Μηχανισμοί της υποτριγλυκεριδαιμίας της άσκησης

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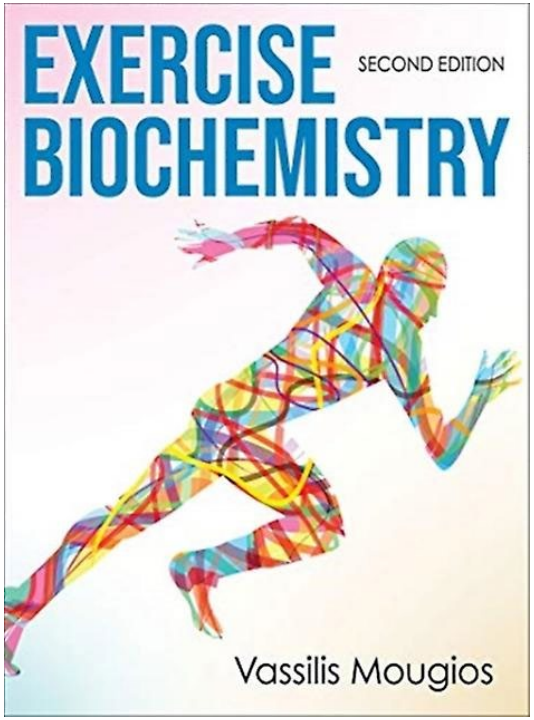
21.10
2022

Δήλωση σύγκρουσης συμφερόντων

Κανένα οικονομικό συμφέρον.

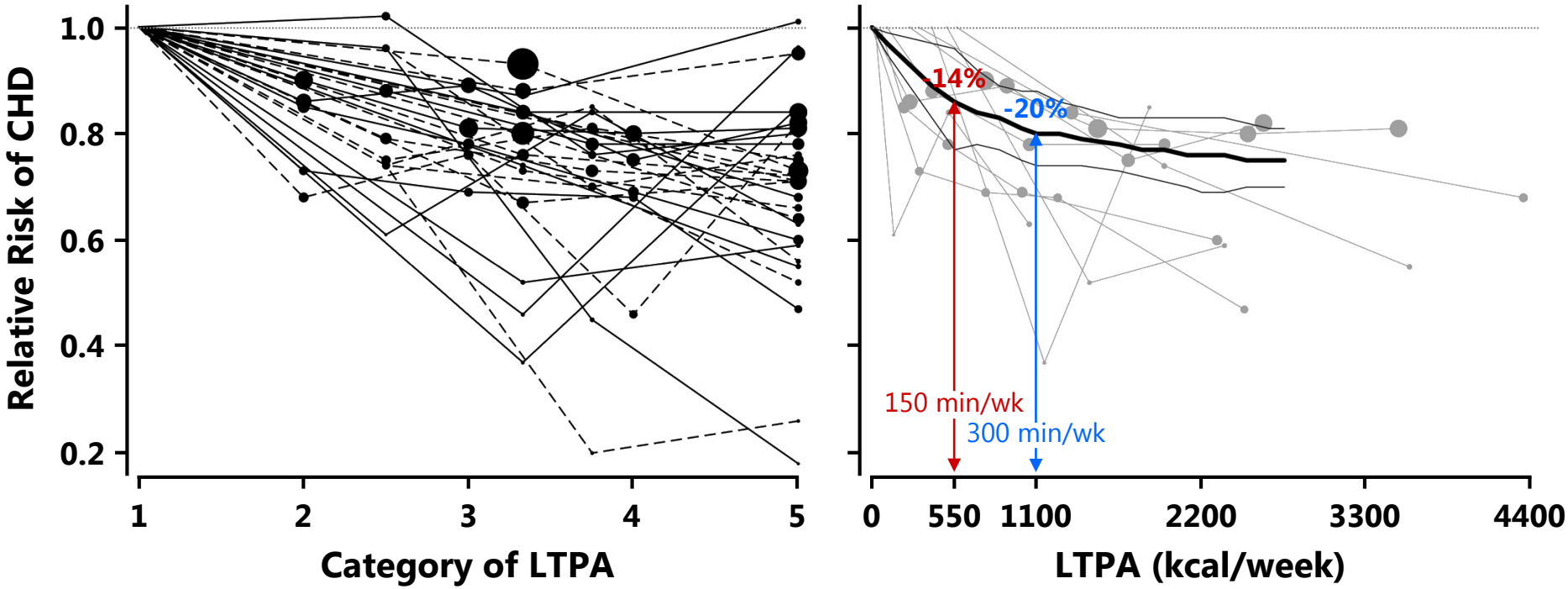
Ωστόσο, …



Περίγραμμα ομιλίας

- **Άσκηση, καρδιαγγειακά και τριγλυκερίδια**
- **Χαρακτηριστικά της υποτριγλυκεριδαιμίας της άσκησης**
- **Αλλαγές στο μεταβολισμό των VLDL και μηχανισμοί της υποτριγλυκεριδαιμίας της άσκησης**

Η τακτική σωματική δραστηριότητα ελαττώνει τον κίνδυνο καρδιαγγειακών με δοσοεξαρτώμενο τρόπο

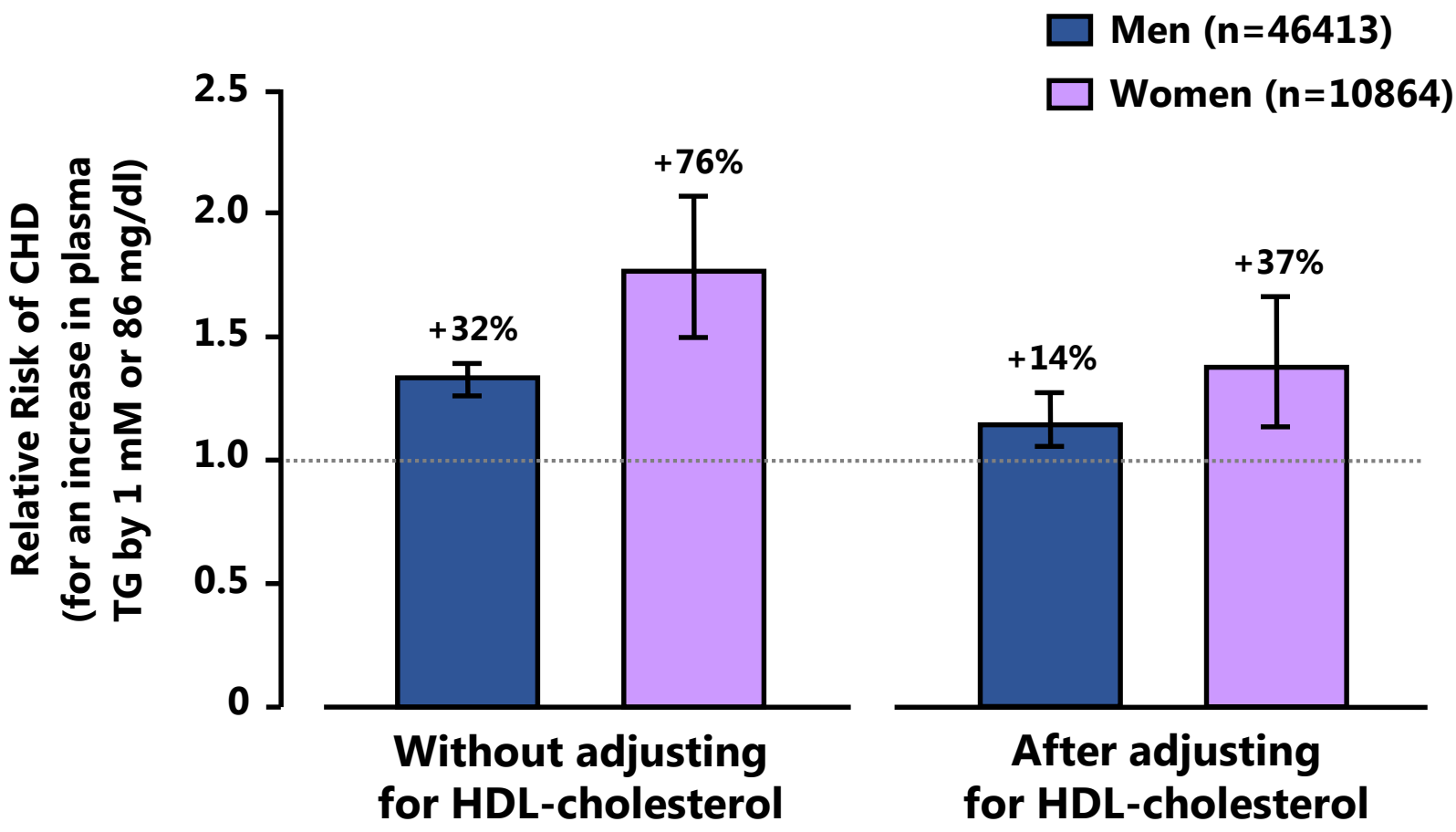


Meta-analysis of 33 prospective cohort studies of leisure-time physical activity (LTPA) and CHD risk. The summary risk indicated a **26% risk reduction** (R=0.74, 95%CI: 0.69–0.78) between the most physically active group and the referent group.

Left: Dose-response relation between LTPA, assessed categorically, and CHD risk (30 comparisons [26 studies] of 56 comparisons [33 studies]). The size of the data point corresponds to the study sample size. Dashed lines indicate studies with LTPA categorized quantitatively; solid lines, studies with LTPA categorized categorically. **Right:** Dose-response relation between quantitative estimates of LTPA, in kilocalories per week, and CHD risk (10 comparisons; 9 studies).

Sattelmair (2011) Circulation 124:789

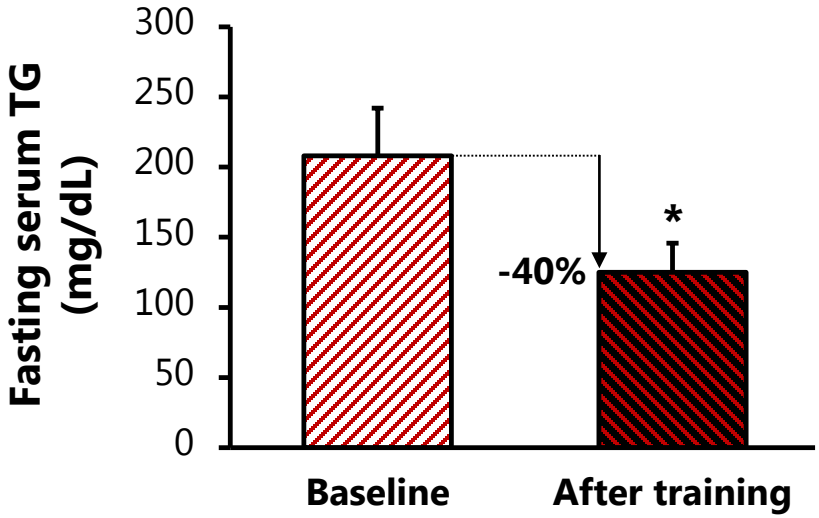
Αυξημένες συγκεντρώσεις τριγλυκεριδίων αυξάνουν τον κίνδυνο καρδιαγγειακών με δοσοεξαρτώμενο τρόπο



