Responses of blood lipids to aerobic and resistance type of exercise

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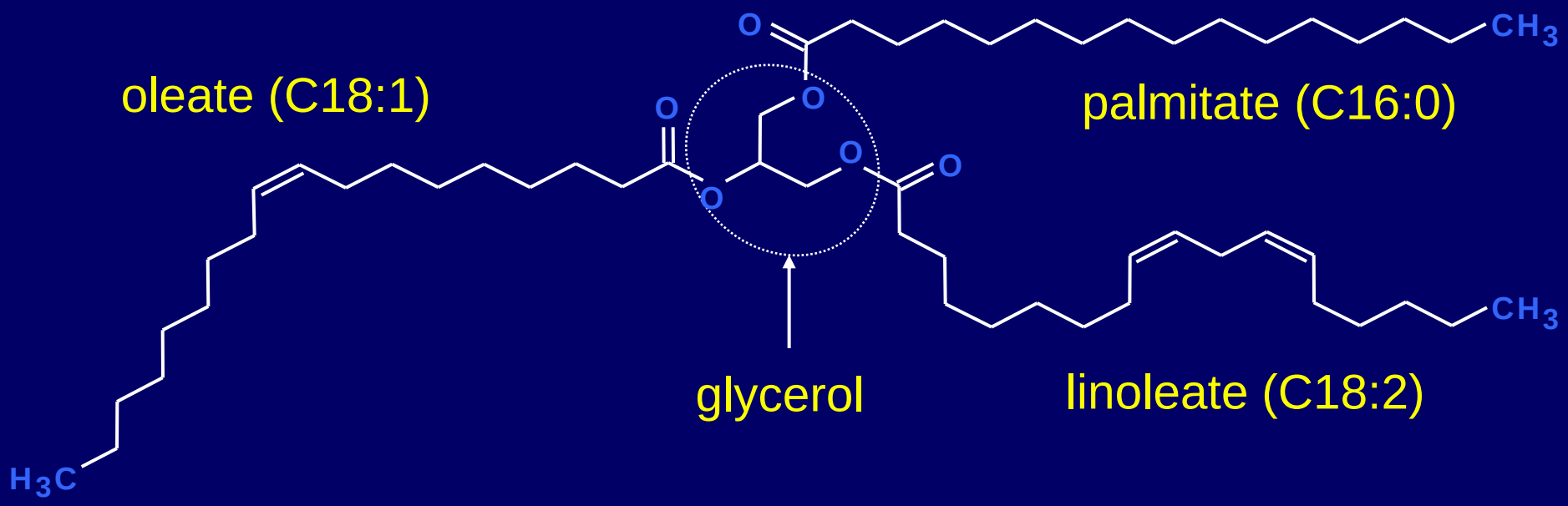
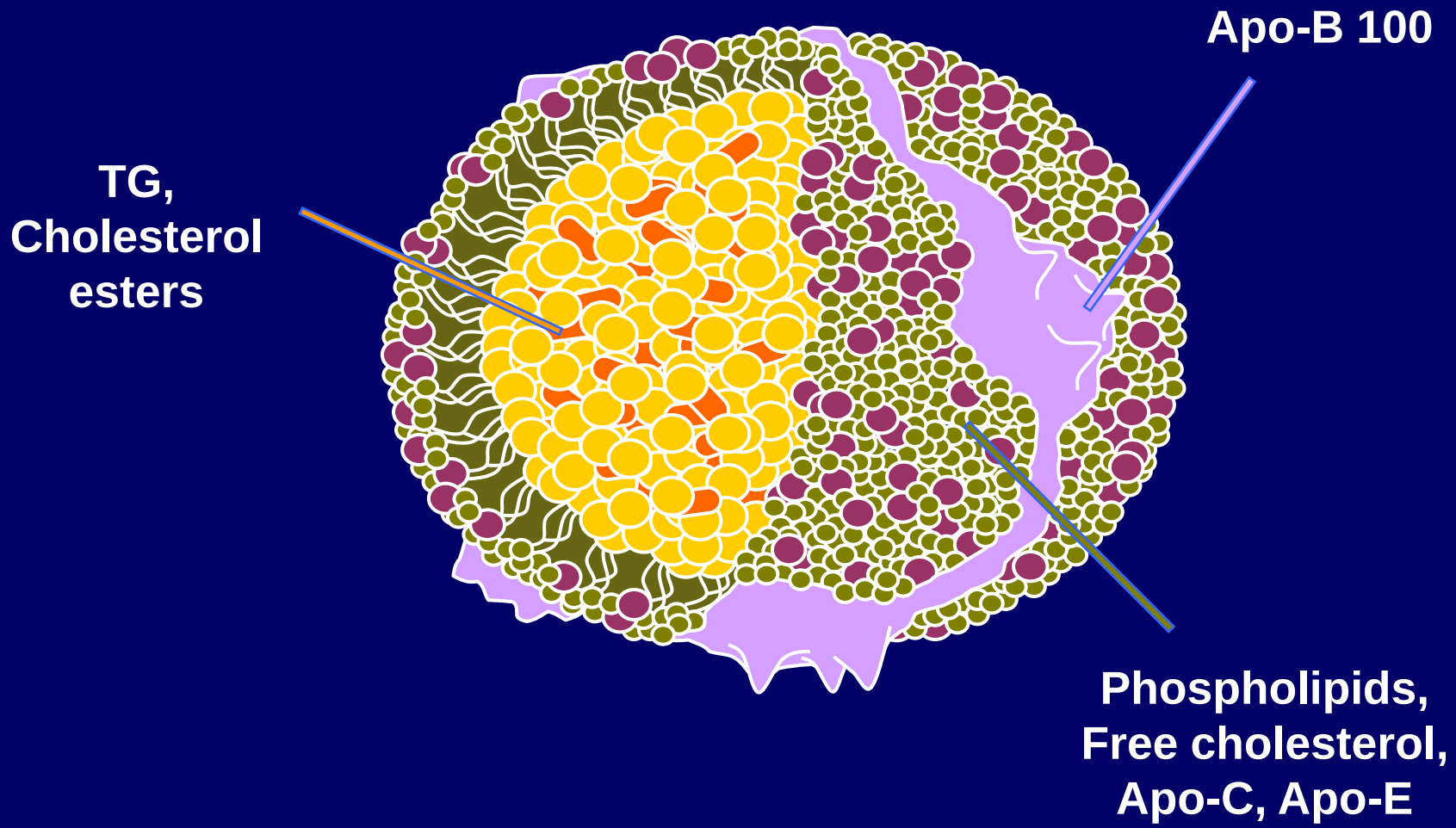
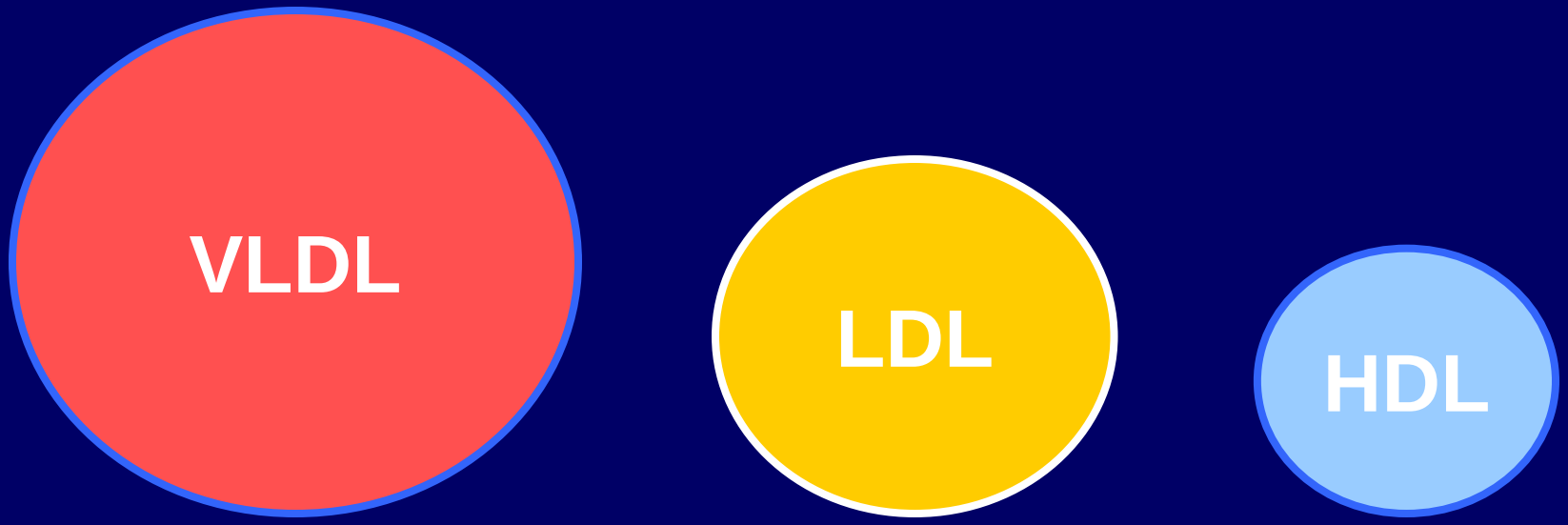
Triacylglycerol structure



Very low density lipoproteins (VLDL)



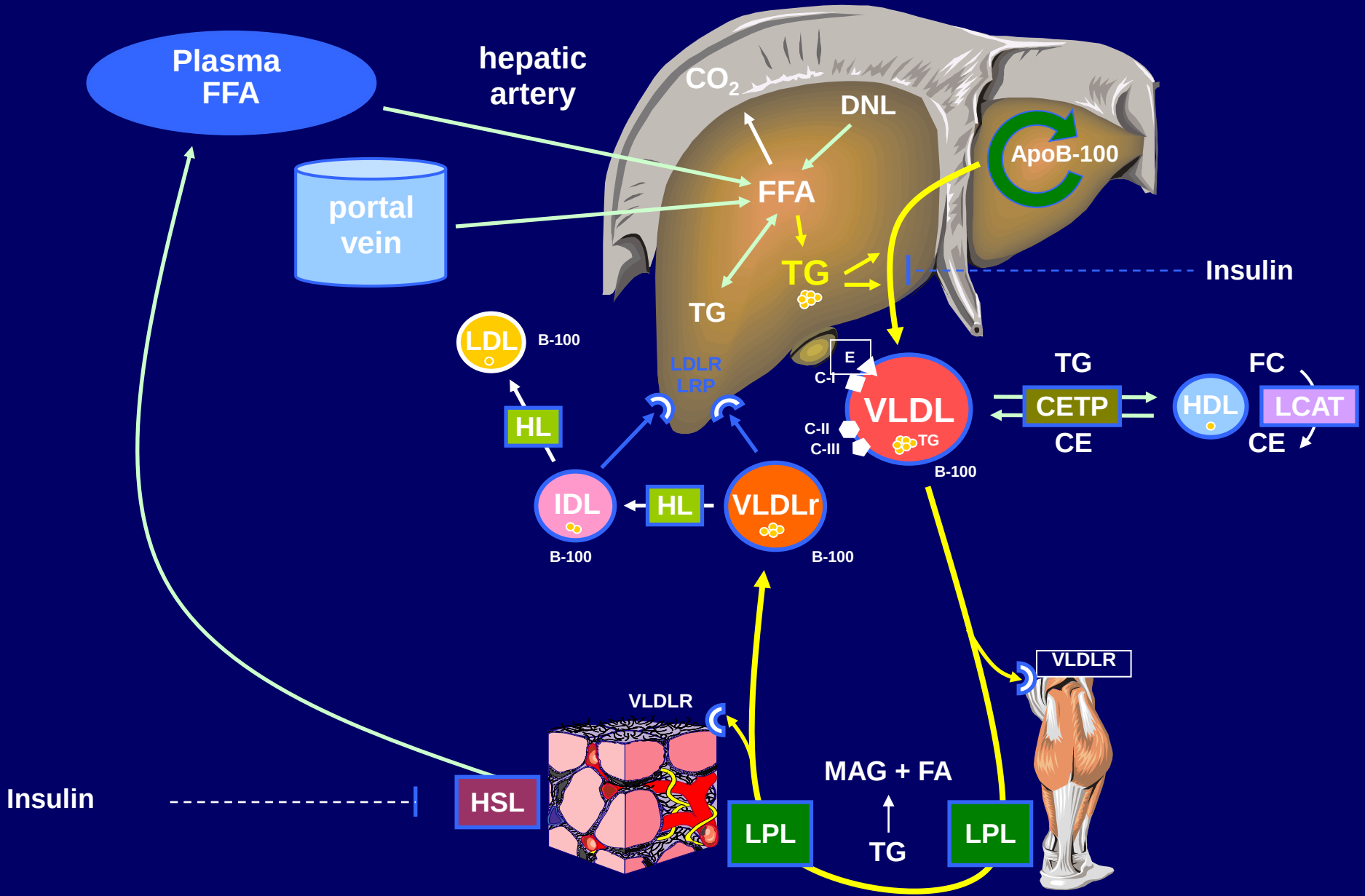
TG transport in blood (fasting state)



