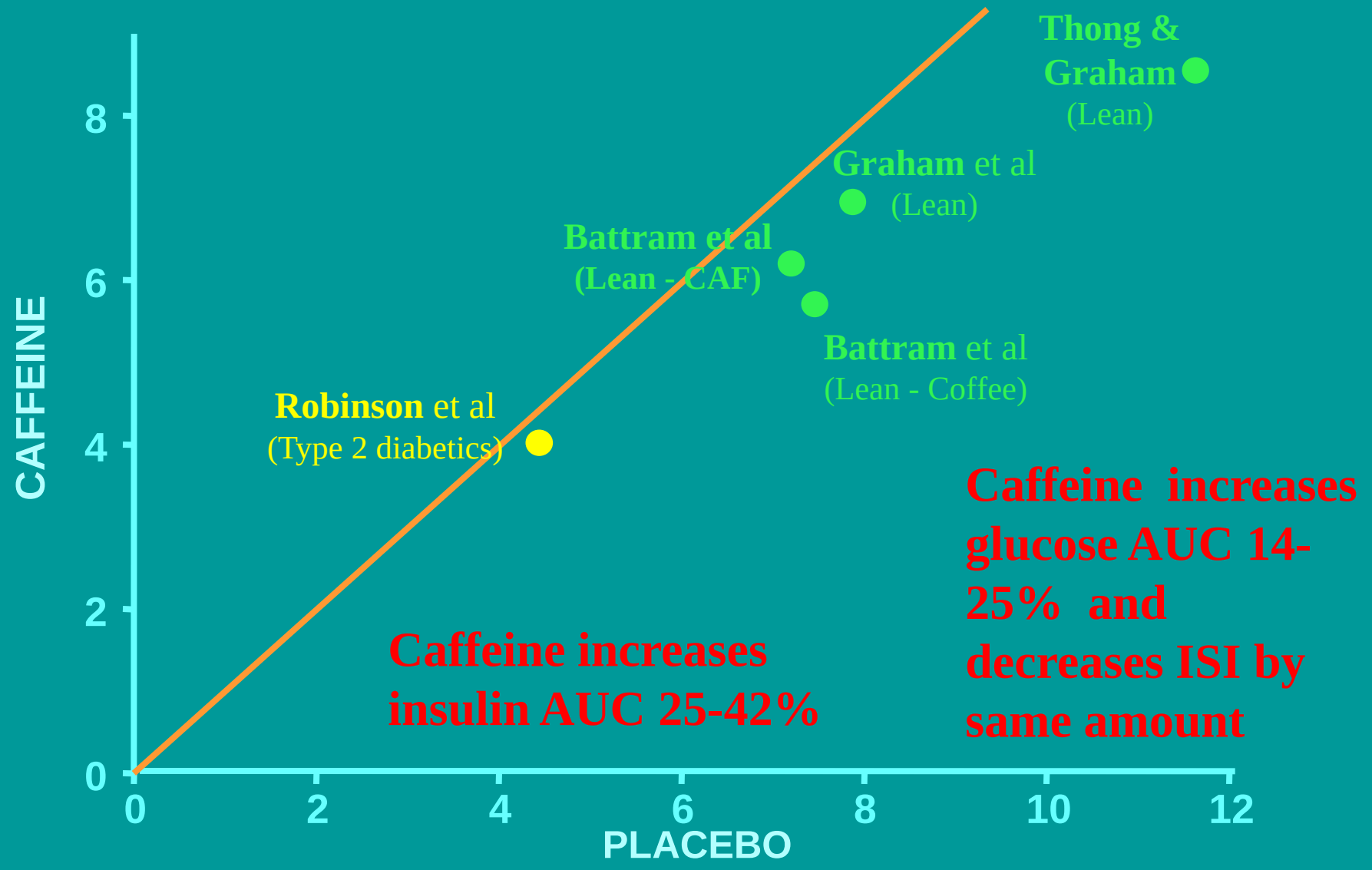




The subjects are resistant to the insulin!