Hokanson (1996) J Cardiovasc Risk 3:213

Meta-analysis of 17 prospective studies

Η τακτική σωματική δραστηριότητα ελαττώνει τις συγκεντρώσεις των τριγλυκεριδίων

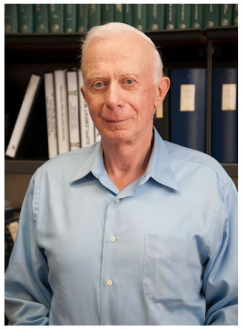


Washington University School of Medicine in St. Louis

Obituary: John O. Holloszy, former director of applied physiology, 85

Considered the father of modern exercise biochemistry

by Jim Dryden • July 25, 2018



Holloszy

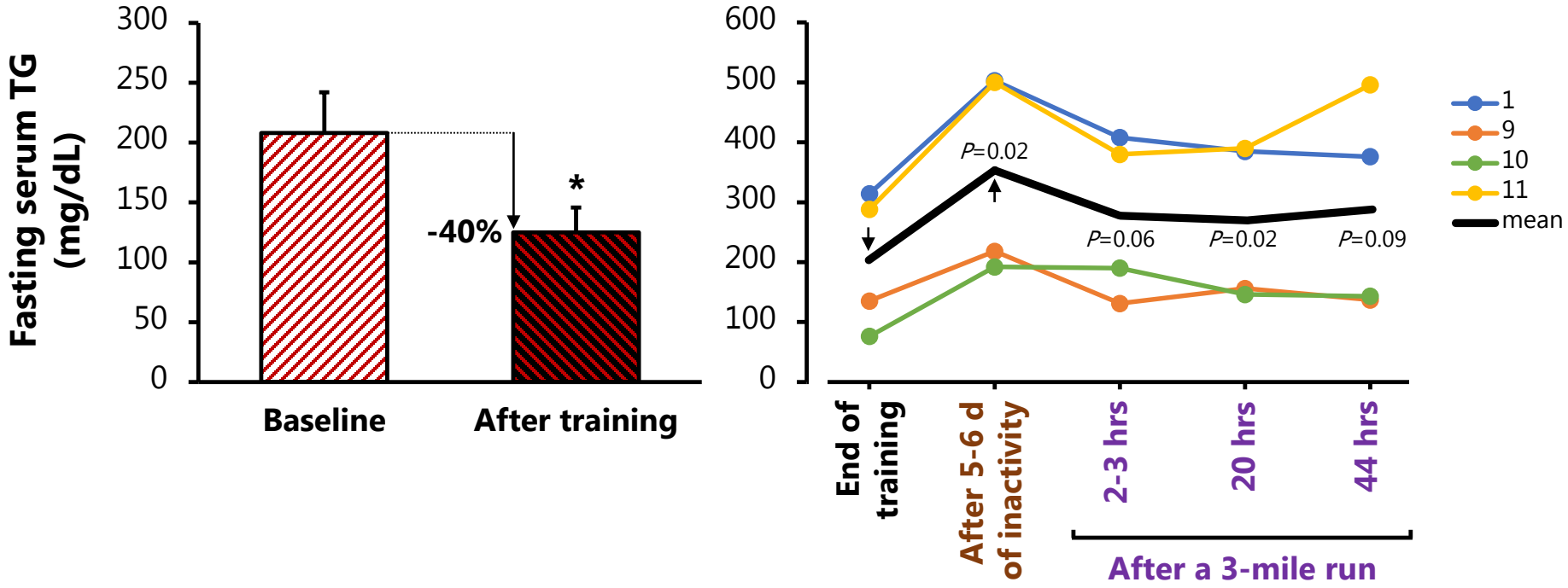
14 sedentary but non-obese men aged 35–55 years were studied before and after a six-month exercise training program (progressively more strenuous endurance calisthenics and distance running—2 to 4 miles—for an average of 3.35 times per week). Body weight remained stable. Four of these men were asked to remain inactive for 5-6 days after the end of the training program and then performed a 3-mile run. Results from these studies demonstrated that 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 (1964) Am J Cardiol 14:753

Values are mean(±SEM) or individual data; *P<0.05 vs Baseline

Είναι λοιπόν πιθανό ότι η καρδιοπροστατευτική δράση της τακτικής σωματικής δραστηριότητας οφείλεται εν μέρει στην ασκησιογενή ελάττωση των τριγλυκεριδίων στο αίμα

Η υποτριγλυκεριδαιμία της τακτικής άσκησης εμφανίζεται άμεσα και δεν είναι απάντηση στη χρόνια προπόνηση



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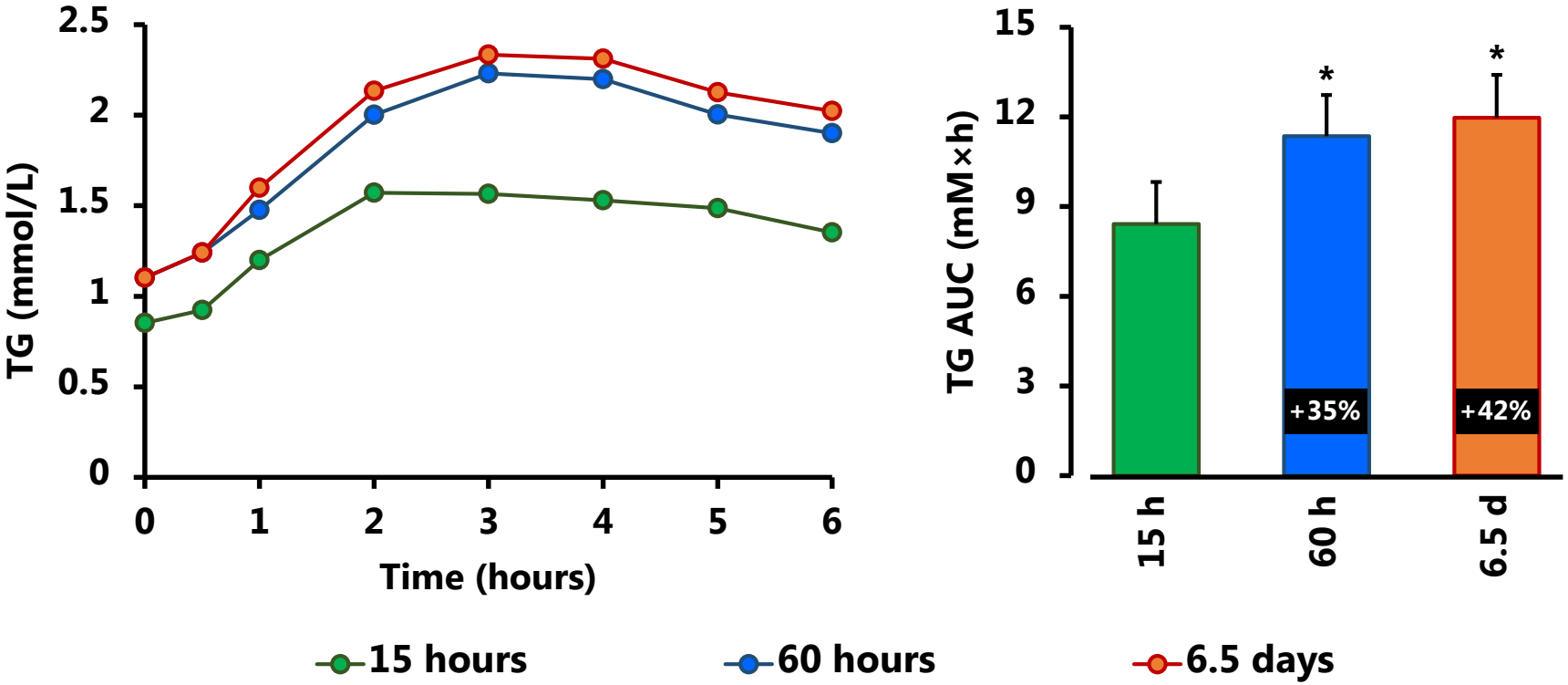
Holloszy (1964) Am J Cardiol 14:753

Values are mean(±SEM) or individual data; *P<0.05 vs Baseline

Η υποτριγλυκεριδαιμία της τακτικής άσκησης είναι βραχύβια

Plasma triglyceride concentrations before and after meal ingestion



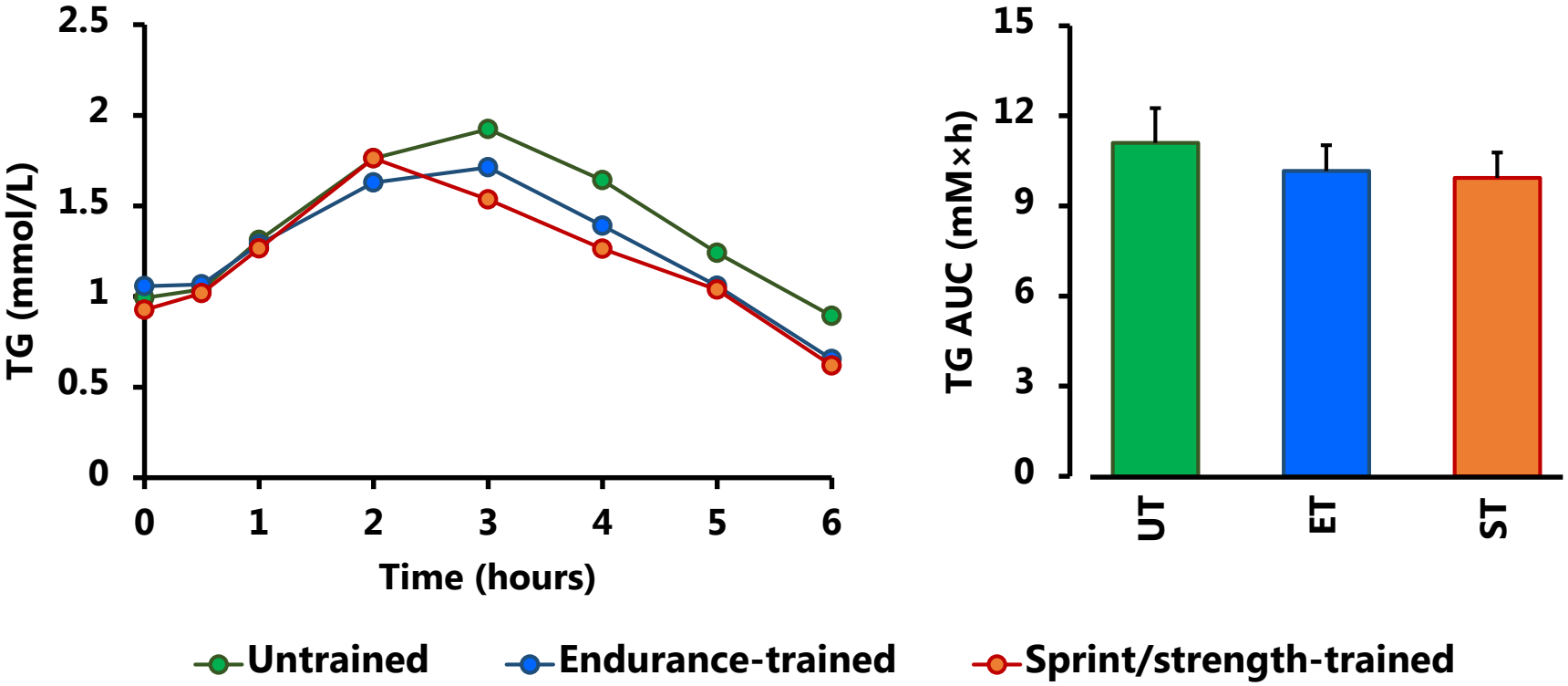
10 professional athletes, aged 18–55 years, were studied 15 h, 60 h, and 6.5 days after their last training session; plasma TG concentrations were measured before and after a high-fat meal (69% fat, 27% carbs, 4% protein). Fasting and postprandial plasma TG concentrations increased by approximately 30% and 35-42% after 60 hrs and 6.5 days without exercise, respectively.