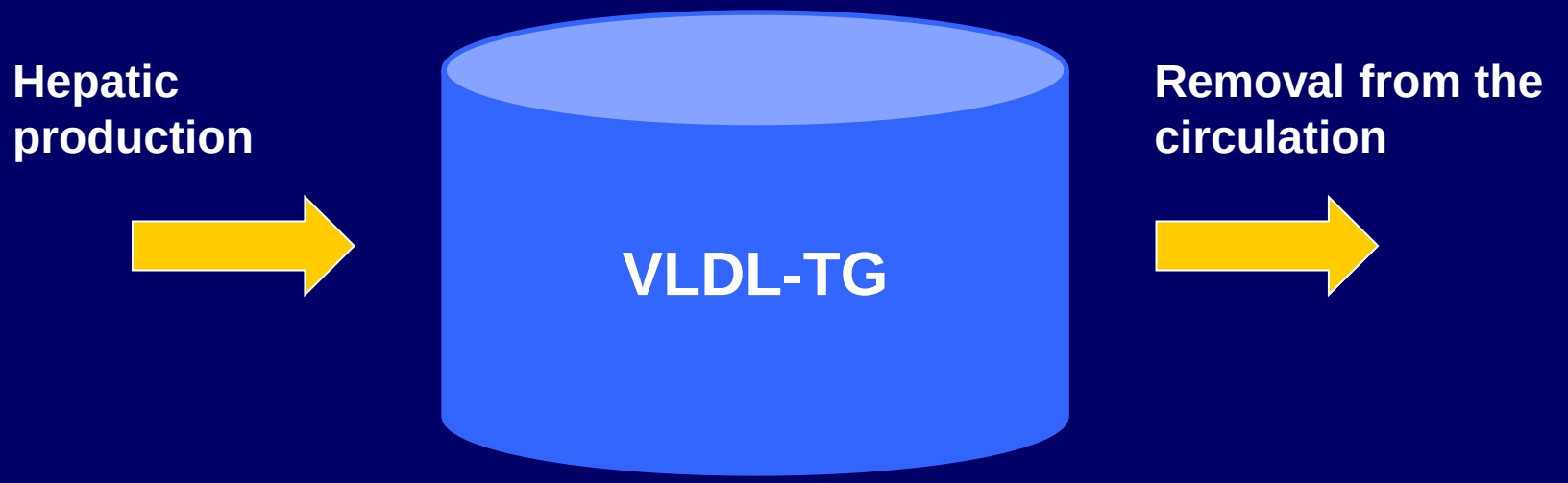
65 - 70% **15 - 20%** **10 - 15%**

Wahl et al (1981) Atherosclerosis 39:111

VLDL metabolism

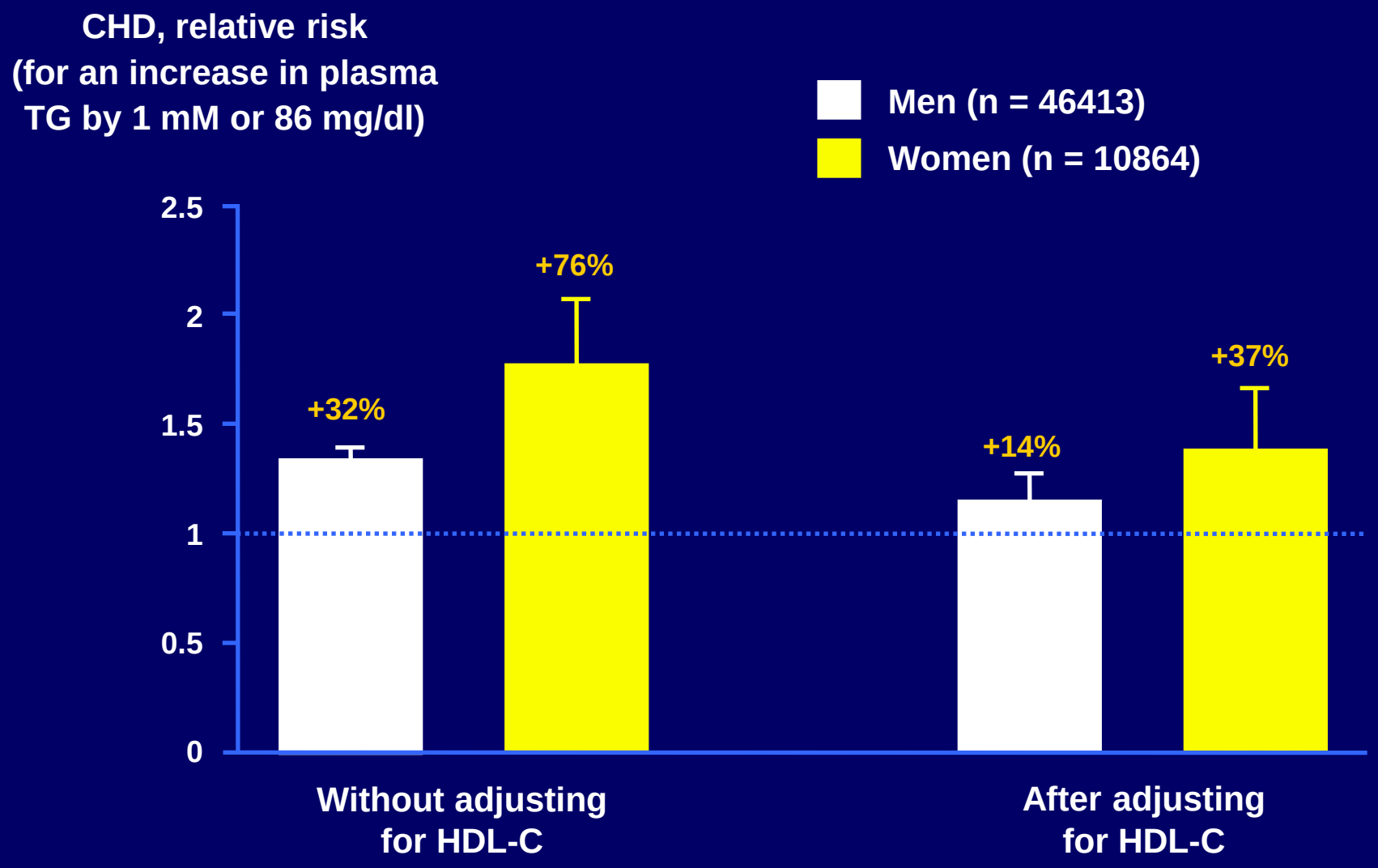


Regulation of plasma VLDL-TG concentration



Triglycerides and CVD

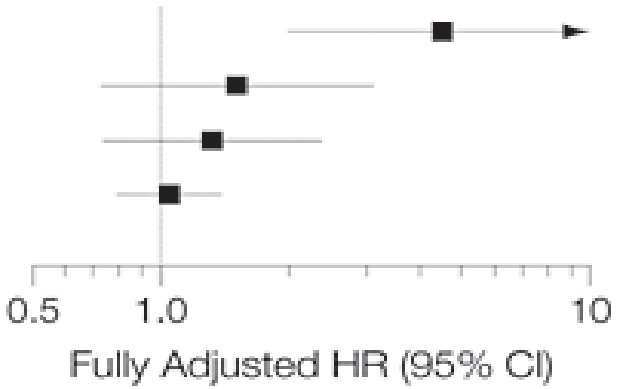
TG and Cardiovascular Disease
(Fasting State)



Hokanson & Austin (1996) J Cardiovasc Risk 3:213

TG and Cardiovascular Disease
(Stratified by Time Since Last Meal)

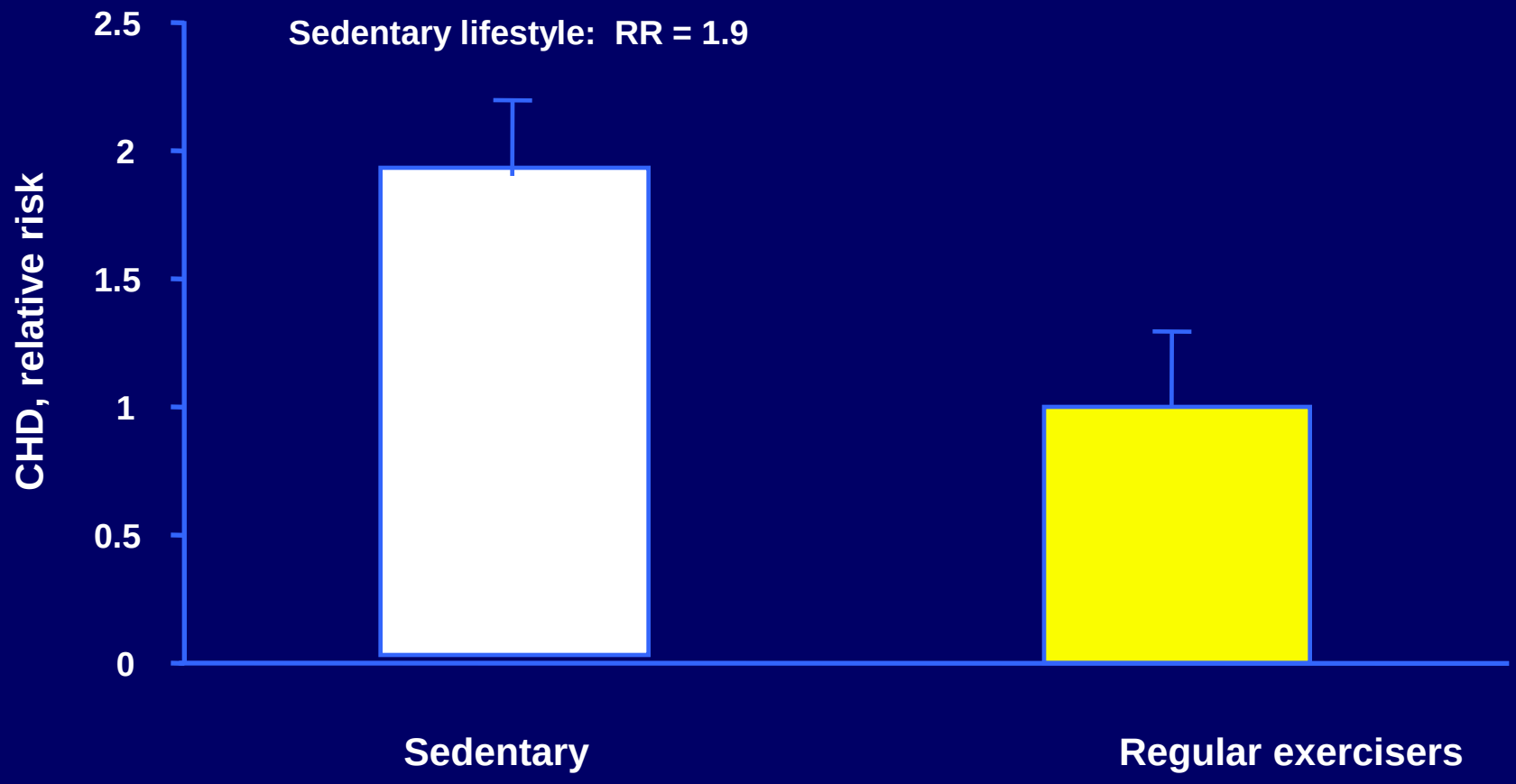
Time From Last Meal, h	No. of Participants	No. of Events	Hazard Ratio (95% Confidence Interval)
2 to <4	2797	98	4.48 (1.98-10.15)
4 to <8	2594	92	1.50 (0.72-3.13)
8 to <12	4846	177	1.31 (0.73-2.36)
≥12	15272	609	1.04 (0.79-1.38)



Bansal, S. et al. JAMA 2007;298:309-316.

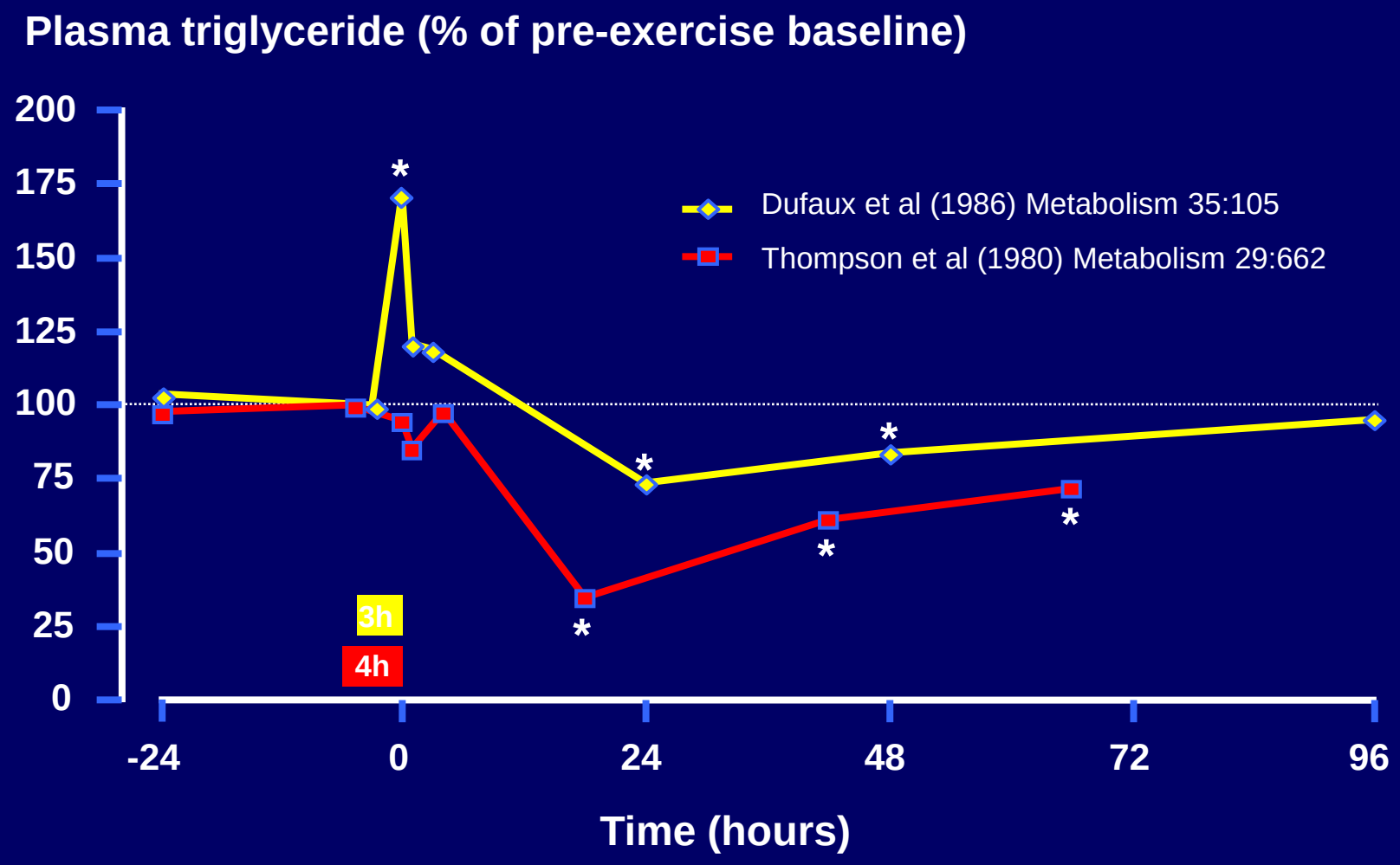
Exercise and cardiovascular disease : What do we know