Insulin Levels for an OGTT on Lean & Obese Subjects

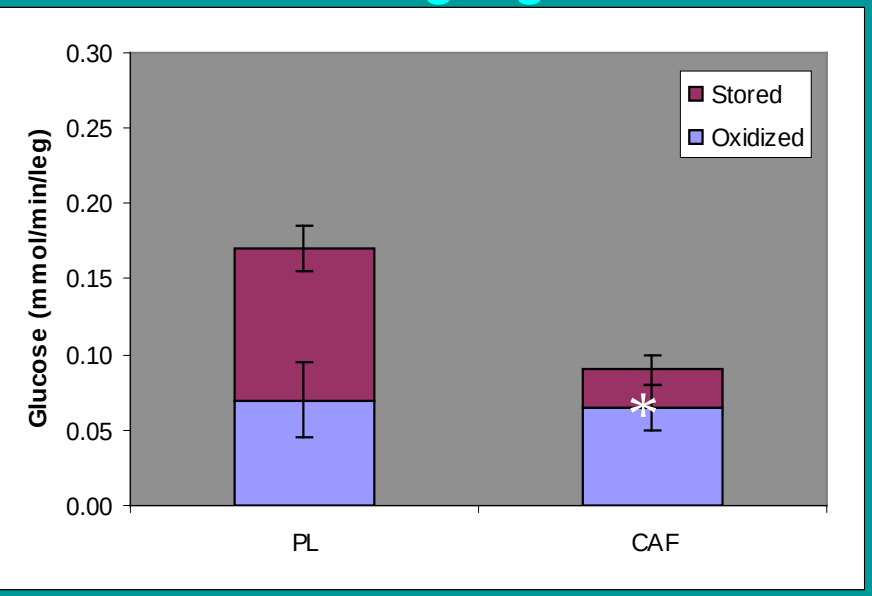
Insulin Sensitivity Index* for Various Studies During Placebo and Caffeine Trials



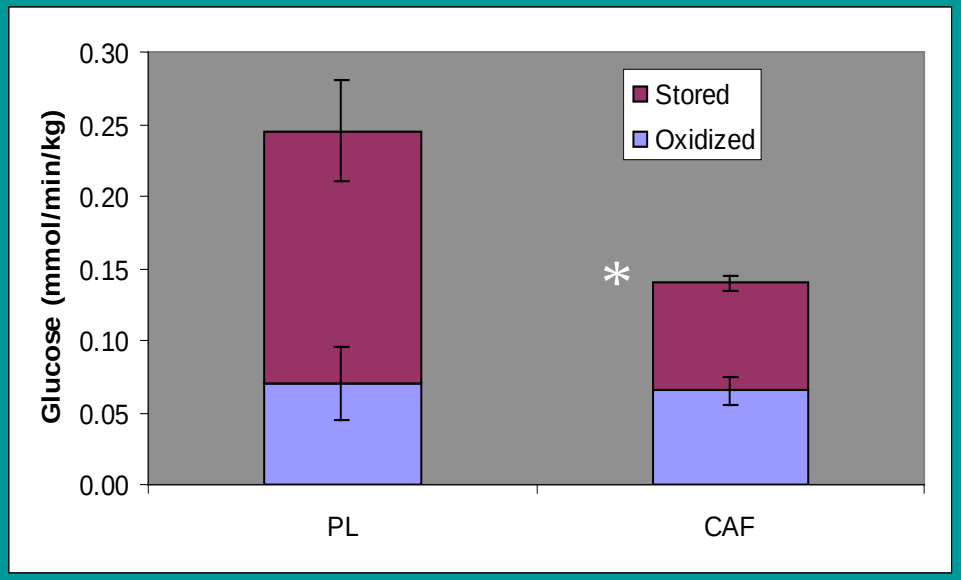
* Index calculation reference: Matsuda & De Fronzo. *Diabetes Care* 22:1462, 1999.

'Clamp Studies'