Hardman (1998) J Appl Physiol 84:1895

Values are mean(±SEM); *P<0.05 vs 15 hours

Η υποτριγλυκεριδαιμία της τακτικής άσκησης δεν είναι εμφανής μετά από 2-3 μέρες χωρίς προπόνηση

Plasma triglyceride concentrations before and after meal ingestion

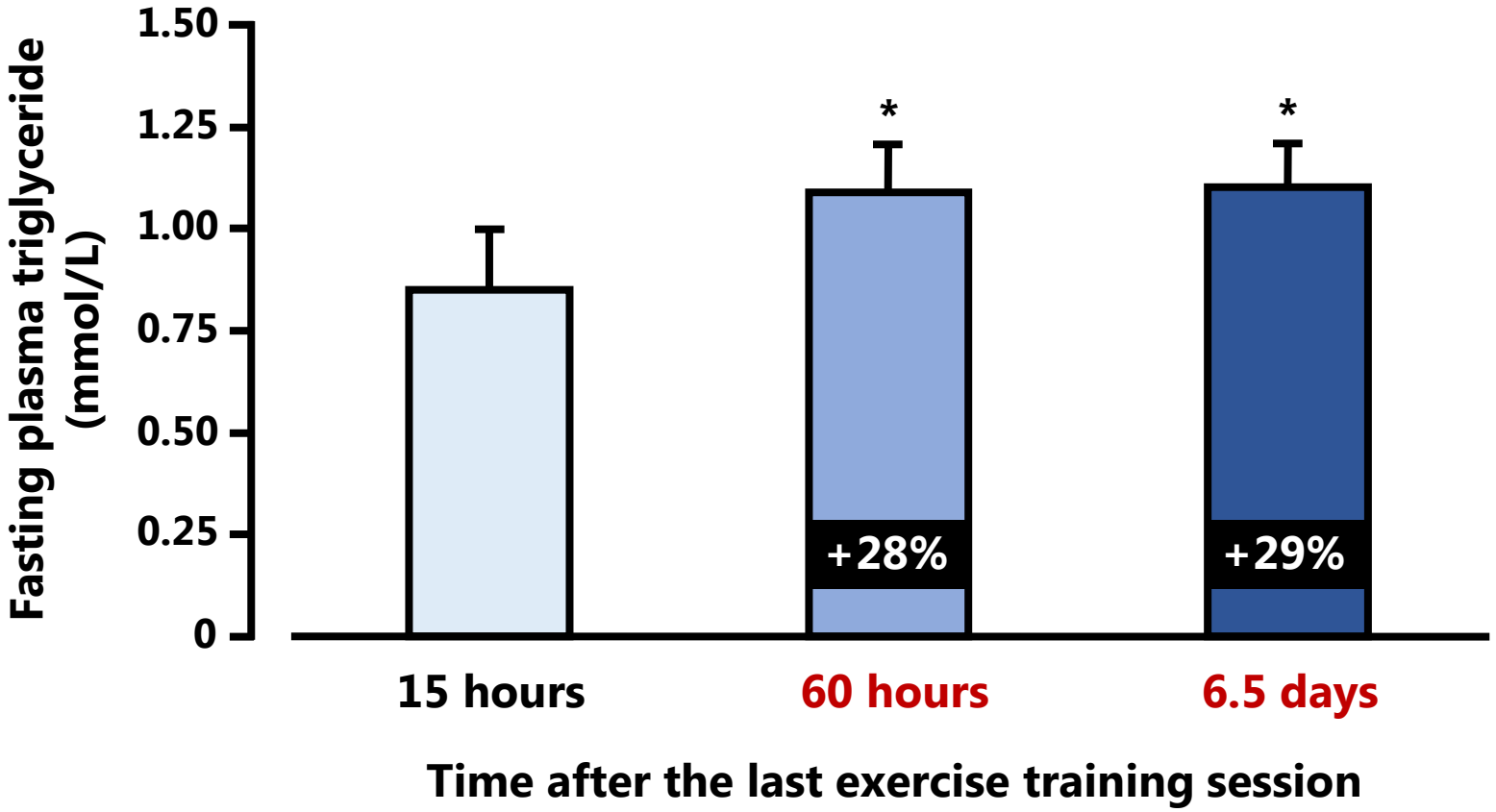


11 untrained men, 11 endurance-trained men (for 6.5 years; currently: 11 times/week), and 10 sprint/strength-trained men (for 9 years; currently 5.5 times/week), aged 18-35 years, with body fat ≤28%, were studied **60 hours after their last training session** (for the athletes); plasma TG concentrations were measured before and after a high-fat meal (69% fat, 27% carbs, 4% protein).

Herd (2000) J Appl Physiol 89:2049

Values are means (±SEM)

Η υποτριγλυκεριδαιμία της άσκησης στο μεταπορροφητικό στάδιο (νηστεία) είναι βραχύβια

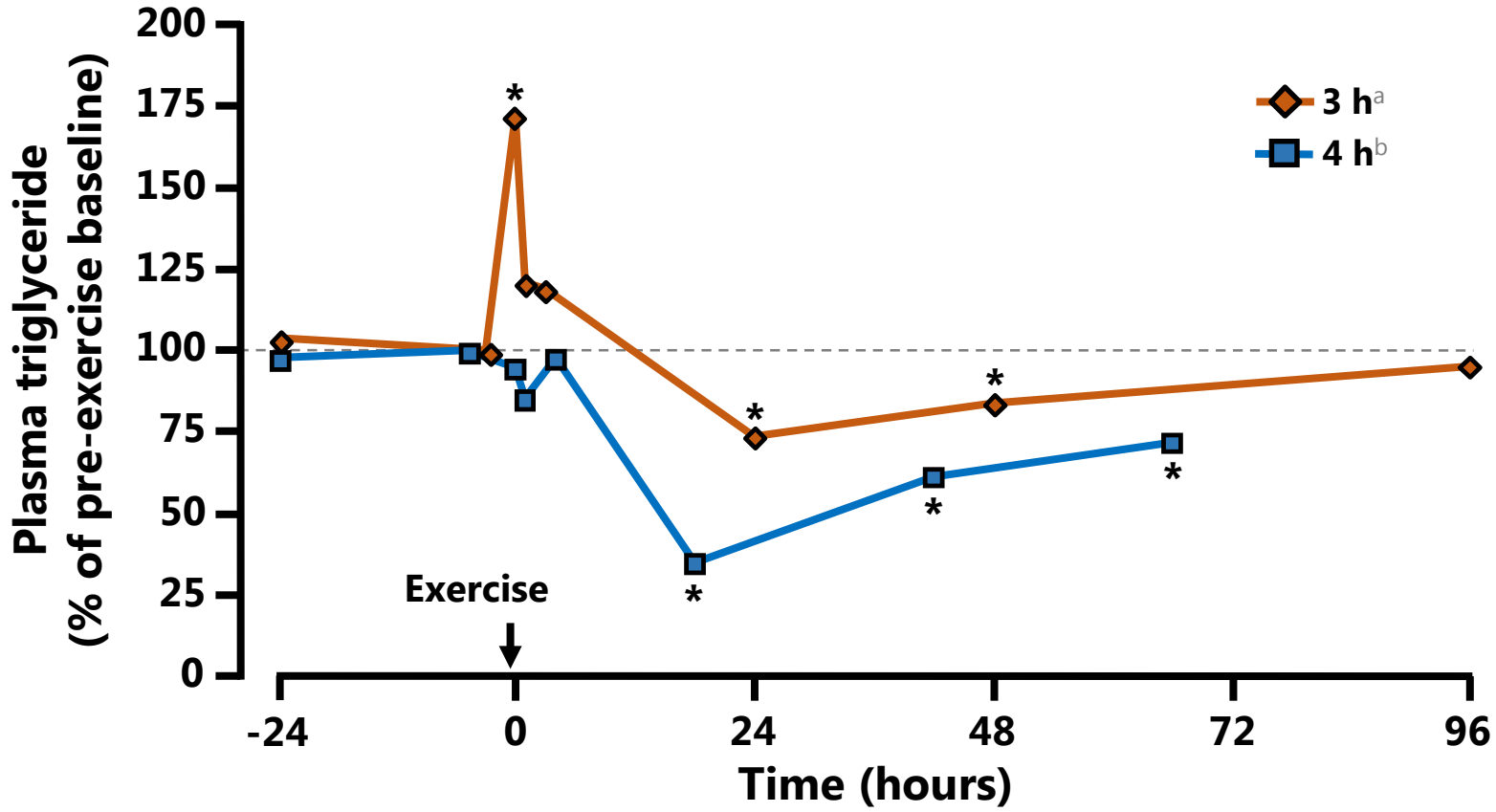


10 professional athletes, aged 18–55 years, were studied 15 h, 60 h, and 6.5 days after their last training session; fasting plasma TG concentrations increased by ~30% after 60 hrs and 6.5 days without exercise.

Hardman (1998) J Appl Physiol 84:1895

Values are mean±SEM; *P<0.05 vs 15 hours

Εμφανίζεται με καθυστέρηση 12-24 ωρών από το τέλος της άσκησης

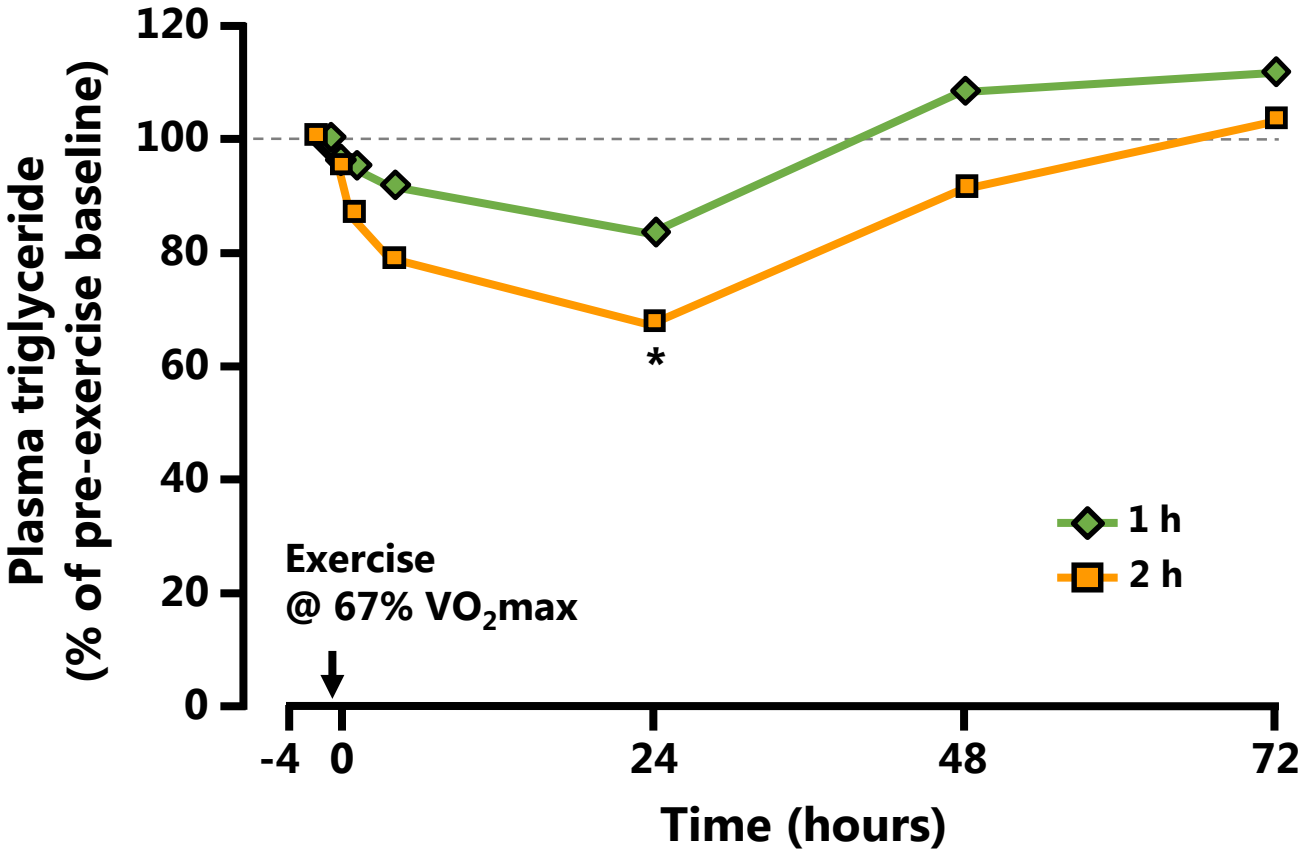


[a]14 recreationally active men, aged 20–28 years, ran for 3 h at 75% of lactate threshold; [b]12 trained men, aged 24–50 years, ran 42 km at race pace which took, on average, 3.9 h for completion. The exercise-induced reduction in fasting plasma TG concentration occurs with a delay of 12–18 h and lasts for 2–3 days (time 0 is immediately post-exercise).