Exercise and cardiovascular disease

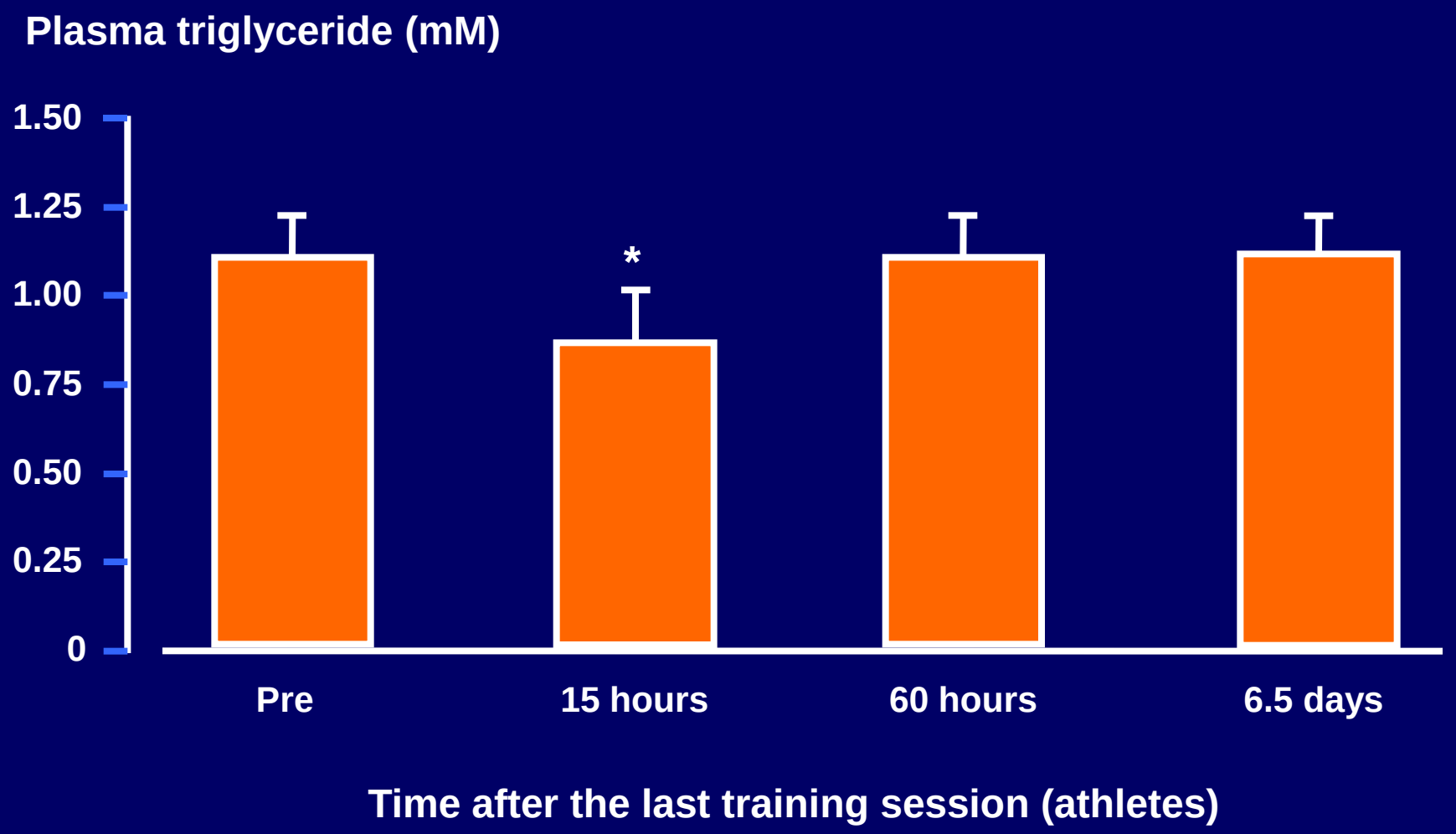


Berlin & Colditz (1990) Am J Epidemiol 132:612

Hypotriglyceridemia is acute and short-lived

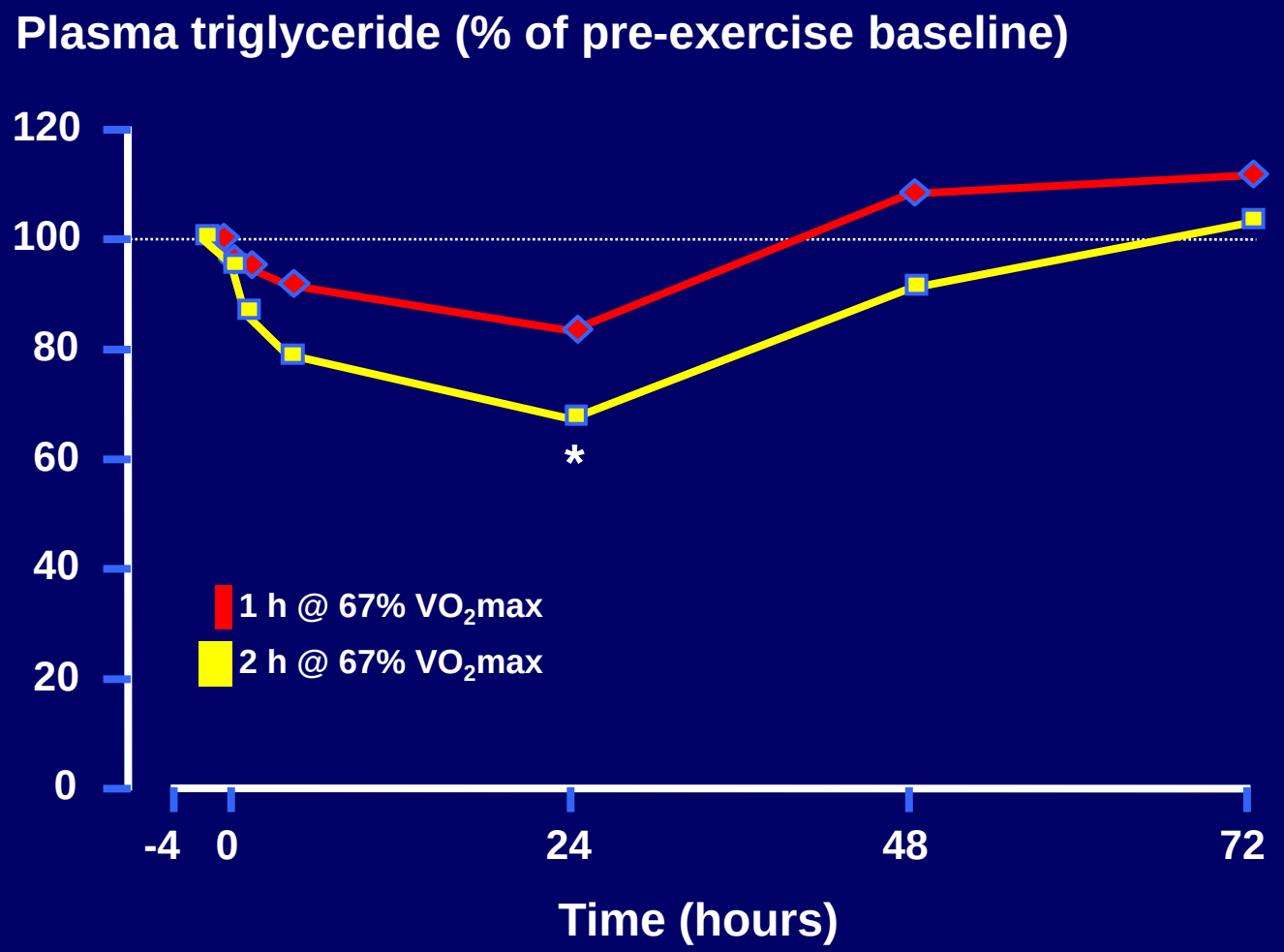


Hypotriglyceridemia does not result from training



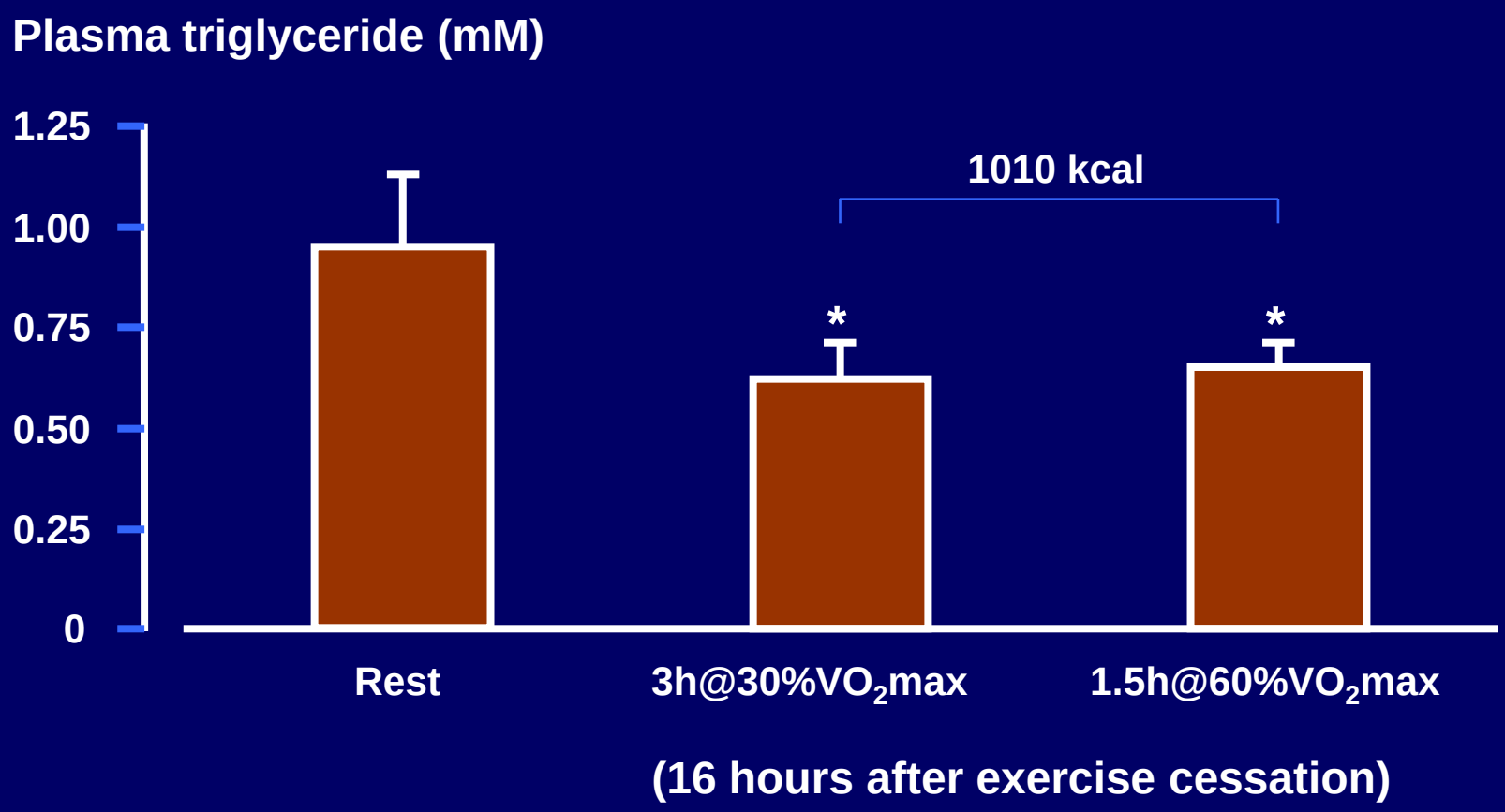
Hardman et al (1998) J Appl Physiol 84:1895

Hypotriglyceridemia is dose-dependent



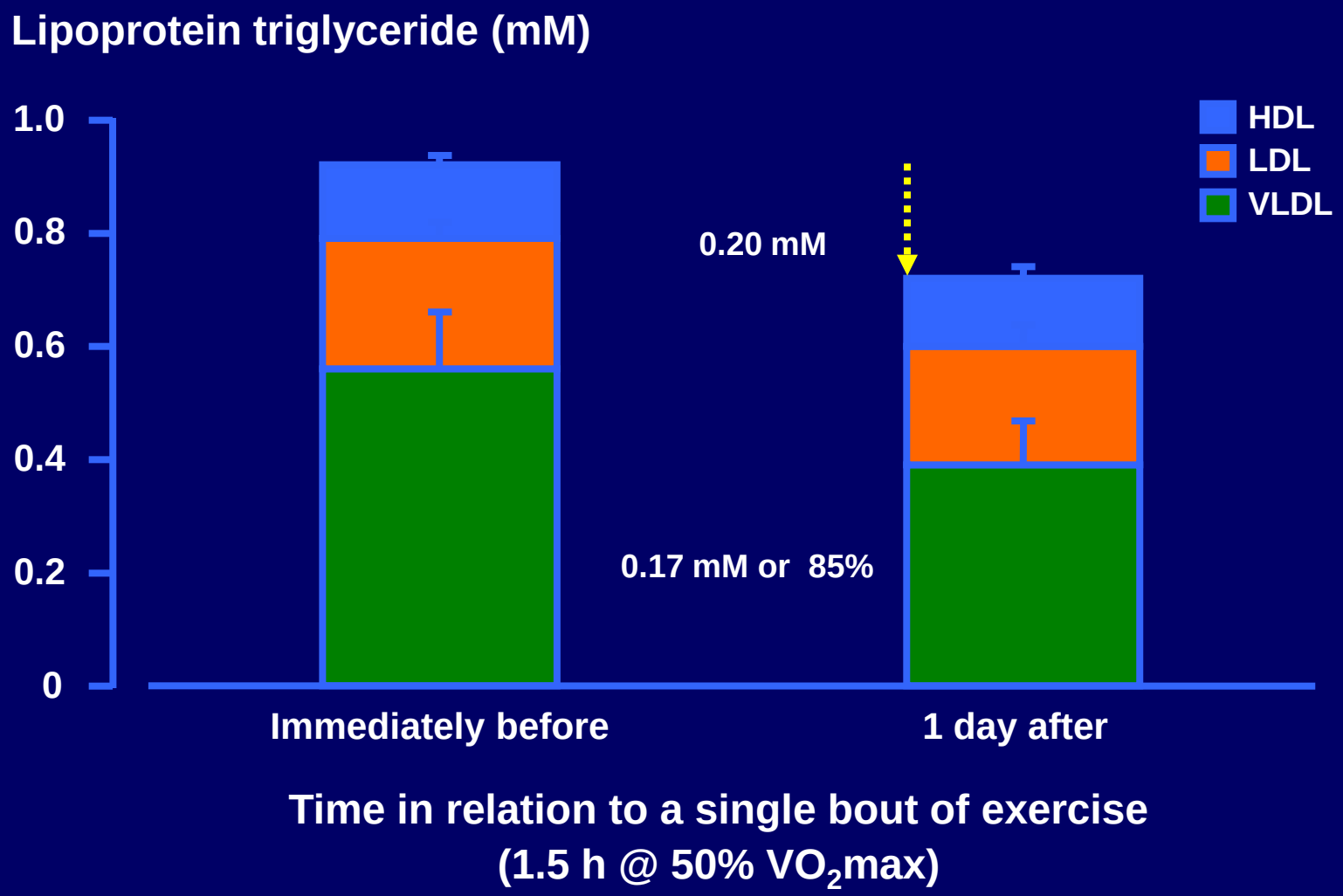
Cullinane et al (1982) Metabolism 31:844