Resting leg



Exercised leg

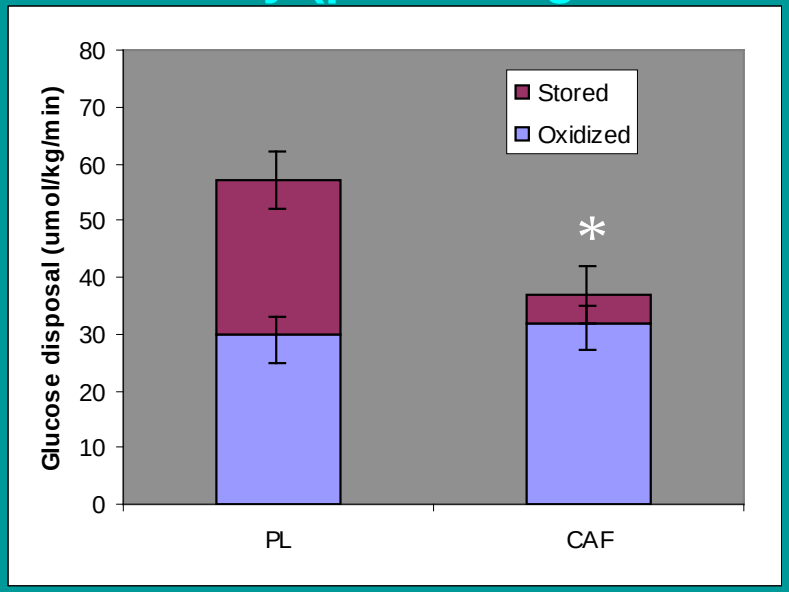


caffeine decreased insulin-mediated but not exercise-mediated glucose uptake

Muscle is the major tissue storing CHO postprandially

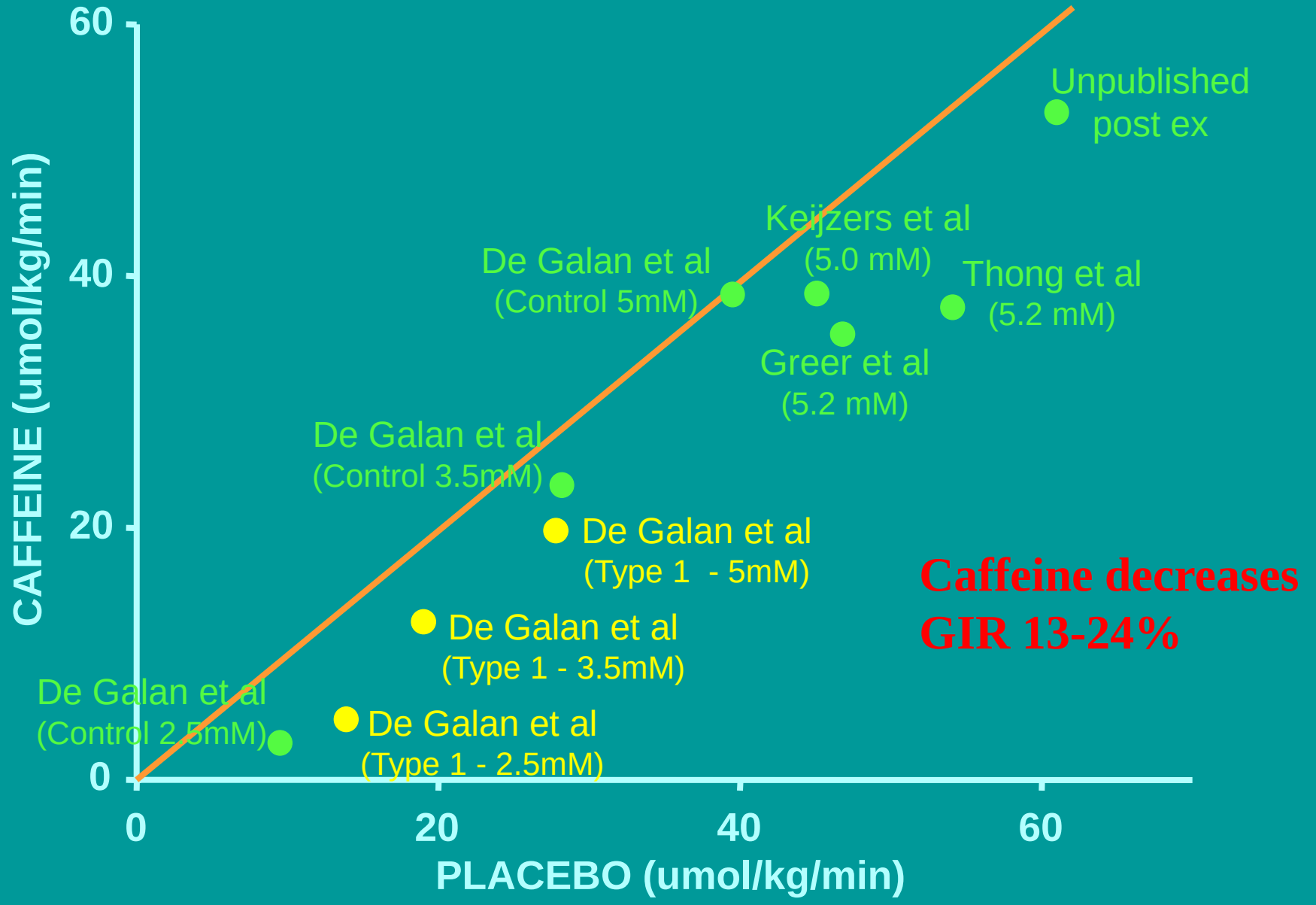
Less glucose taken up for a given insulin and of this amount, less is stored, but oxidation is not effected!

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 lypolysis
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; Ca^{2+} 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