[a]Dufaux (1986) Metabolism 35:105; [b]Thompson (1980) Metabolism 29:662

*P<0.05 vs baseline

Εμφανίζεται πάνω από κάποιο κατώφλι άσκησης

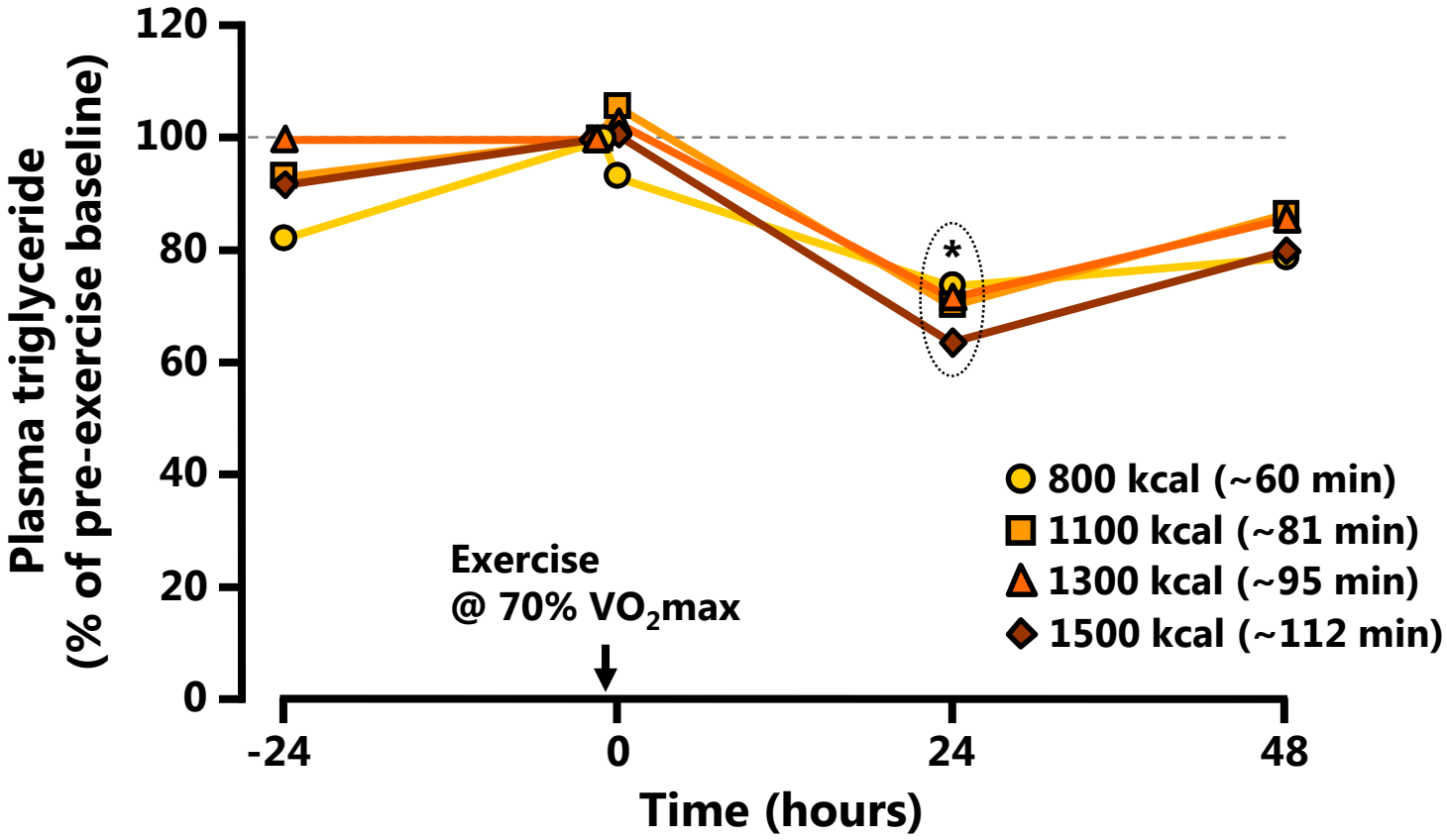


9 trained subjects, aged 18–37 years, cycled for 1 h and 2 h at 67% of VO_2max (time 0 is immediately post-exercise). A certain threshold of energy needs to be expended during exercise for hypotriglyceridemia to manifest, whereas less exercise does not significantly lower fasting plasma TG concentrations.

Cullinane (1982) Metabolism 31:844

*P<0.05 vs baseline

Κάνει plateau πάνω από κάποιο άλλο κατώφλι άσκησης

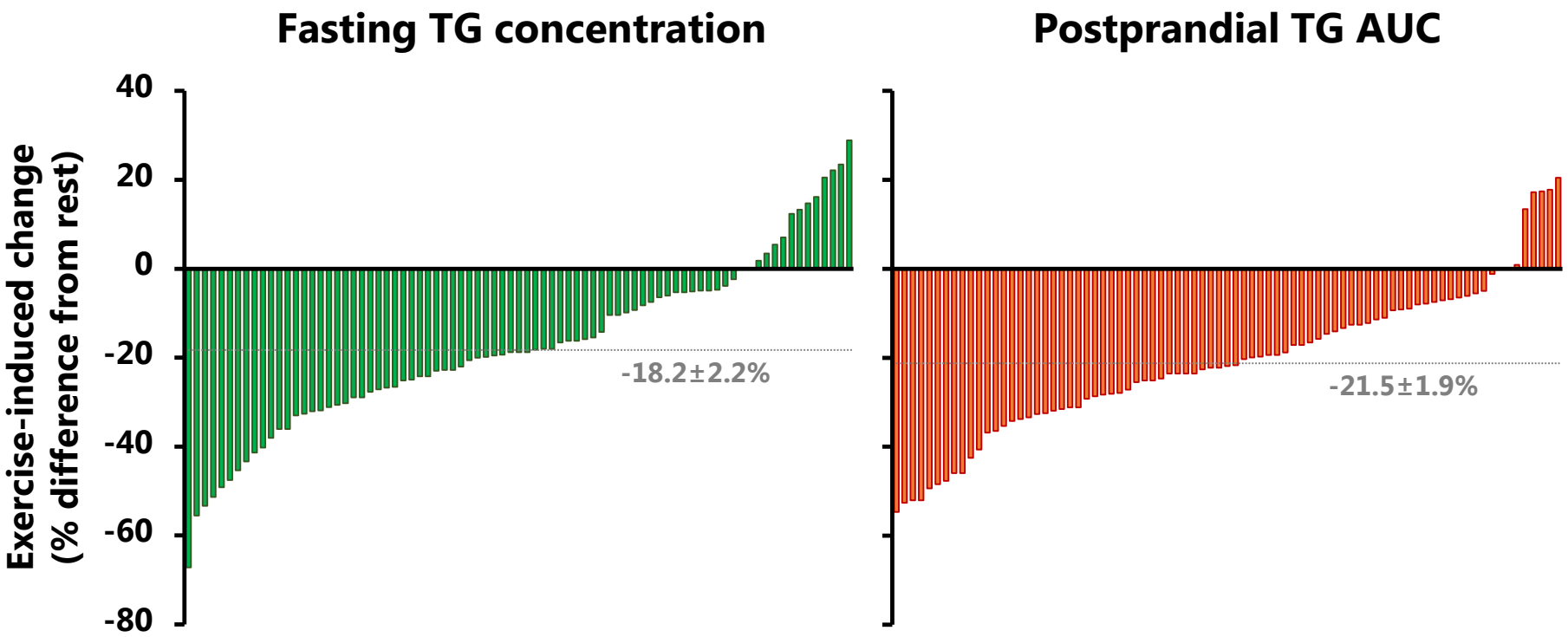


11 trained men, aged 21–44 years, ran at 70% of VO_2max until 800, 1100, 1300, and 1500 kcal were expended (time 0 is immediately post-exercise). The hypotriglyceridemic effect of exercise plateaus after a certain energy expenditure threshold is achieved; more exercise does not elicit greater reductions in plasma TG concentrations.

Ferguson (1998) J Appl Physiol 85:1169

*P<0.05 vs baseline

Έχει μεγάλη διακύμανση μεταξύ διαφορετικών ατόμων

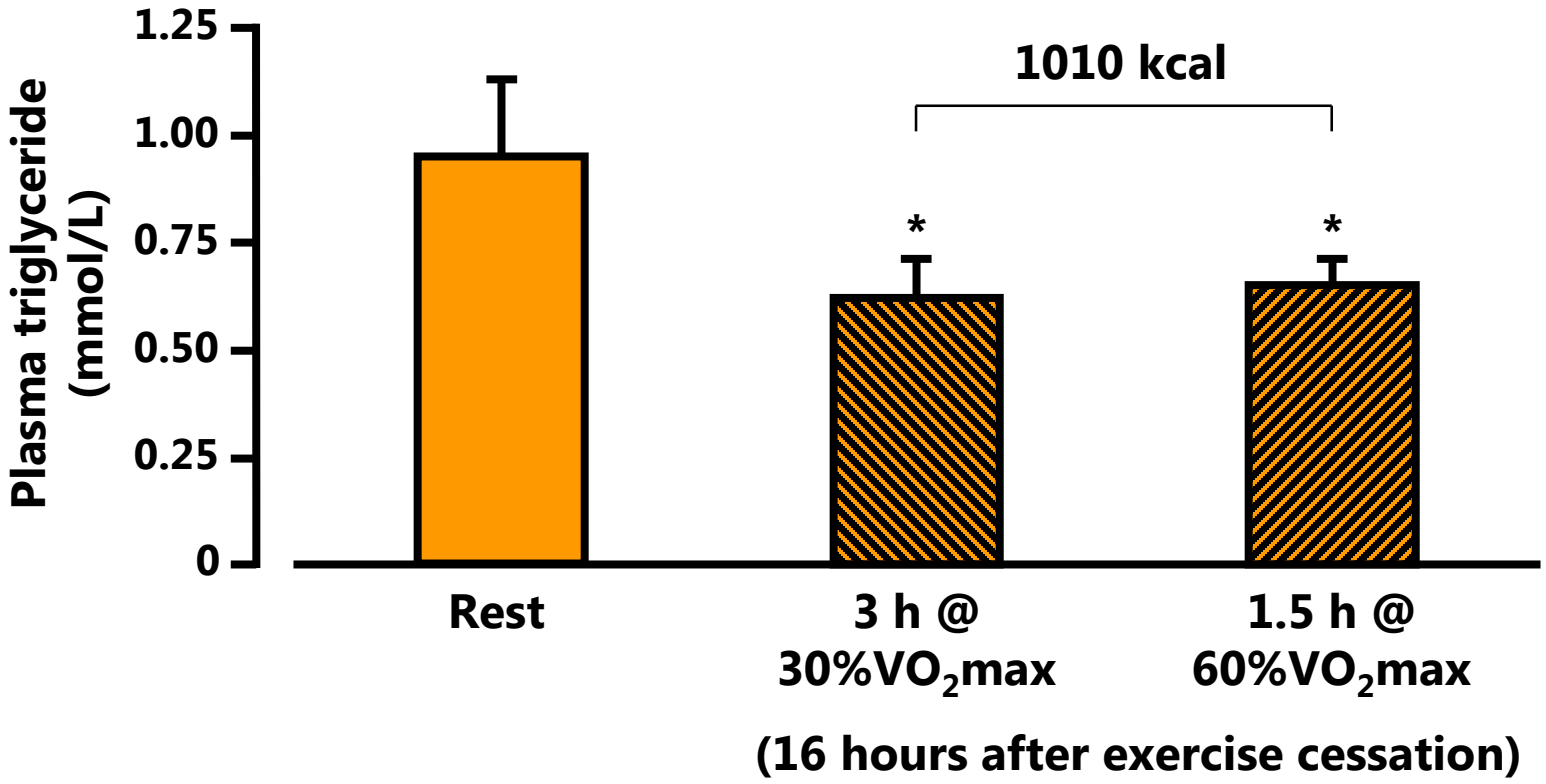


81 subjects (38 men and 43 women; aged 21-64 years, BMI 23.9±0.3 kg/m^2, VO_2max 41.2±1.1 ml/kg·min) participated in two 6-hour oral fat tolerance tests (17 kcal/kg BW; 66% from fat, 29% from carbohydrate, 5% from protein), in random order separated by 5-10 days. On the previous afternoon, they completed a single 90-minute bout of exercise (walking, jogging or running on a motorized treadmill, or cycling on a stationary ergometer) at moderate intensity (61.9±0.4% of VO_2max), or an equivalent period of rest.