Hypotriglyceridemia depends on energy expenditure



Tsetsonis & Hardman (1996) Med Sci Sports Exerc 28:1235

Hypotriglyceridemia results from hypo-VLDL-triglyceridemia

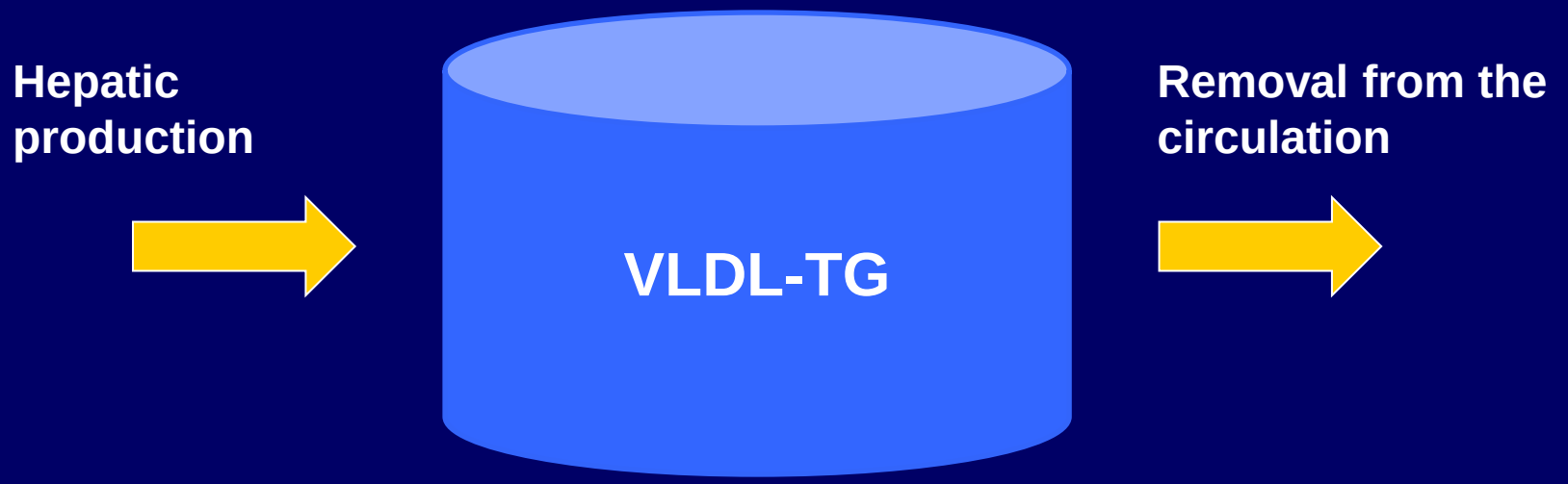


Annuzzi et al (1987) Metabolism 36:438

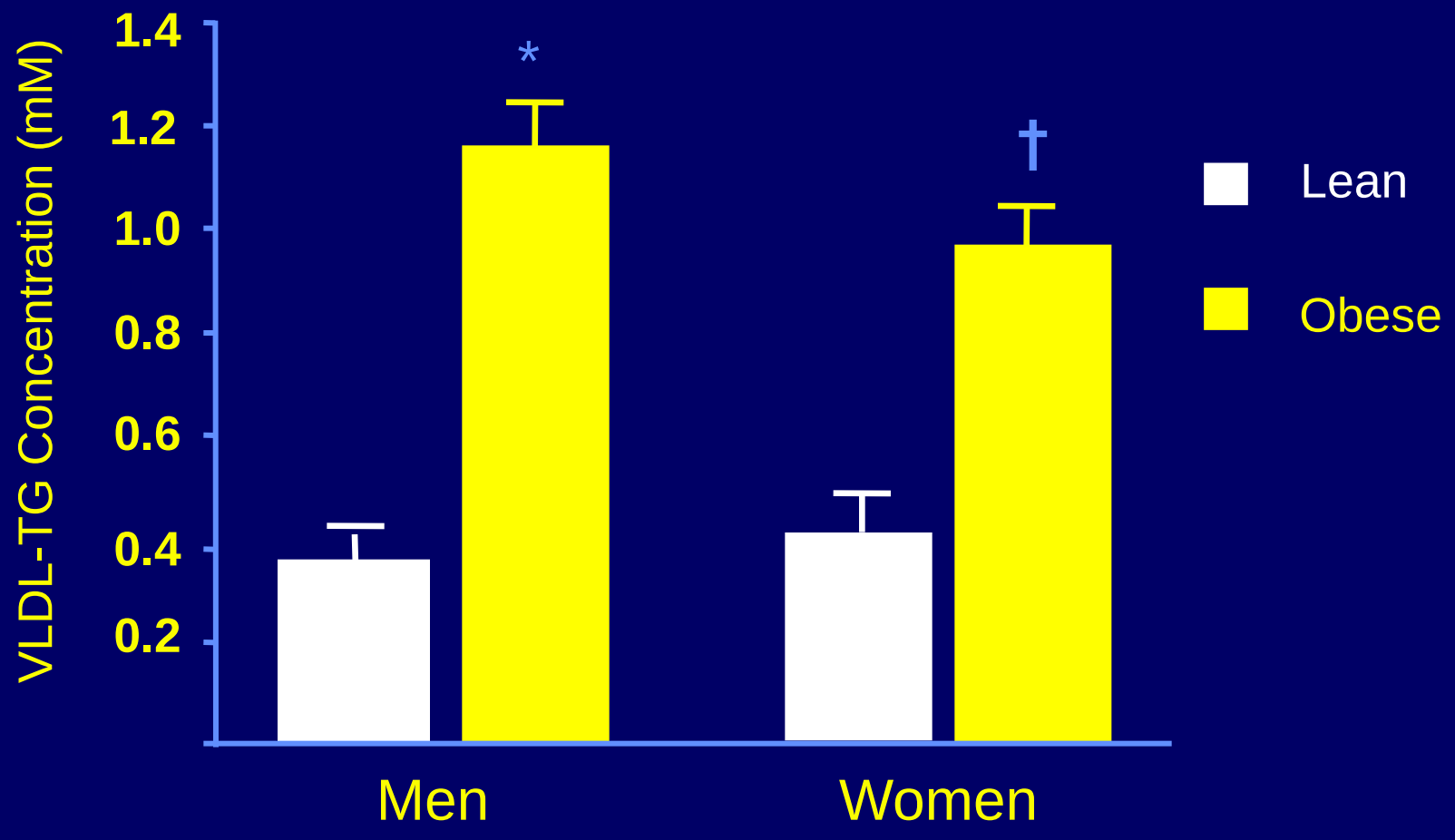
Mechanisms of acute exercise – induced decrease in fasting and post-prandial lipemia

Why do we need to look at mechanisms?

Regulation of plasma VLDL-TG concentration

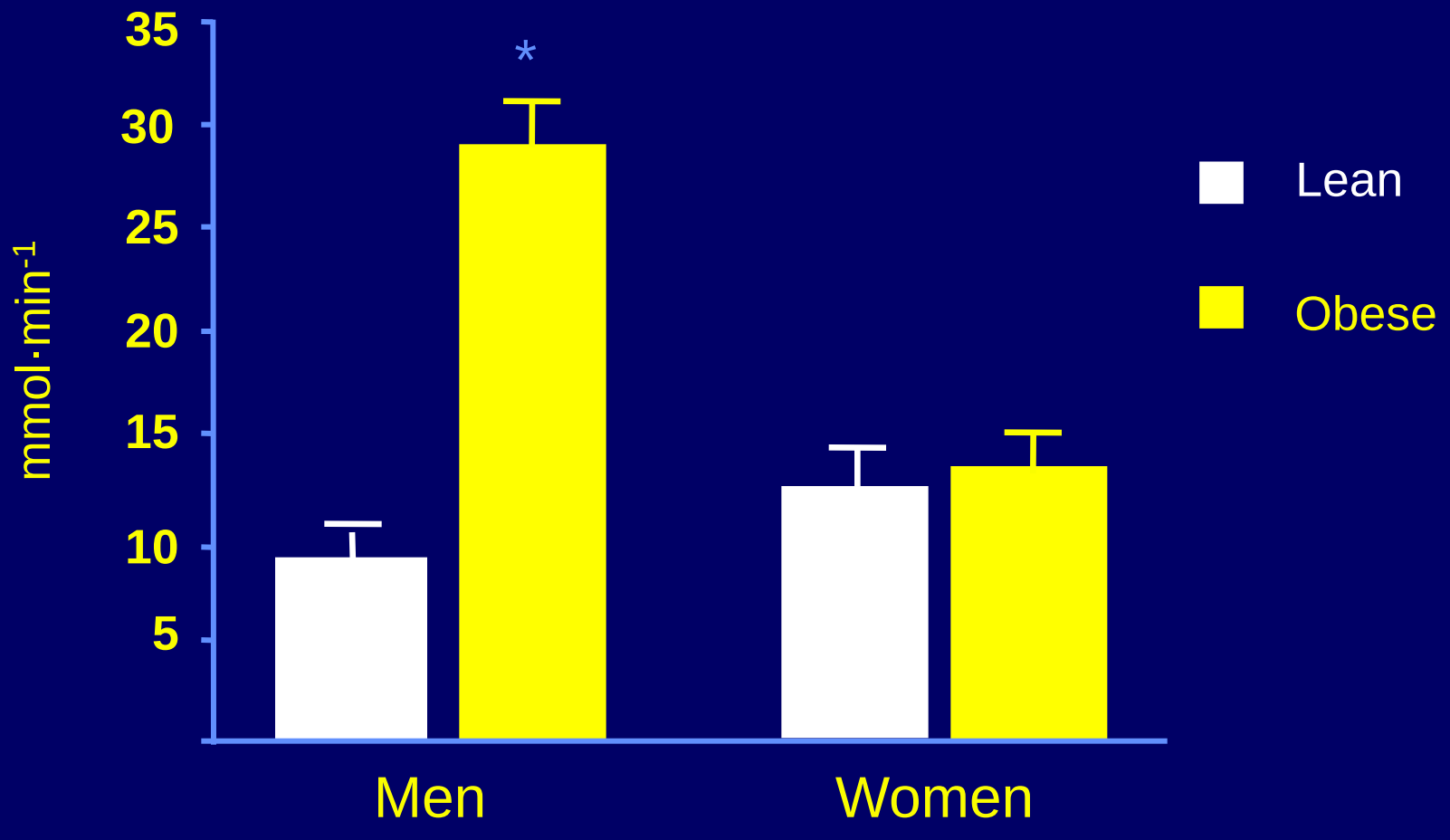


VLDL-triglyceride concentration: effects of sex and obesity



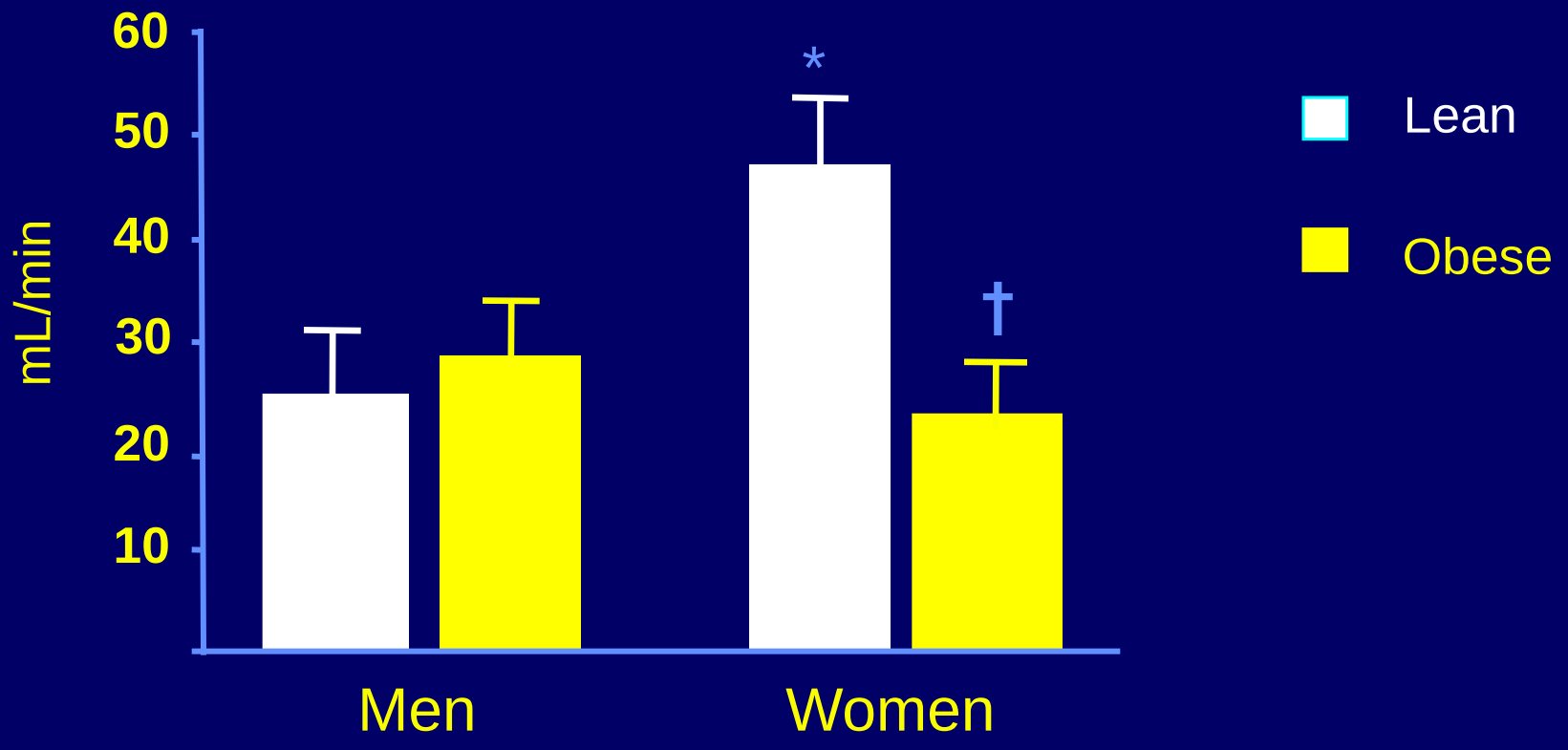
Mittendorfer B et al, AJP 284: E708–E715, 2003

Effect of Obesity and Gender On VLDL-TG Production Rate



Mittendorfer B et al, AJP 284: E708–E715, 2003

Effect of Obesity and Gender On VLDL-TG Clearance



Mittendorfer B et al, AJP 284: E708–E715, 2003

Mechanisms explaining the observed hypotriglyceridemic effect of exercise:

Aerobic exercise

A single bout of brisk walking decreases basal VLDL-TG **concentration**

Exercise: 90 min at 60% VO_2 max; 800 Kcal

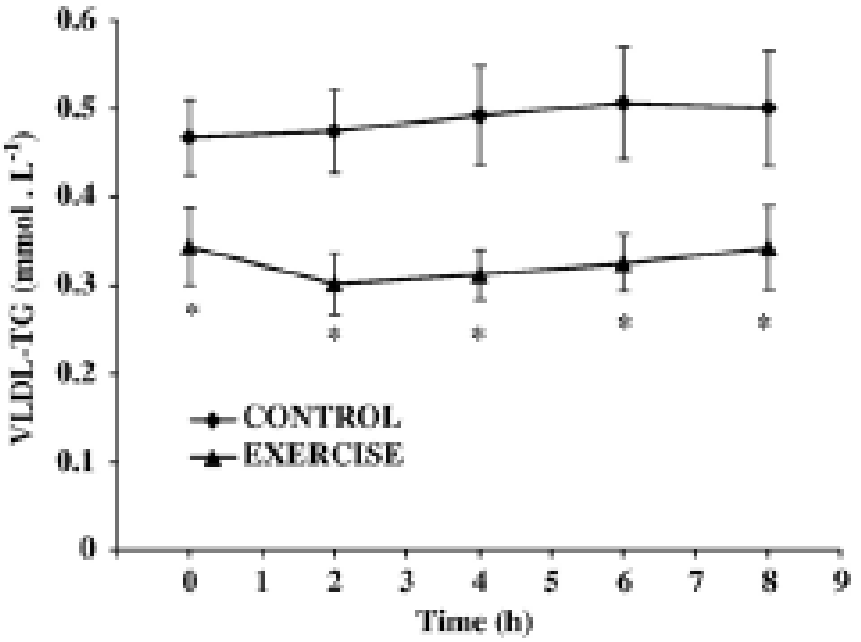
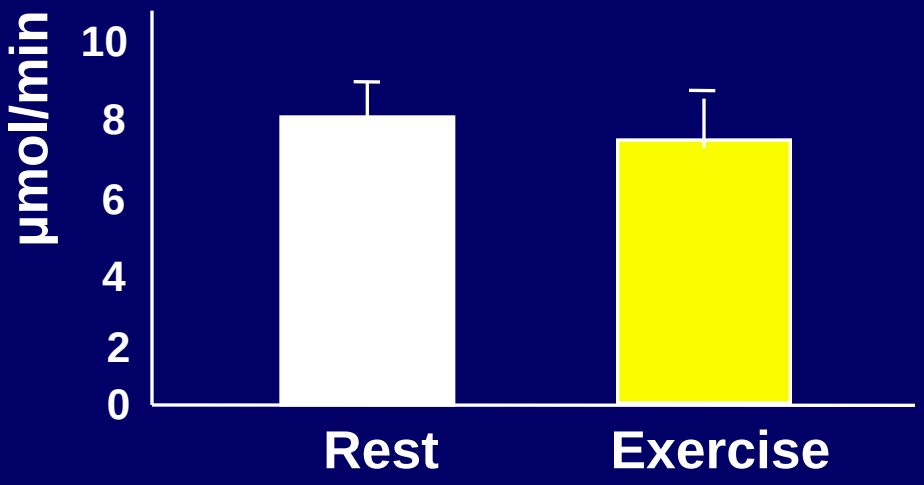


Fig. 3. VLDL-TG concentration throughout the 8-hour study period for the CON and EXE trials, respectively. *$P < .05$, significantly different from control.