Gill (2002) Clin Sci (Lond) 102:223

Values are individual data

Εξαρτάται από την ενεργειακή δαπάνη της άσκησης (διάρκεια και ένταση)

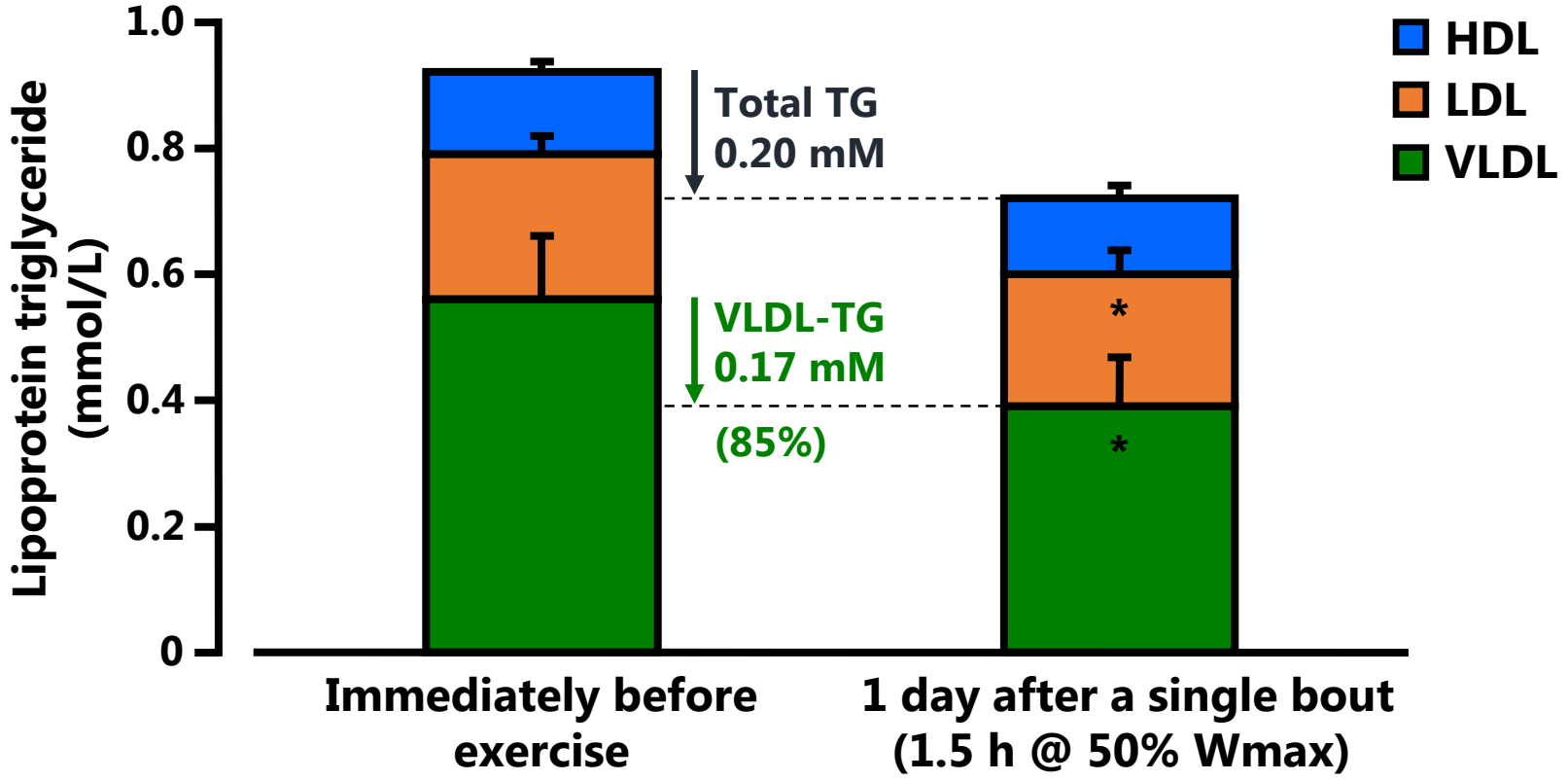


9 recreationally active men and women, aged 25–32 years, exercised for 1.5 hrs at 60% of VO_2max (1020 kcal) or 3 hrs at 30% of VO_2max (1000 kcal), or rested, and measurements were performed 16 h later. Exercise intensity and duration are interchangeable when the total energy expenditure is held constant, in that they result in similar reductions in fasting plasma TG concentrations.

Tsetsonis (1996) Med Sci Sports Exerc 28:1235

*P<0.05 vs rest

Οφείλεται κυρίως σε μειωμένη συγκέντρωση τριγλυκεριδίων στις VLDL

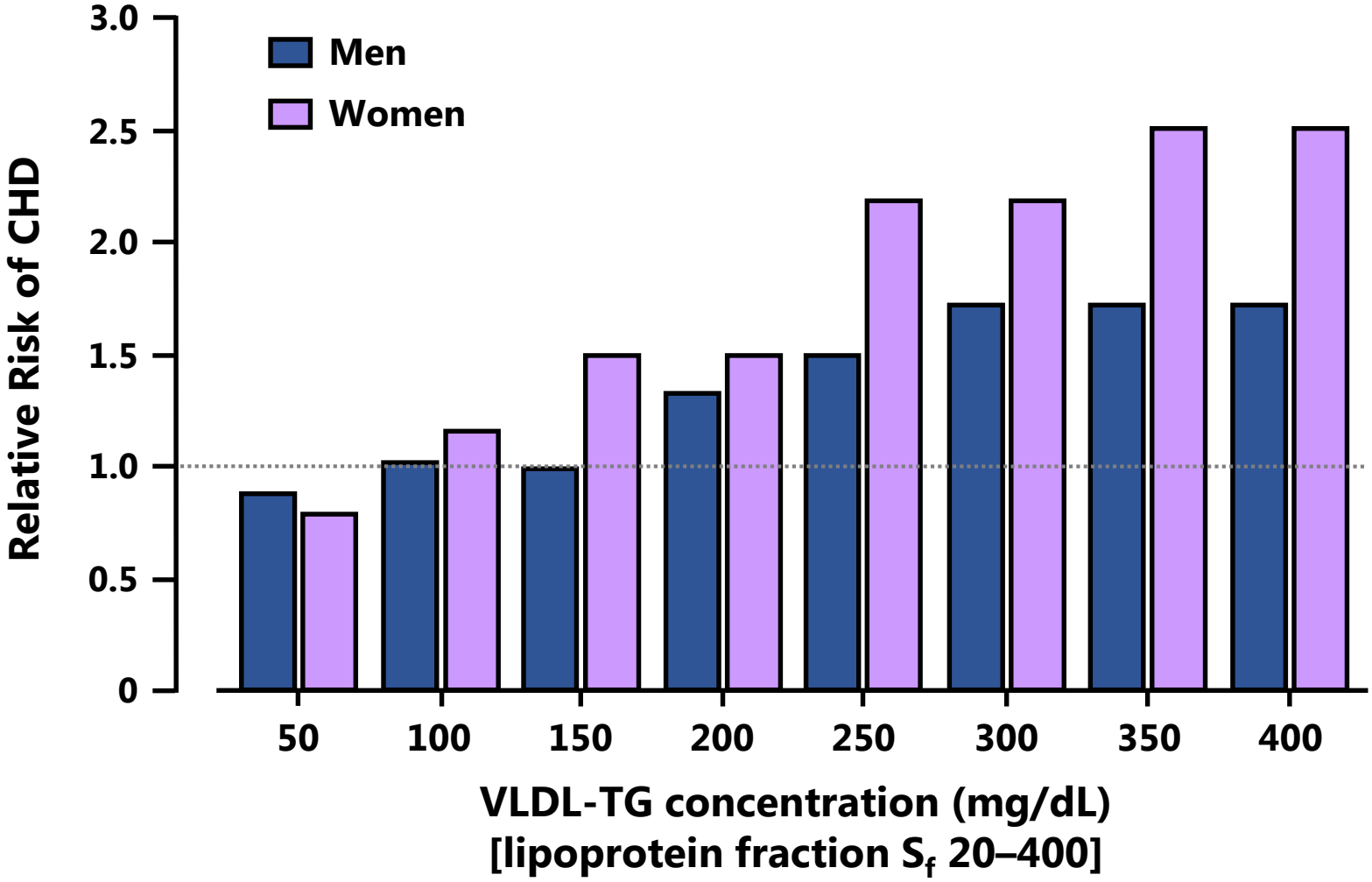


10 recreationally active men, aged 24–33 years, exercised for 1.5 h at 50% of maximal workload and fasting blood samples were collected before and 1 day after exercise for lipoprotein fractionation. The lowering of total plasma TG concentration the day after exercise is primarily due to reduced TG concentrations in VLDL with little if any change in TG concentration in LDL and HDL.

Annuzzi (1987) Metabolism 36:438

*P<0.05 vs rest

Αυξημένες συγκεντρώσεις VLDL-TG αυξάνουν τον κίνδυνο καρδιαγγειακών

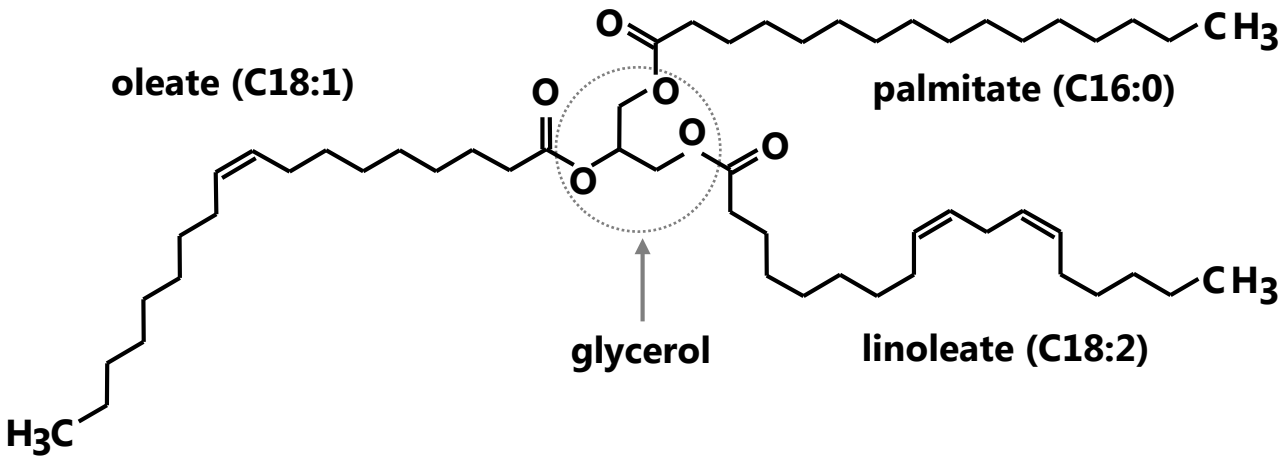


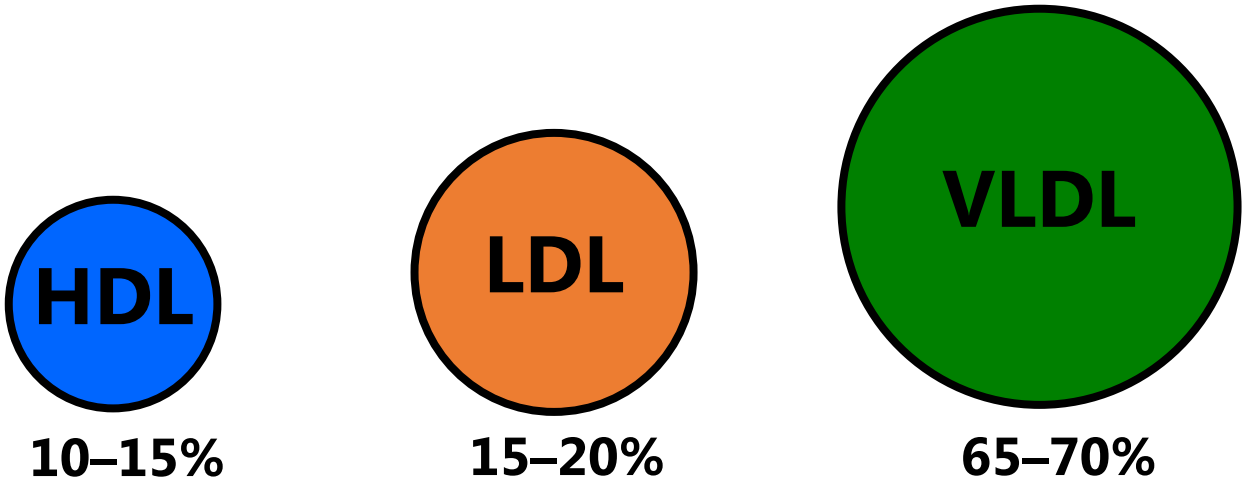
Castelli (1992) Am J Cardiol 70:3H

The Framingham Heart Study (n=5127, follow-up 30 yr), univariate

Τι είναι οι VLDL;

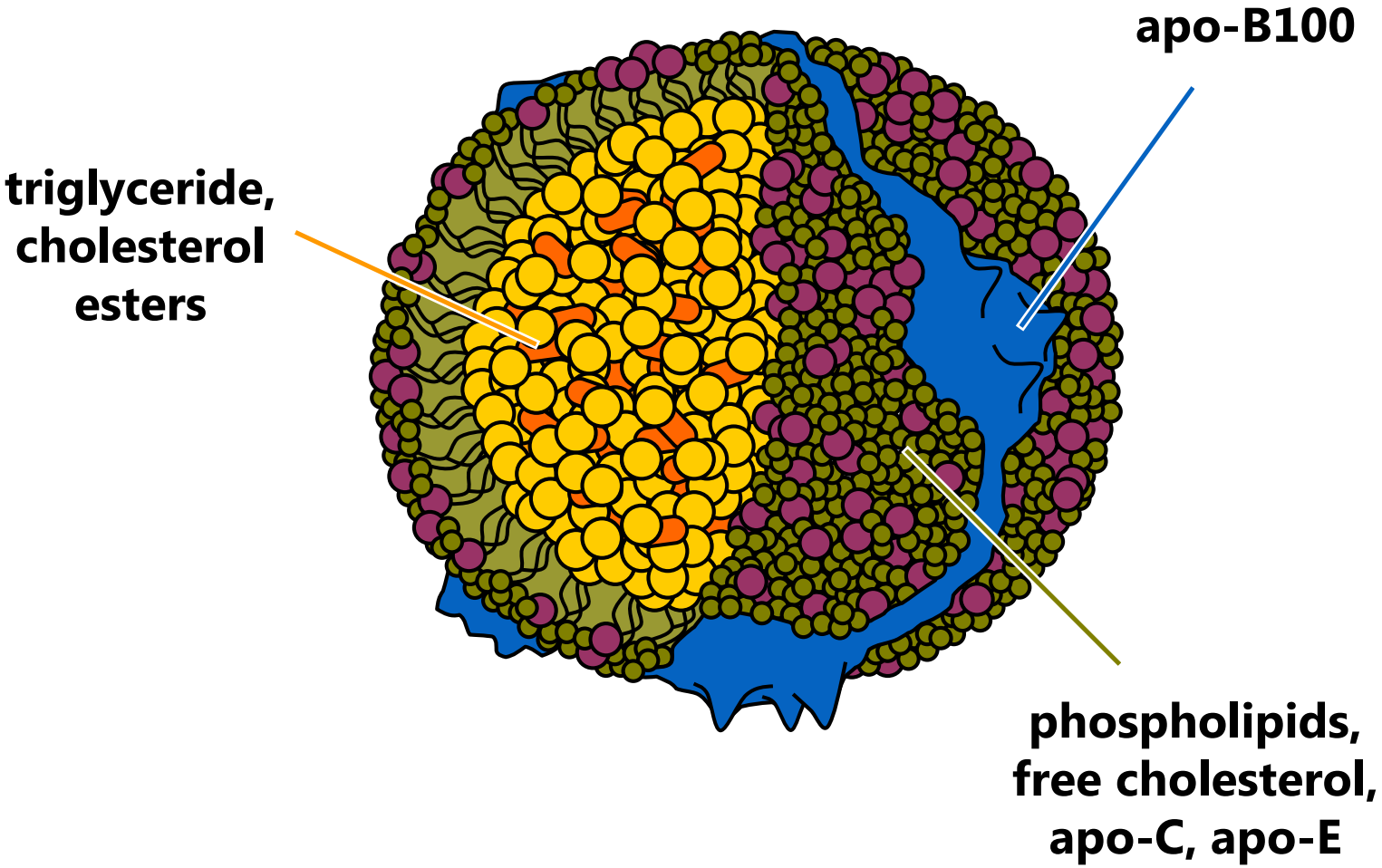
Δομή των τριγλυκεριδίων και μεταφορά τους στο αίμα κατά το στάδιο της νηστείας



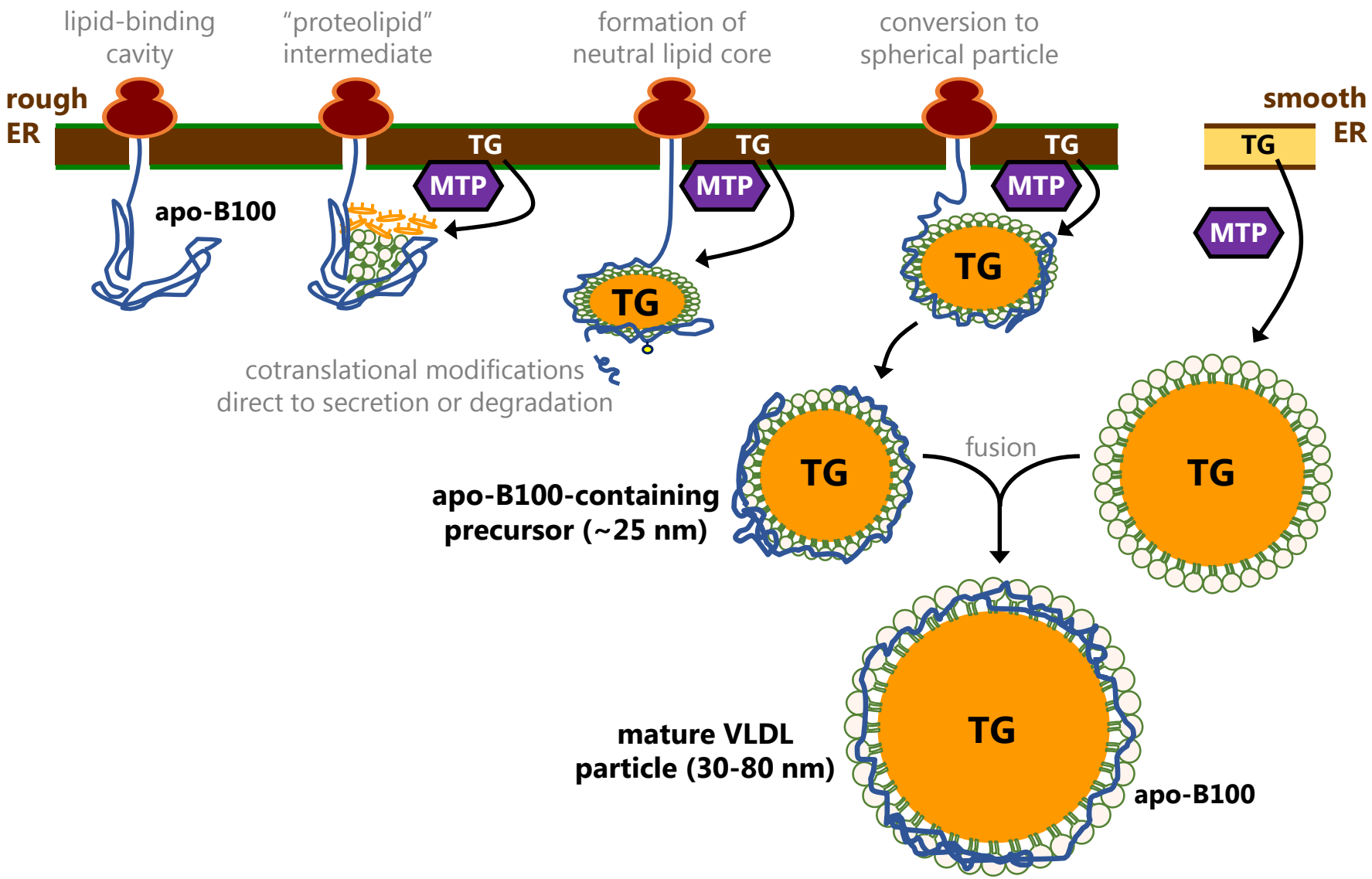


Wahl (1981) Atherosclerosis 39:111

Δομή των λιποπρωτεϊνών πολύ χαμηλής πυκνότητας (VLDL)