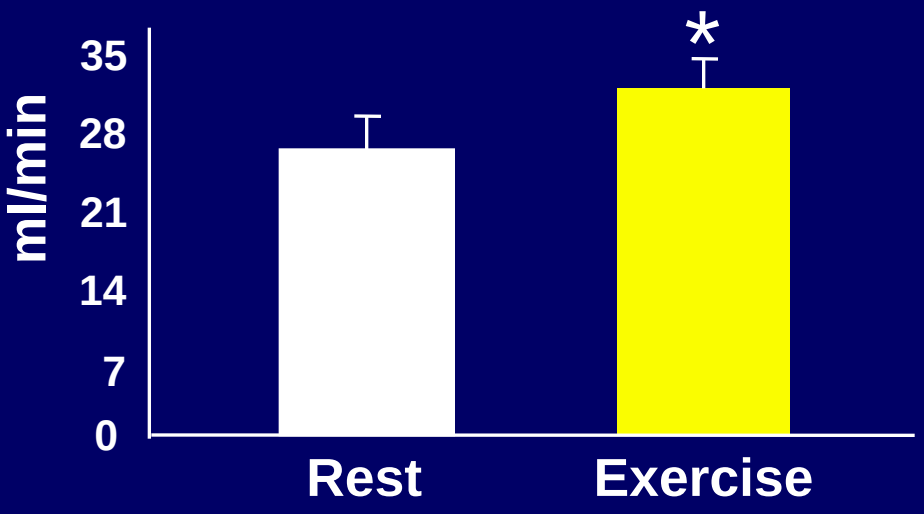
(Tsekouras et al. Metabolism, 2007)

A single bout of brisk walking (90 min at 60% VO_2 peak; 800 Kcal) increases basal VLDL-TG clearance in men

(*a*) VLDL-TAG secretion rate



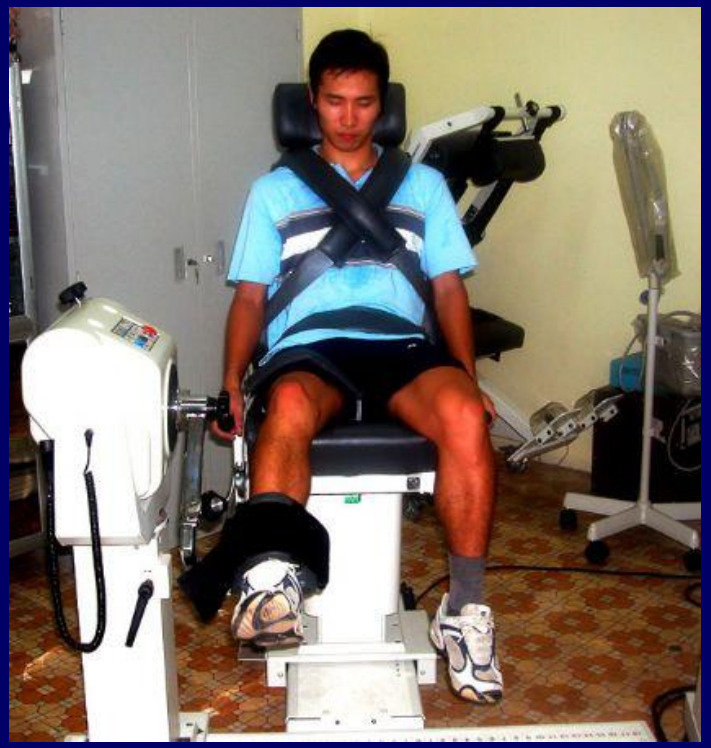
(*b*) VLDL-TAG plasma clearance rate



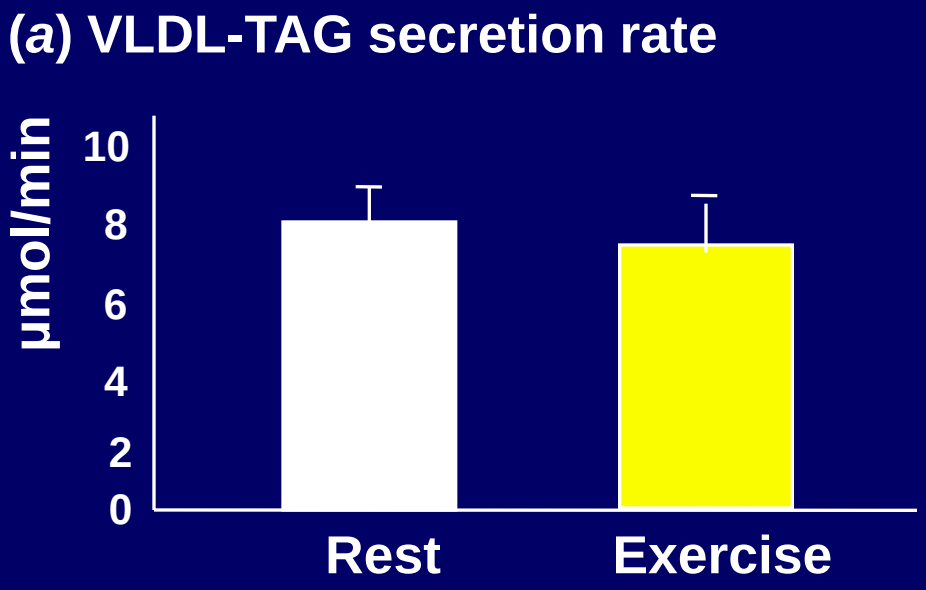
(Tsekouras et al. Metabolism, 2007)

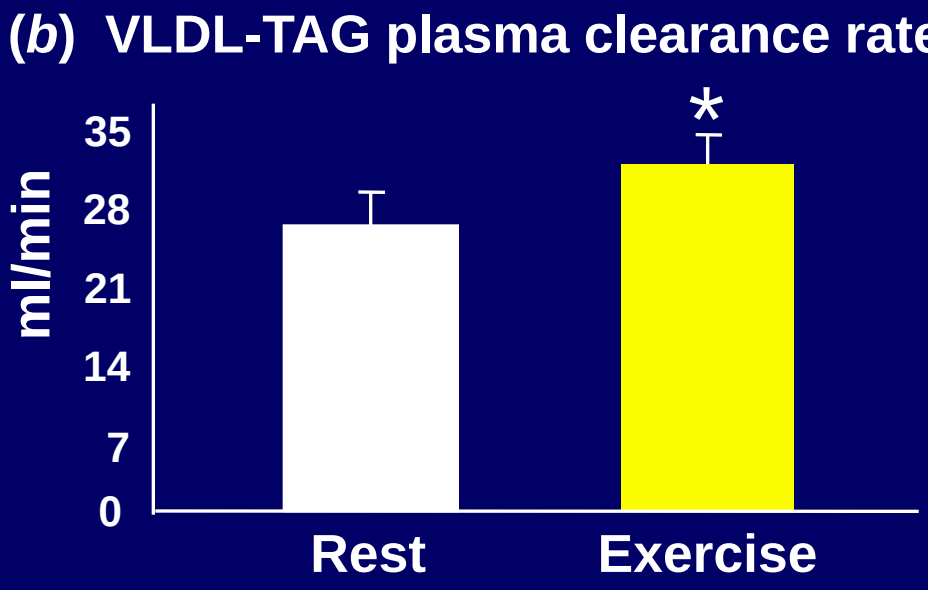
Mechanisms explaining the observed hypotriglyceridemic effect of exercise:

Resistance exercise



A single bout of resistance exercise (90 min resistance exercise; 400 Kcal) increases basal VLDL-TG clearance in men



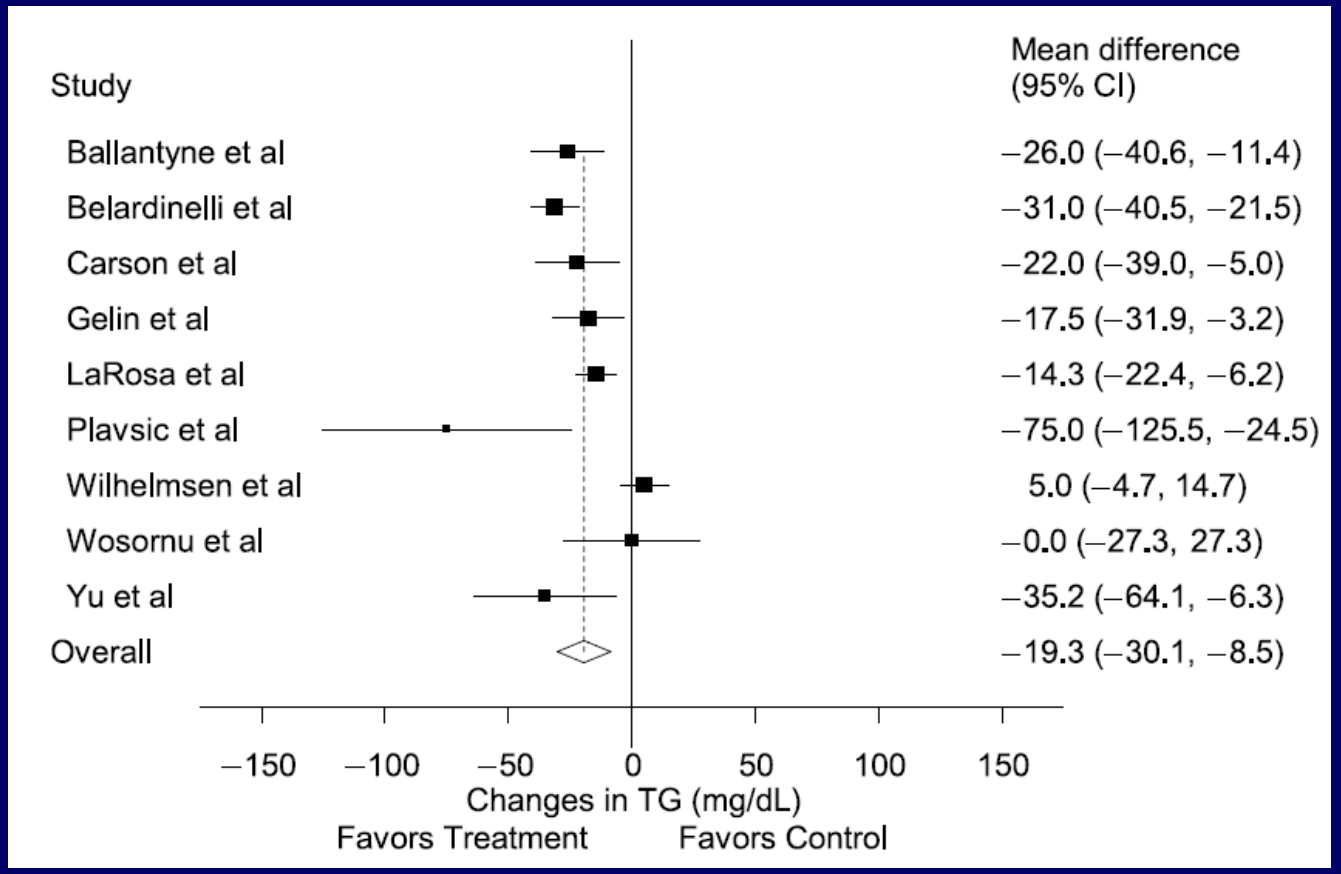


(Tsekouras et al. Metabolism, 2008)

Mechanisms explaining the observed hypotriglyceridemic effect of exercise:

Aerobic training

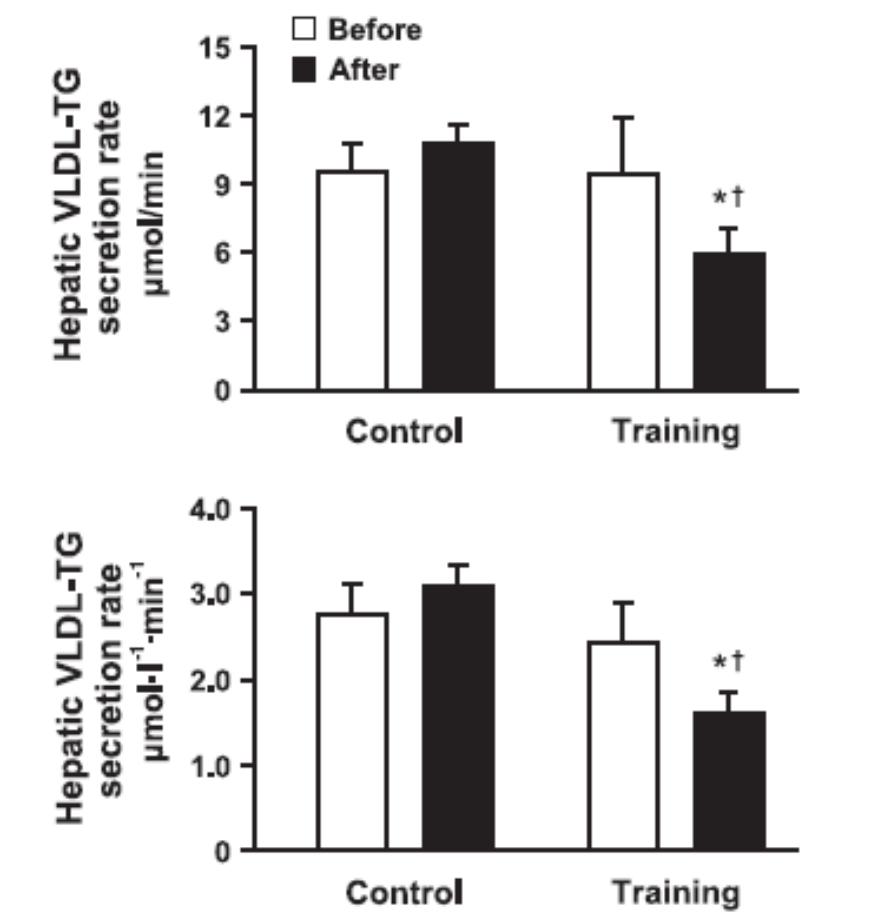
Effect of exercise training on fasting plasma TG in patients with CVD