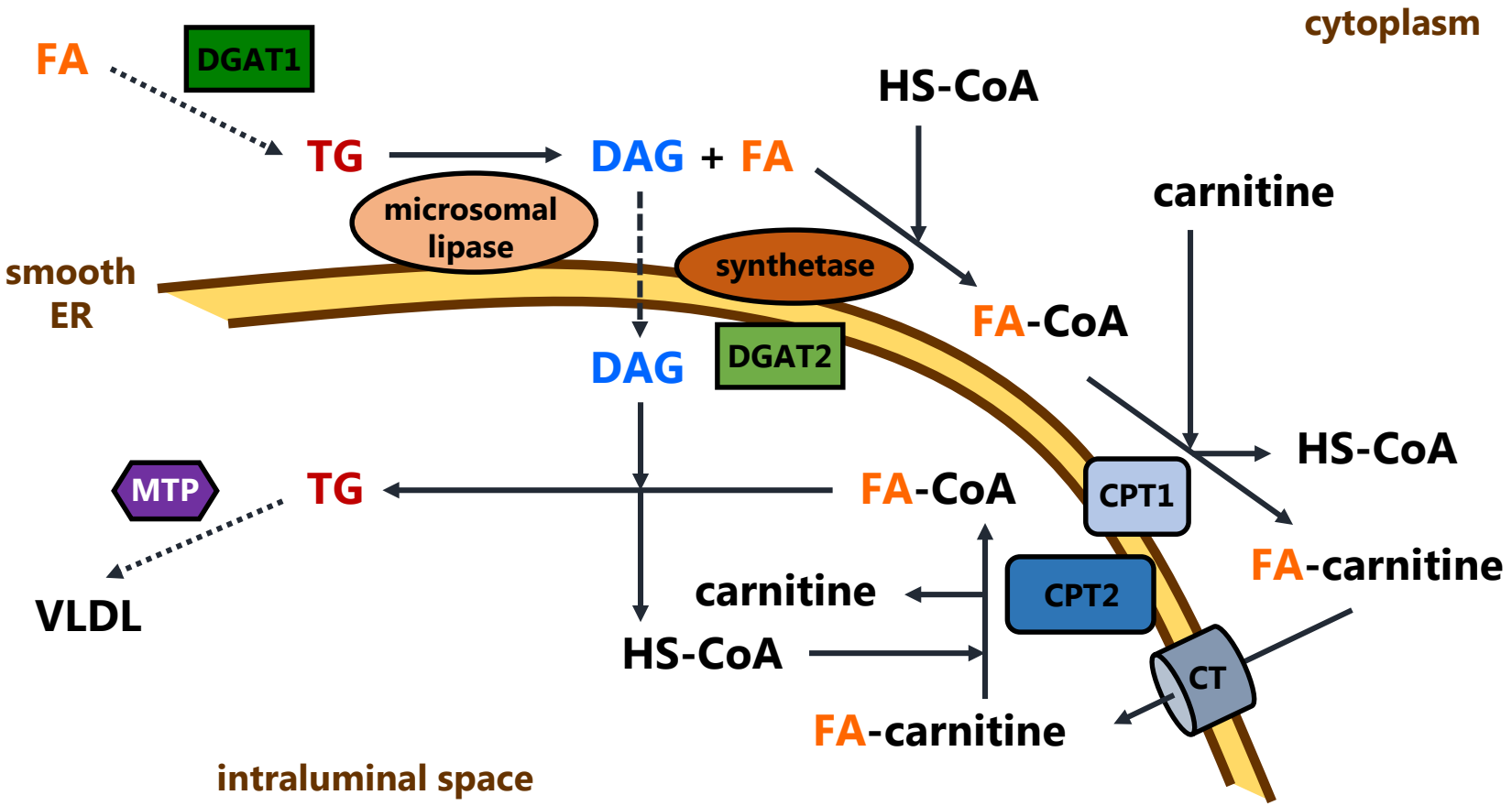


Σύνθεση των VLDL στο ενδοπλασματικό δίκτυο σε δύο στάδια



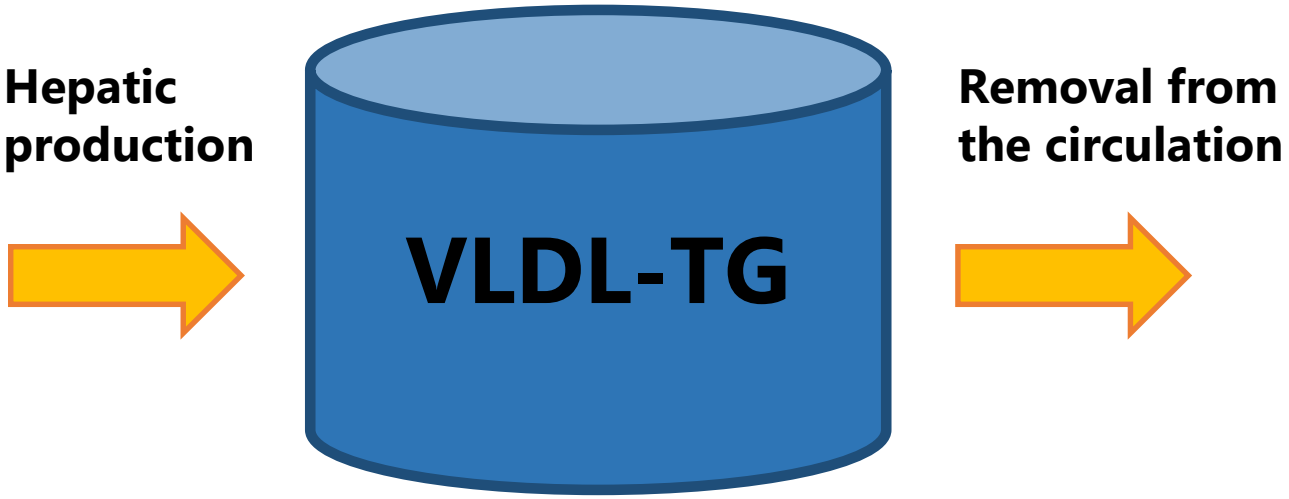
Shelness (2001) Curr Opin Lipidol 12:151

Προέλευση των τριγλυκεριδίων των VLDL: λιπόλυση και επανεστεροποίηση



Magkos (2009) Prog Lipid Res 48:171; Abo-Hashema (1999) J Biol Chem 274:35577

Ομοιόσταση των VLDL-TG: η απλή εικόνα



When the concentration in the bloodstream is constant (e.g. in the postabsorptive state), the rate of influx must equal the rate of efflux.

Ποιοι είναι οι πιθανοί μηχανισμοί με τους οποίους η άσκηση ελαττώνει τη συγκέντρωση των VLDL-TG;

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

- 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

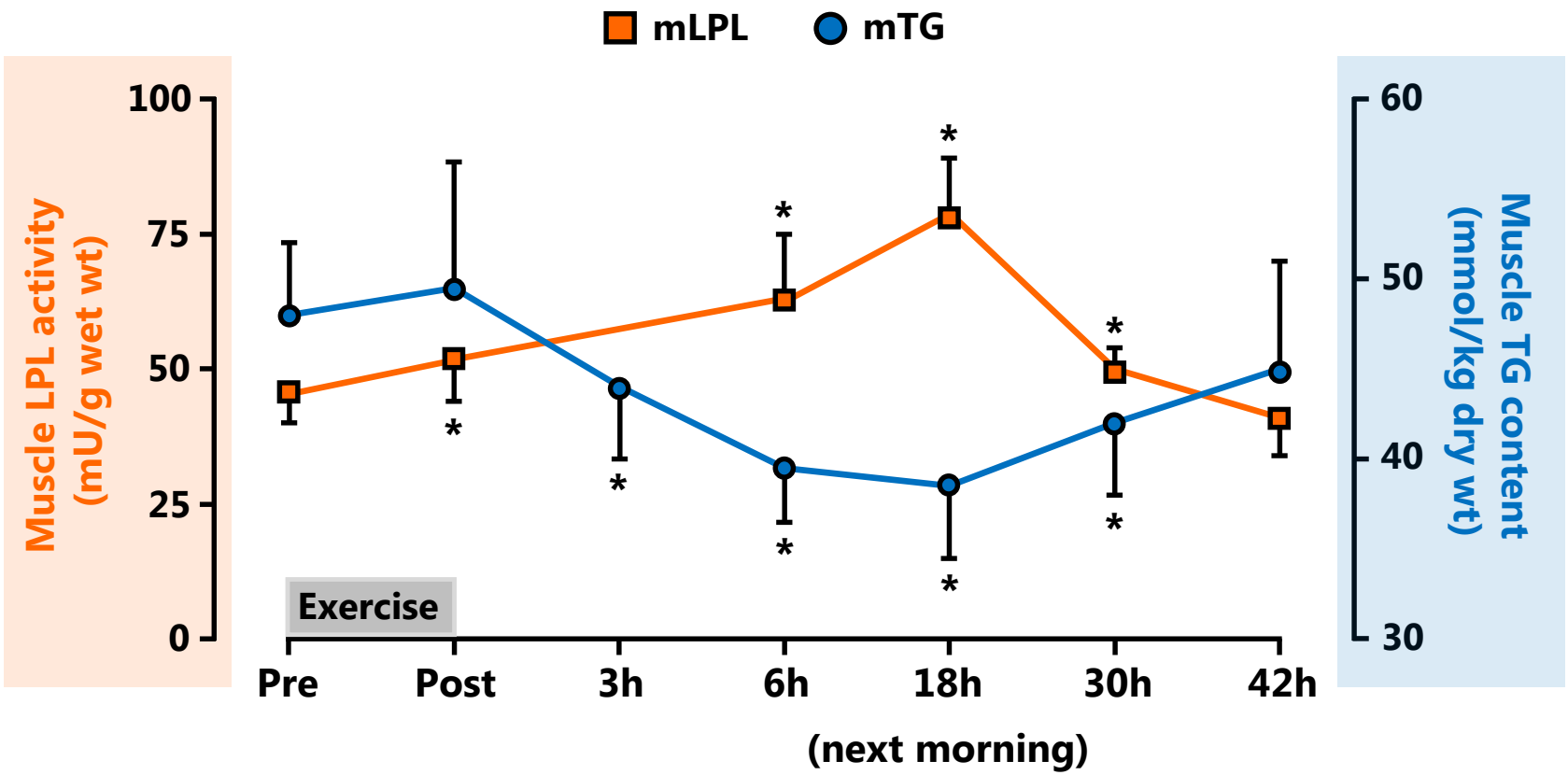
Mondon et al (1984) J Appl Physiol 57:1466

- Reduced [TG] without changes in mLPL or IVFTT *k*

Herd et al (2001) Metabolism 50:756

Gill et al (2001) Eur J Clin Invest 31:201

Μία συνεδρία εξαντλητικής άσκησης αυξάνει τη δραστικότητα της λιποπρωτεϊνικής λιπάσης στο μυ

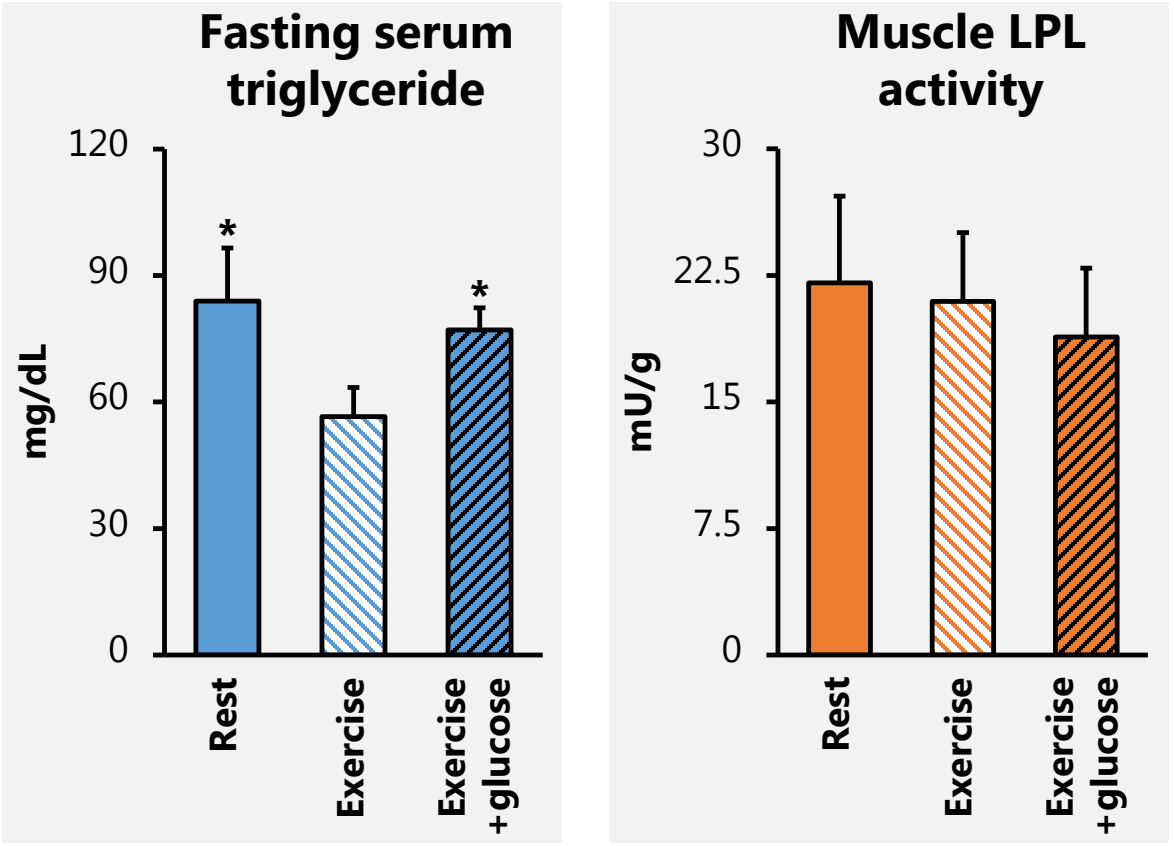


8 male athletes completed glycogen-depleting exercise (20 min at 75% of VO_2max followed by ~90 min of 2-min stages at 50%-90% of VO_2max); no other exercise for 2 days before and after, and controlled diet; biopsies from the vastus lateralis muscle for LPL and TG analyses.

Kiens & Richter (1998) Am J Physiol 275:E332

Values are means±SEM; *P<0.05 vs pre

Η υποτριγλυκεριδαιμία της άσκησης μπορεί να εμφανιστεί απουσία αυξημένης LPL στο μυ



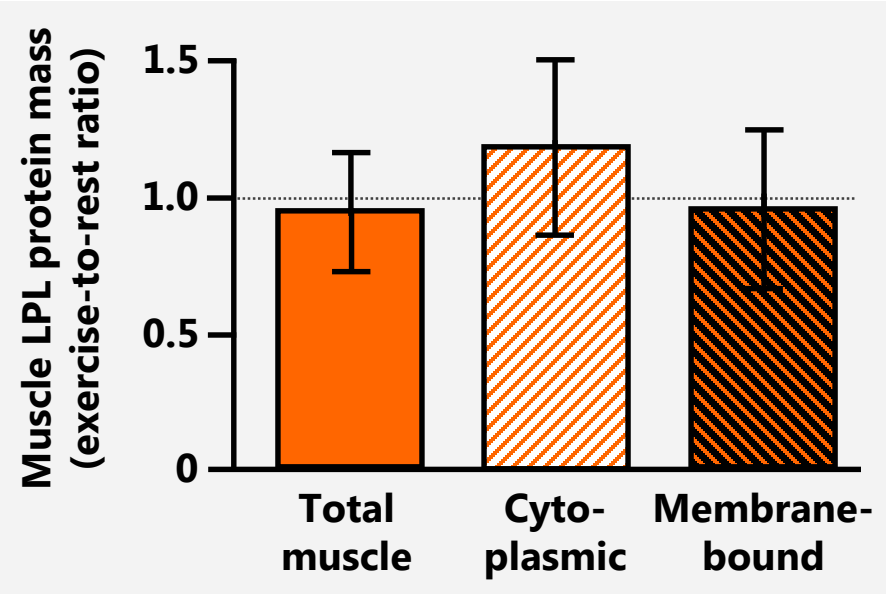
8 moderately active men (age 26.9±1.4 years, VO_2peak 46.8±1.7 mL/kg·min, BMI 26.0±1.3 kg/m^2, body fat 15.2±1.8%) performed three trials in random order separated by seven days: evening rest (control), evening exercise without subsequent food intake (cycling for 90 min at 70% VO_2peak, followed by ten 1-min full effort sprints interspersed with 1 min of resting recovery; total EE ~1500 kcal), and evening exercise with subsequent glucose intake (~370 g) to replace all expended energy. The next morning a muscle biopsy and a fasting blood sample were obtained.