~11% reduction (*P*<0.05)

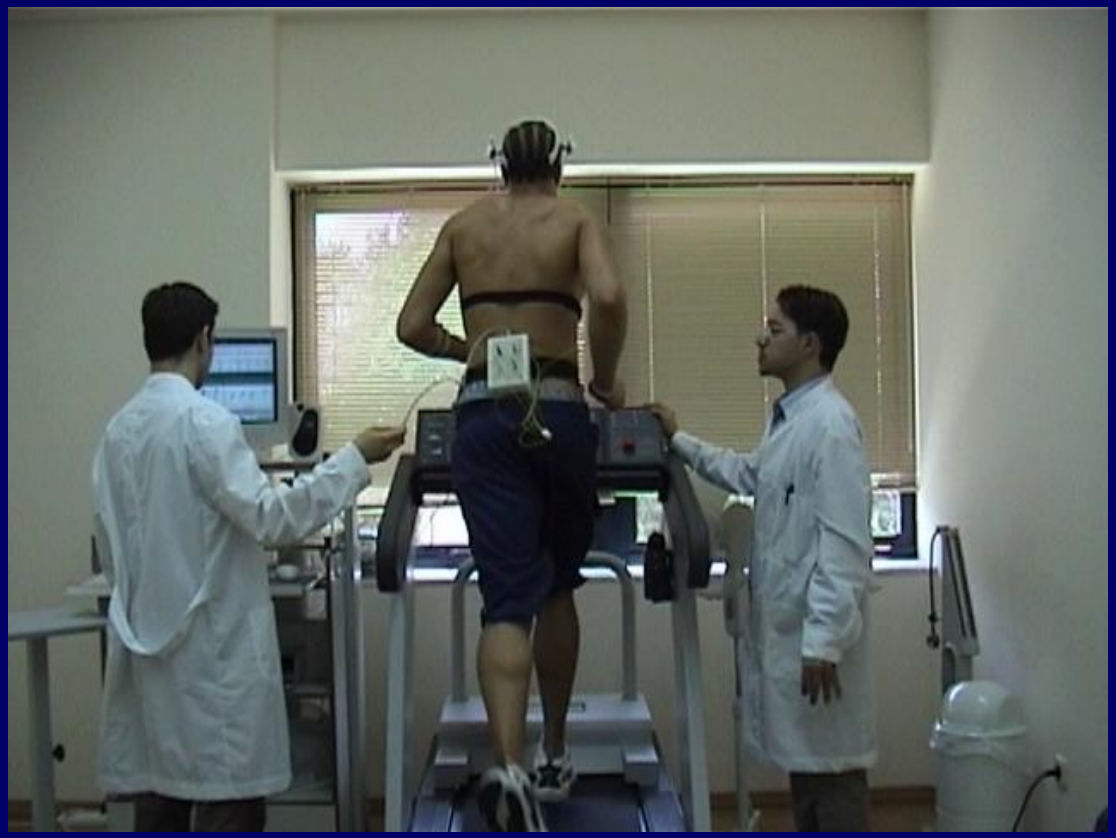
Kelley et al (2006) J Cardiopulm Rehabil 26:131

Aerobic training reduces basal hepatic VLDL-triglyceride **secretion** rate in healthy men

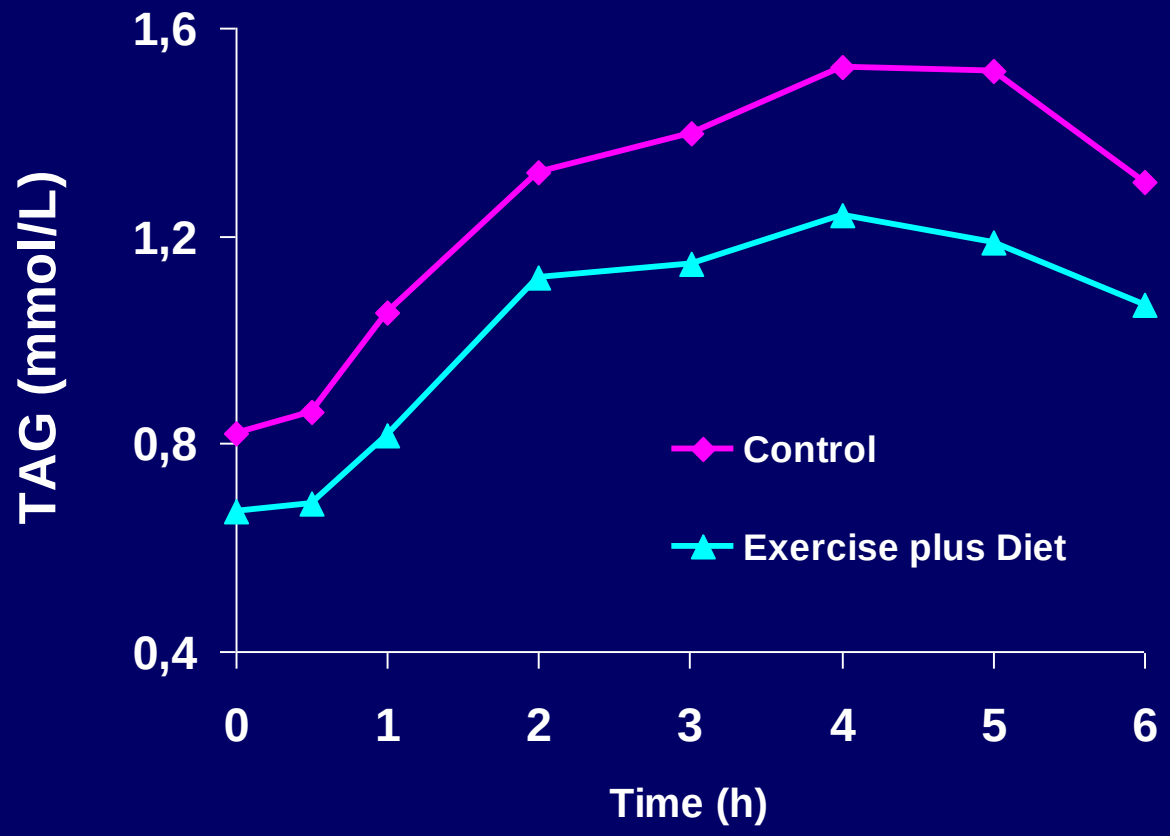


(Tsekouras et al. AJP, 2008)

Effect of diet and exercise on postprandial triglyceride levels

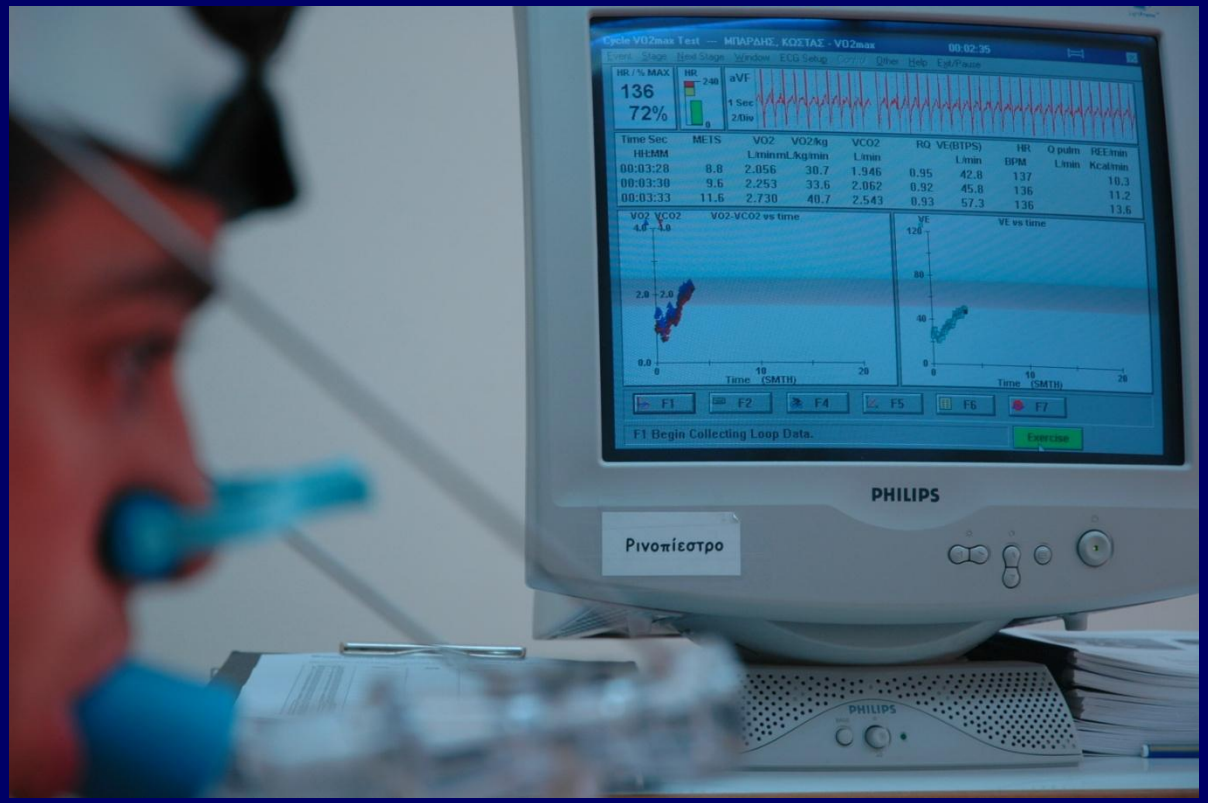


Exercise (250 Kcal) + Diet (250 Kcal) acutely reduces fasting and postprandial triacylglycerolaemia in young lean women

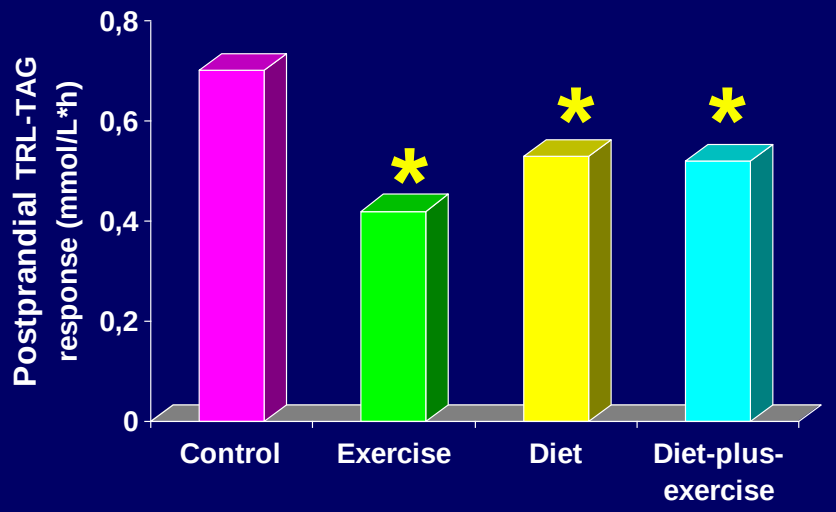


(Maraki et al, Br J Nutr. 2008)

Is the effect on triglycerides due to exercise or diet *per se* or is it due to the negative energy balance



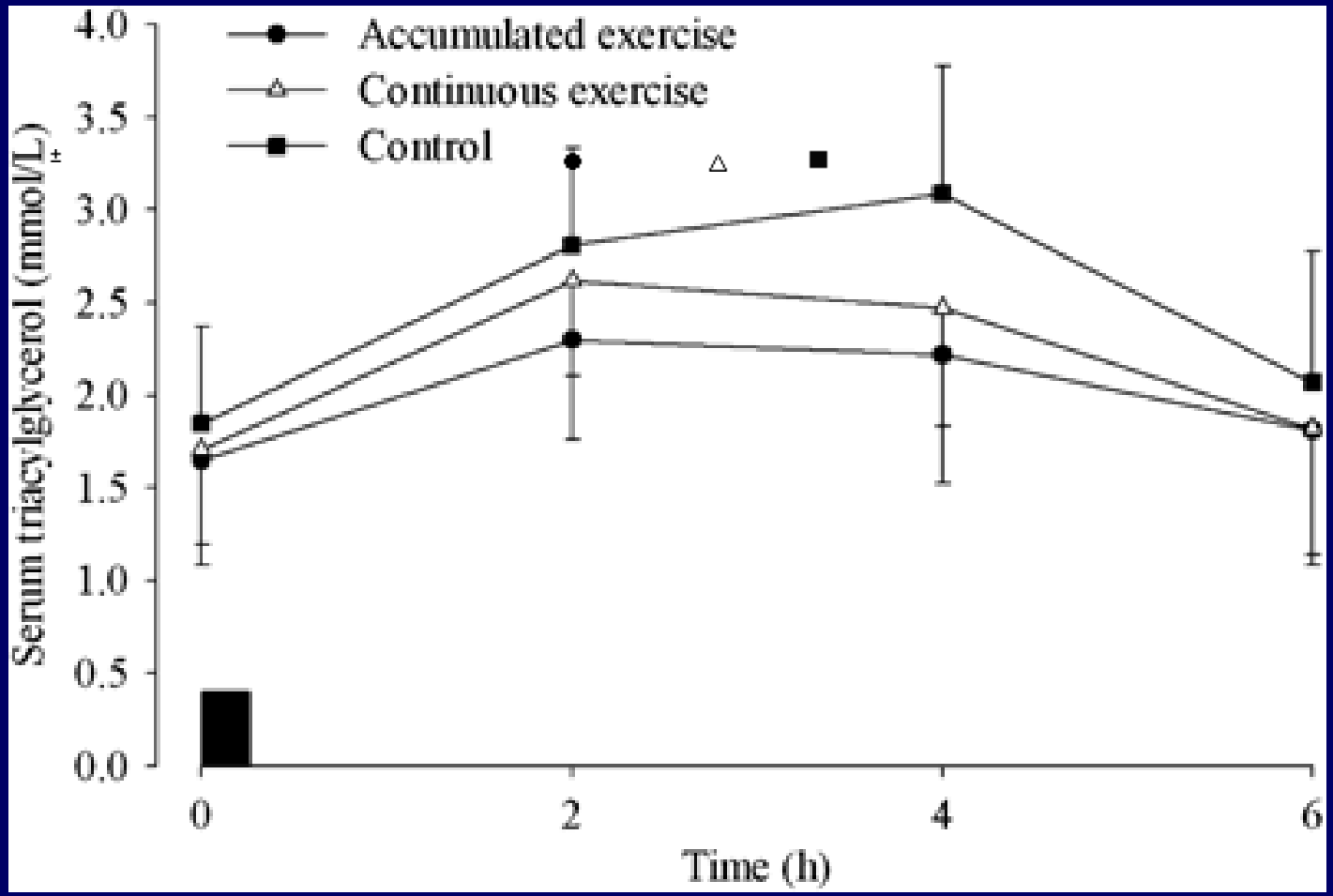
Negative energy balance from exercise, diet or a combination of both: effect on fasting and postprandial TG



(Maraki et al, Clin Nutr 2009)

* p<0.05 vs Control

Effects of continuous vs accumulated activity on postprandial TG concentrations in obese men



Miyashita, International Journal of Obesity, 2008

Conclusions

- Aerobic and resistance exercise significantly reduce plasma triglycerides
- The effect of exercise
  - is acute (manifests after a single bout of exercise)
  - is short-lived (lasts for 1-2 days)
  - It depends on energy expenditure

- The mechanisms responsible for the diet and exercise-induced effects on TG metabolism need to be further elucidated

Exercise and VLDL metabolism: future directions

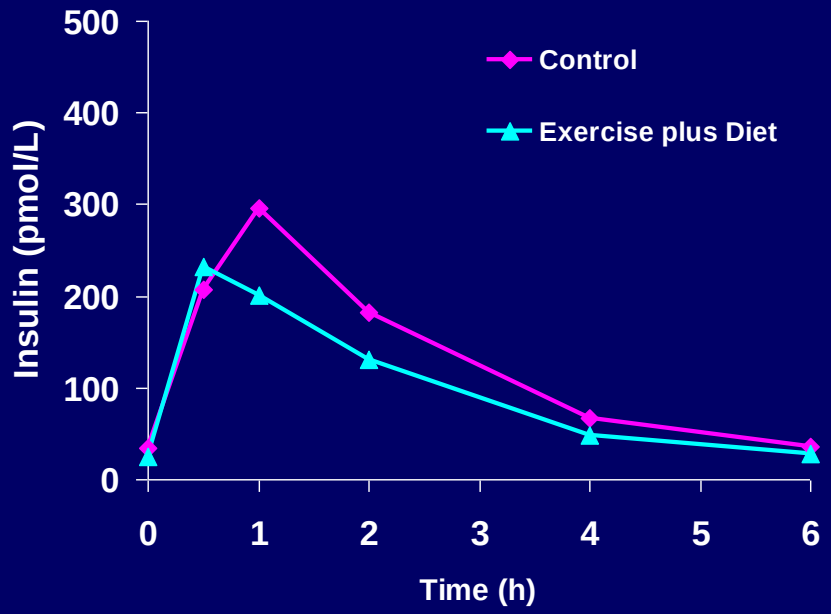
1. What is the optimum / minimum exercise (type – intensity – duration combination) and the proper diet – exercise combination for correcting hyper-TAG in various diseases

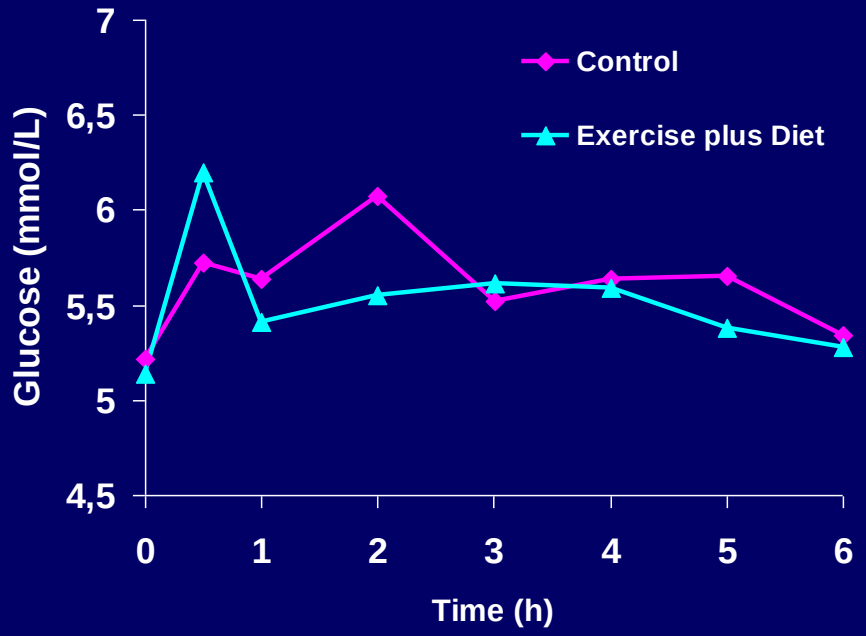
2. What are the **mechanisms** responsible for the observed improvements on lipid / lipoprotein profile brought about by exercise and diet manipulation

Harokopio University, Athens, Greece
S. Kavouras, G. Nassis, F. Magkos, Y. Tsekouras, M. Maraki, K. Anastasiou, K. Skenderi, A. Yianni, D. Panagiotakos, E. Bathrellou
Washington University School of Medicine, St. Louis, MO, USA
S. Klein, B. Mittendorfer, B. Patterson
University of Texas Medical Branch at Galveston, TX, USA
R. Wolfe, J. Romijn, A. Gastaldelli, D. Chinkes

Thank you for your attention

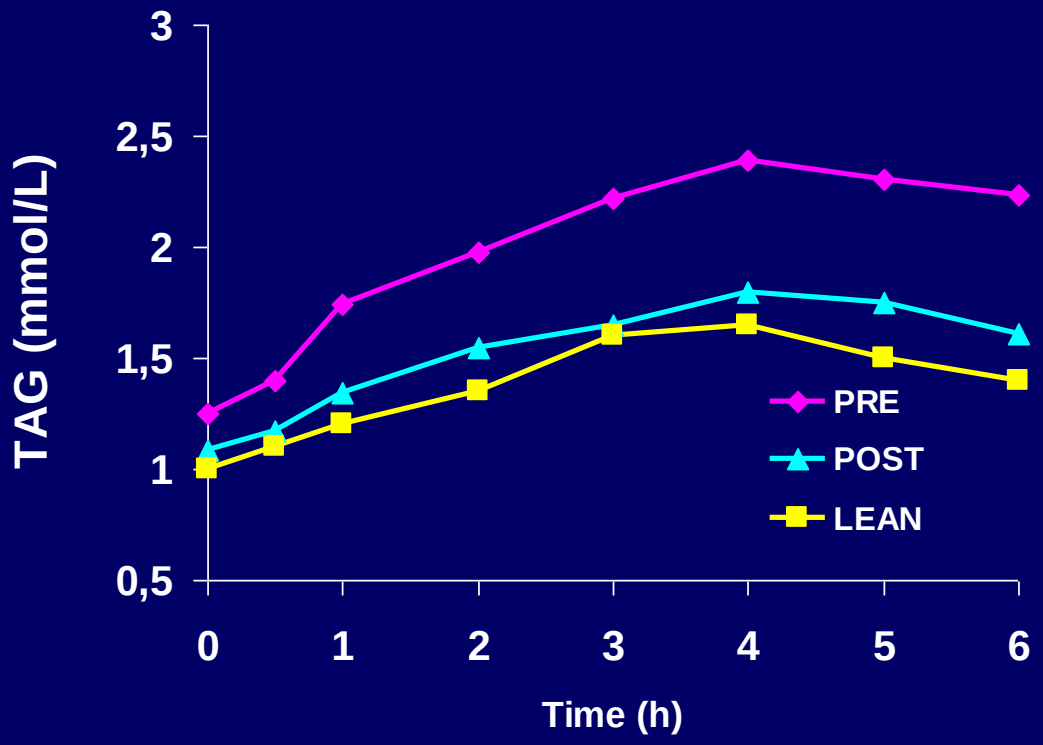
Effect of exercise (250 Kcal) + Diet (250 Kcal) on OFTT insulin and glucose response





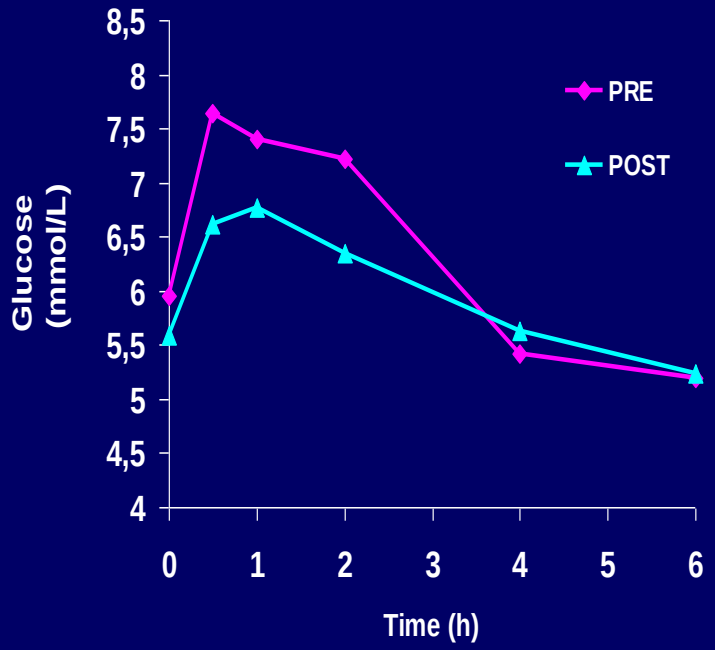
(Maraki et al, *Br J Nutr. 2008)*

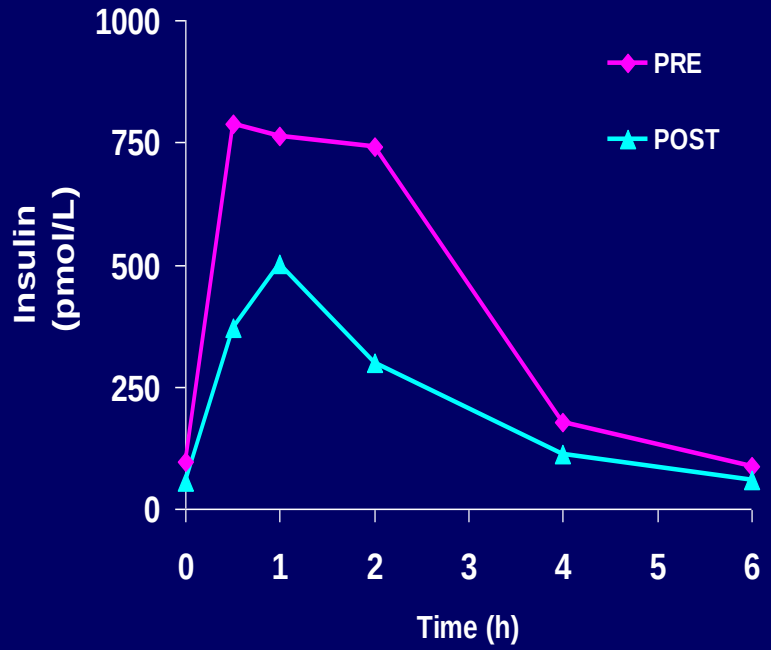
A 10% weight loss reduces postprandial triacylglycerolemia in obese subjects



Maraki et al. (Obesity, in press)

Effect of 10% weight loss on OFTT insulin and glucose response





Maraki et al. (unpublished)

Aerobic exercise training improves insulin sensitivity without changes in body weight, body fat, adiponectin, and inflammatory markers in overweight and obese girls (Nassis et al, Metabolism 2005)

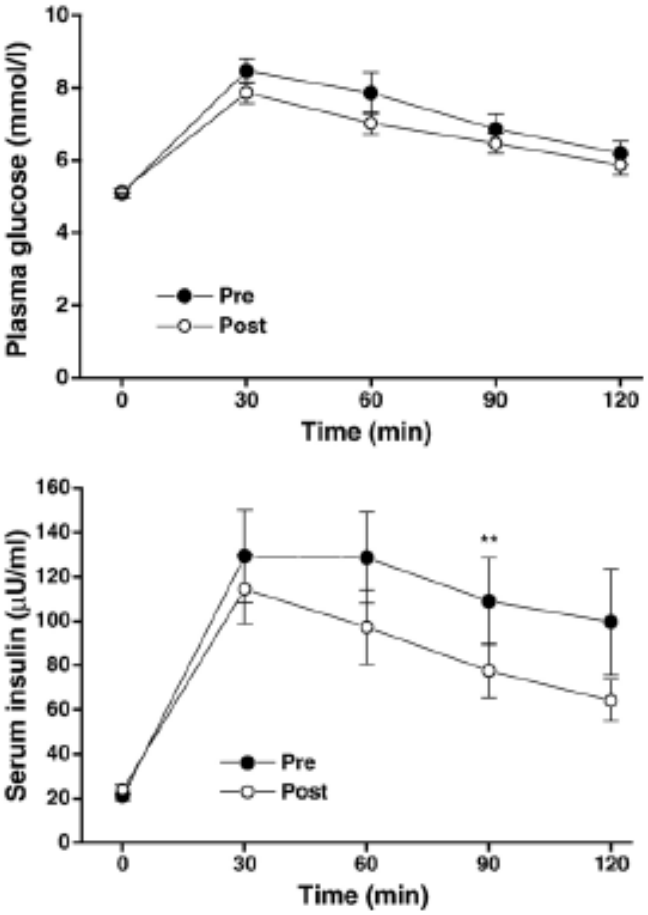


Fig. 1. Plasma glucose (top panel) and serum insulin (bottom panel) responses during the 2-hour OGTT before and after 12 weeks of aerobic training in overweight and obese girls (n = 15). Values are means ± SE; double asterisk in the bottom panel indicates $P < .01$ vs postintervention.

Improved insulin sensitivity after a single bout of exercise is curvilinearly related to exercise intensity

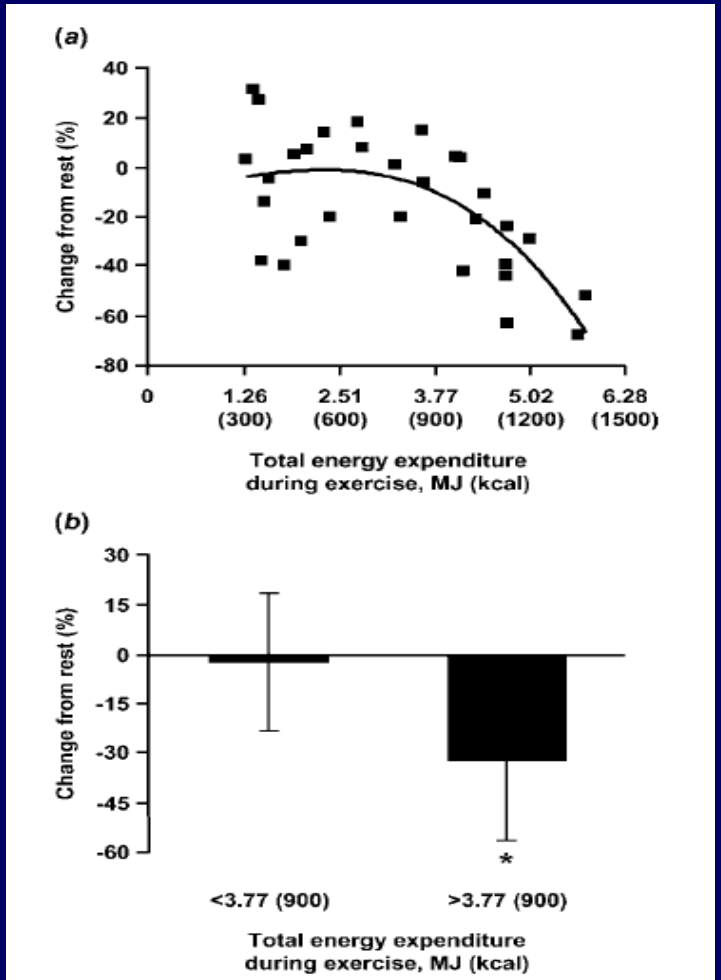
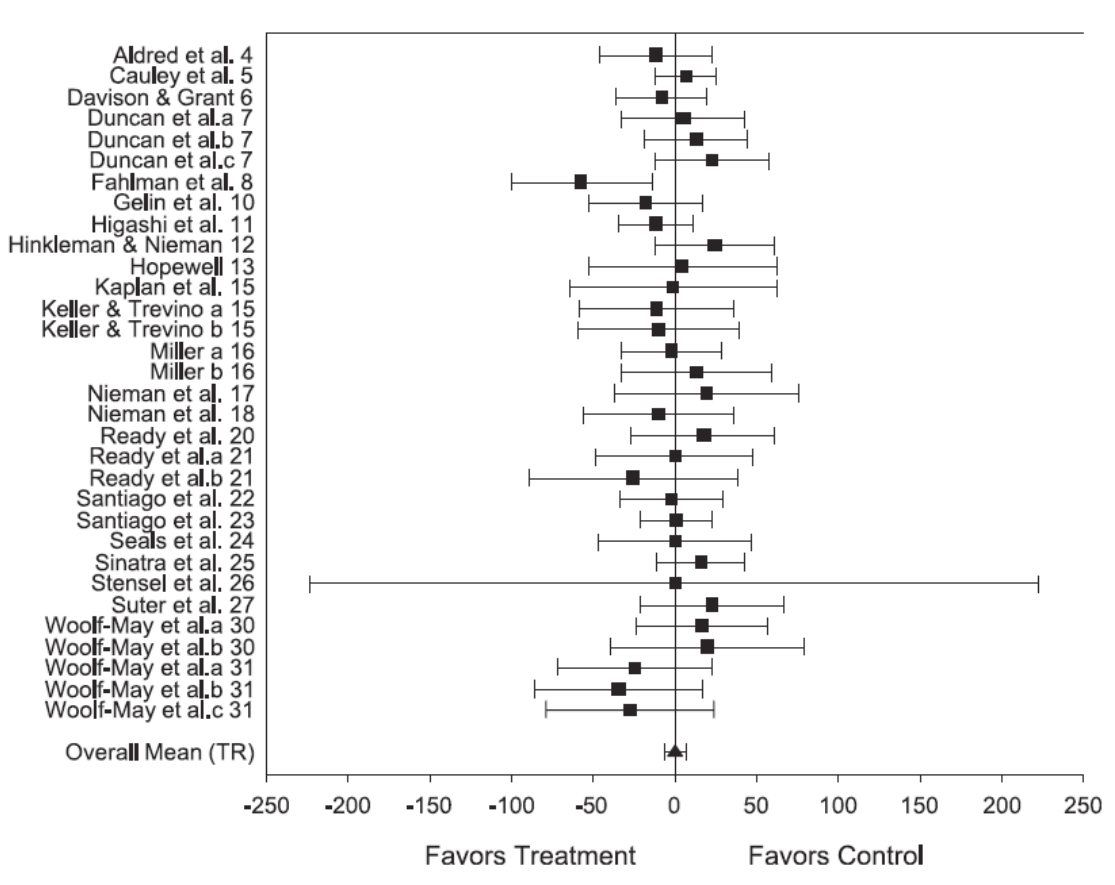


Figure 1 Exercise-induced changes in $HOMA_{IR}$ as a function of total energy expenditure during exercise (a), and for subjects who expended less than or more than 3.77 MJ (900 kcal) during the exercise bout (b)

In (b), values are means ± S.D. $^*P < 0.05$ compared with rest.

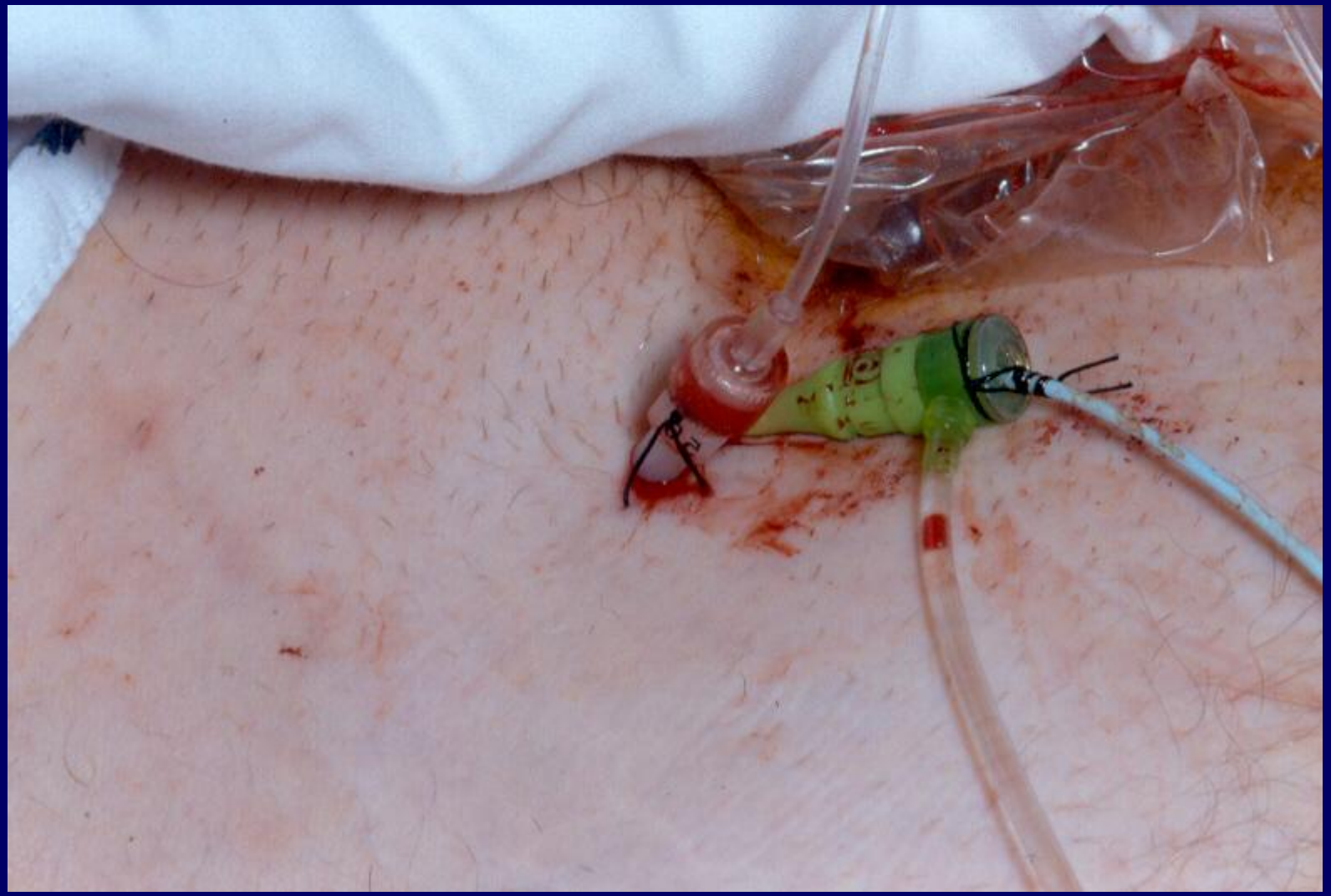
Magkos et al, Clin Sci, 2008

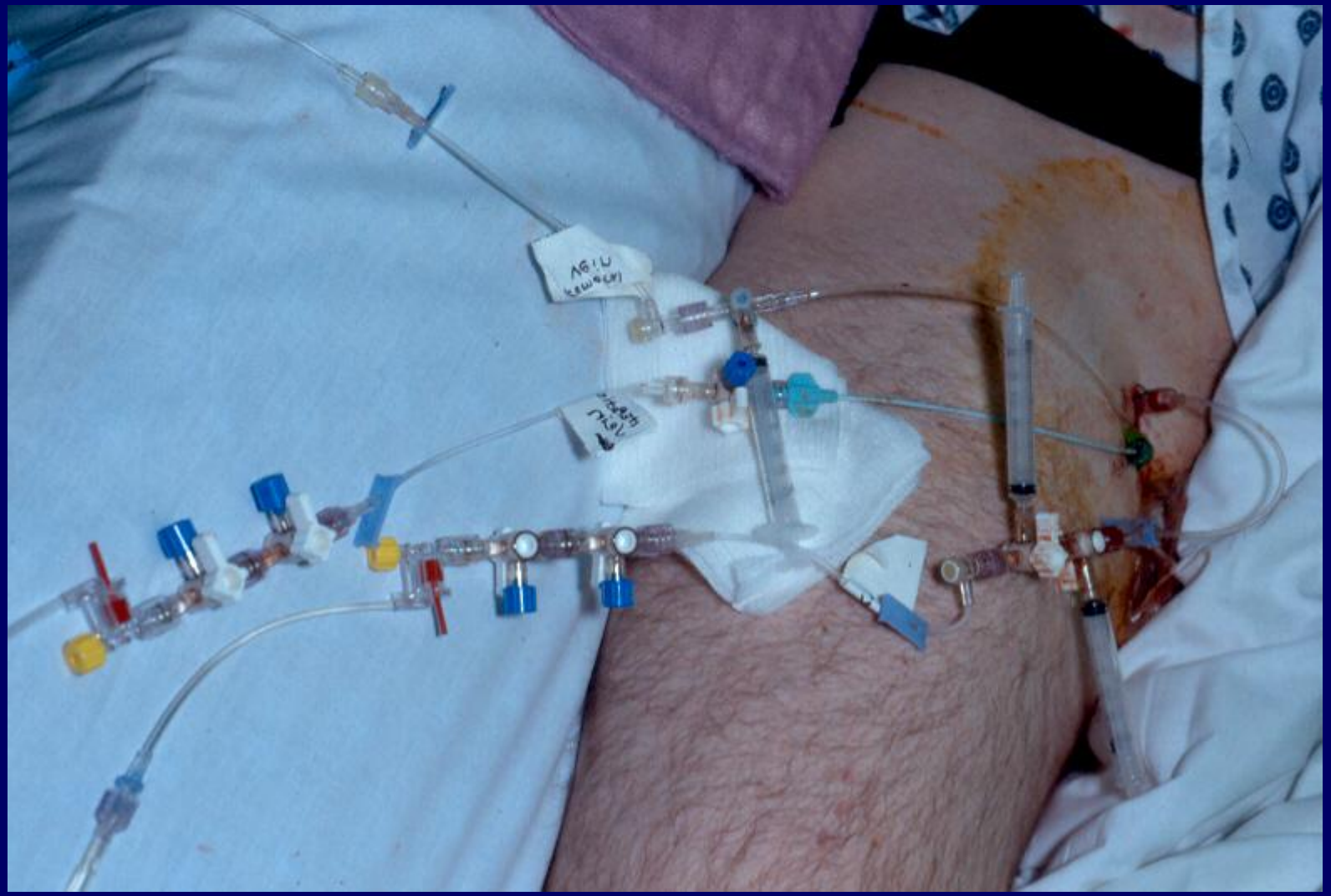
Effect of walking on fasting plasma TG



(*P*=NS)

Kelley et al (2004) Prev Med 38:651





Exercise-induced hypotriglyceridemia

The hypotriglyceridemic effect of exercise is **acute** (manifests after a single bout of exercise and is not the result of repeated exercise sessions, i.e. training) and **short-lived** (lasts for 1-2 days). Holloszy et al (1964) Am J Cardiol 14:753

	Effect of training	**Effect of a single bout**
Plasma [TG]	↓ 24% (4 – 37%)	↓ 20% (14 – 50%)

Durstine et al (2002) J Cardiopulm Rehabil 22:385

Possible mechanisms

Indirect evidence:

Increased VLDL-TG removal from plasma

- Skeletal muscle LPL mass/activity

Seip & Semenkovich (1998) Exerc Sport Sci Rev 26:191
Kiens & Richter (1998) Am J Physiol 275:E332

- Postheparin plasma LPL activity

- Clearance of exogenous TG (IVFTT)

Sady et al (1986) J Am Med Assoc 256:2552
Annuzzi et al (1987) Metabolism 36:438

Reduced VLDL-TG secretion from the liver

- Animal studies; isolated hepatic tissue

Simonelli & Eaton (1978) Am J Physiol 234:E221
Mondon et al (1984) J Appl Physiol 57:1466

- Increased ketone body concentrations

- Reduced [TG] without changes in LPL or IVFTT clearance

Herd et al (2001) Metabolism 50:756
Gill et al (2001) Eur J Clin Invest 31:201

Exercise and VLDL-TG metabolism in men

		Exercise-induced change (% from resting values)			
Exercise	Gross EE	Concentration	Secretion	Clearance	MRT
2 h cycling at 60% VO_2peak [1]	~1200 kcal	-29.5*	-8.8	29.3*	-21.2*
1.5 h running at 60% VO_2peak [2]	~925 kcal	-33.5*	-8.0	37.9*	-21.6*
1 h cycling at 60% VO_2peak [3]	~570 kcal	5.3	15.1	9.4	-7.5
1.5 h resistance exercise [4]	~500 kcal	-30.3*	-9.6	20.8*	-17.9*

[1]Magkos et al (2006) Am J Physiol Endocrinol Metab 290:E355

[2]Tsekouras et al (2007) Metabolism 56:1037

[3]Magkos et al (2007) Am J Physiol Endocrinol Metab 292:E1568

[4]Tsekouras et al (2008) Am J Physiol Endocrinol Metab