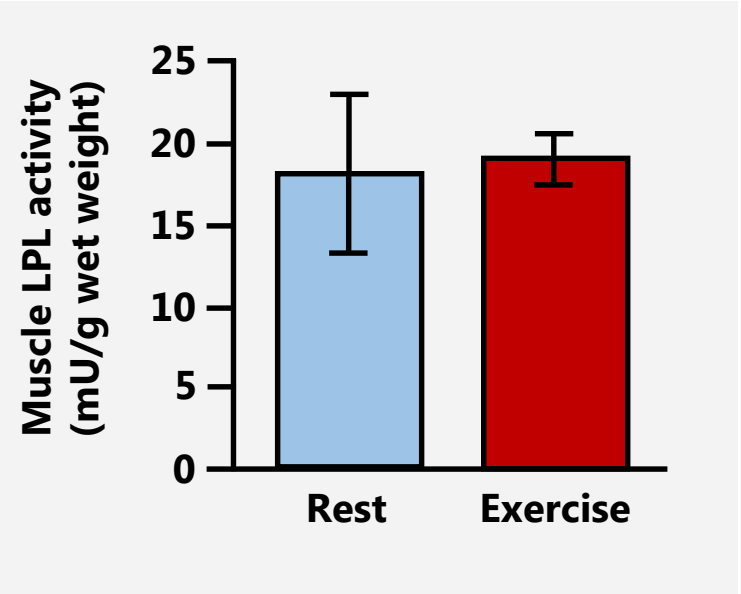
Harrison (2012) Lipids Health Dis 11:64

Values are mean±SEM; *P<0.05 vs Exercise

Η υποτριγλυκεριδαιμία της άσκησης μπορεί να εμφανιστεί απουσία αυξημένης LPL στο μυ

Lower (by 20-30%) fasting and postprandial triglyceride concentrations 12-24 hours after a single bout of prolonged (90-120 min) but non-exhaustive aerobic exercise at moderate intensity are not accompanied by changes in protein mass[a] and activity[b] of skeletal muscle LPL.



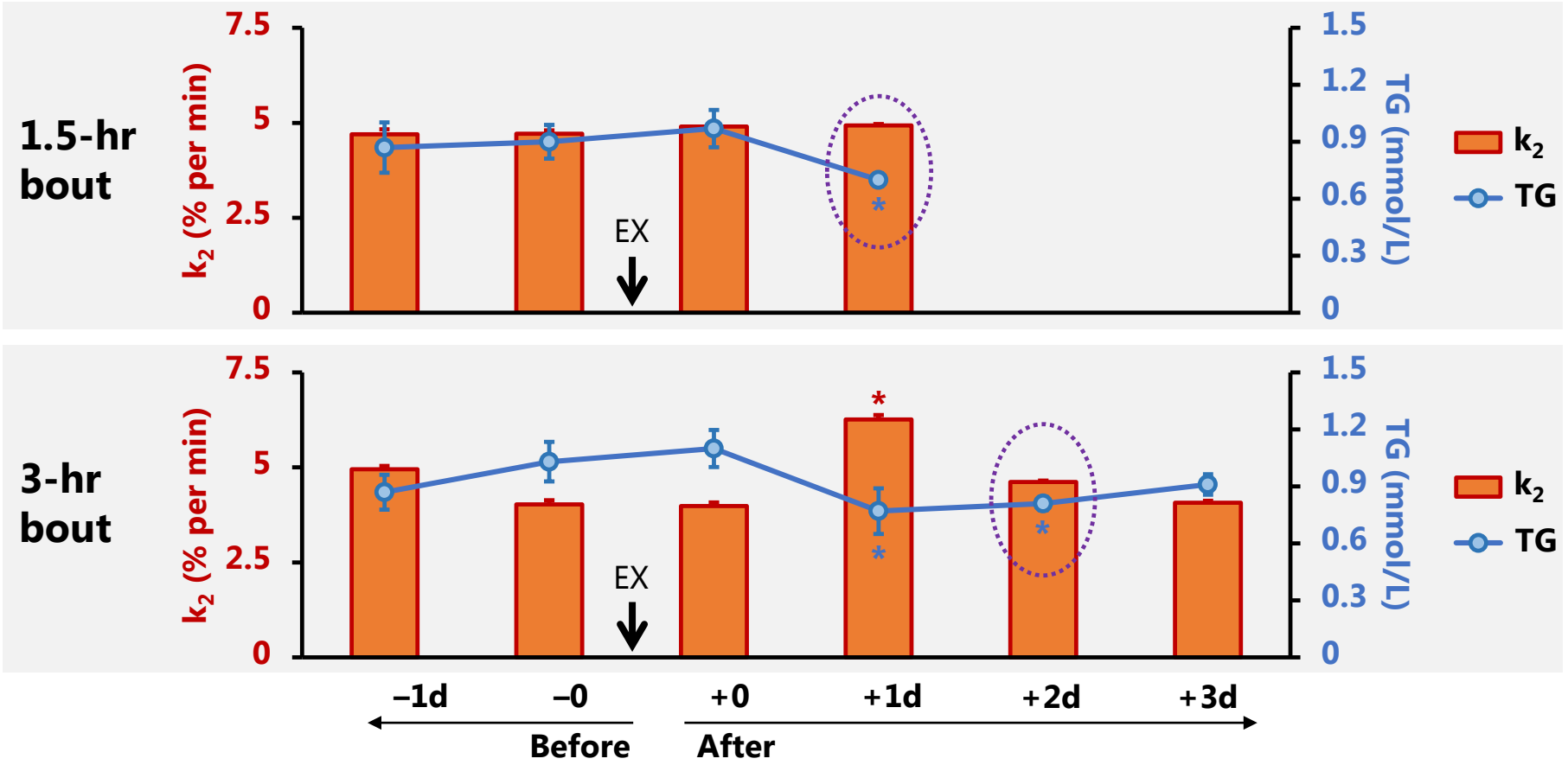


[a]7 men (age ~28 yr, BMI ~22 kg/m^2) cycled for 120 min at 60% VO_2peak (left); [b]8 men (age ~27 yr, BMI ~24.5 kg/m^2) cycled for 90 min at 60% VO_2peak (right). Subjects were healthy and recreationally active but untrained. Plasma TG and skeletal muscle LPL were assessed the day after a single bout of exercise (12–24 h post-exercise).

[a]Magkos (2006) Am J Physiol Endocrinol Metab 290:E355
[b]Herd (2001) Metabolism 50:756

Values are means±SEM

Ο ρυθμός κάθαρσης TG αυξάνει μετά από πολύ άσκηση άλλα όχι μετά από λιγότερη, παρά τις μειωμένες [TG]

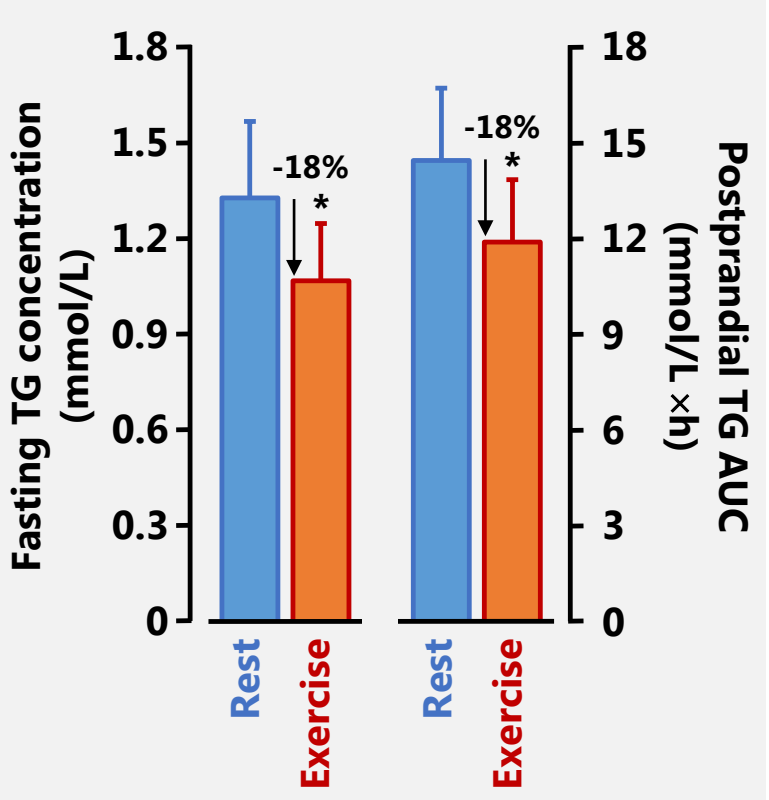


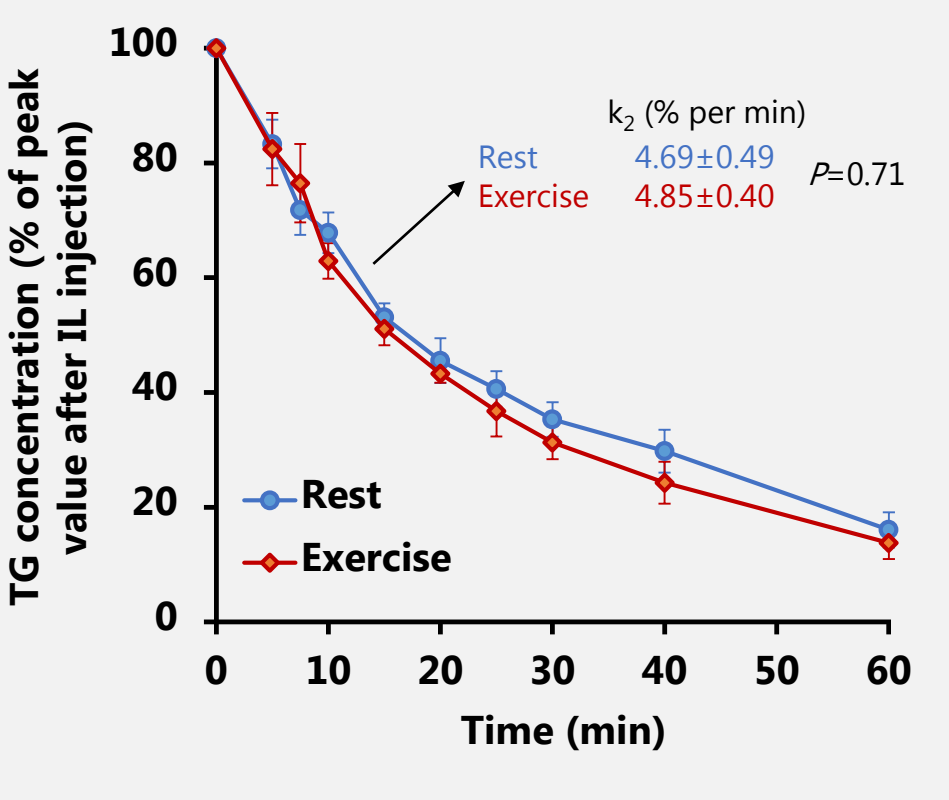
10 normally active men (aged 28±1 years, BMI 22±1 kg/m^2, Wmax 258±11 watt) performed a single 1.5-hr or 3-hr bout of endurance exercise (interchanging 60 min running / 30 min cycling) at moderate intensity (77% of HRmax), in random order 4-6 weeks apart; IVFTTs (10% Intralipid; 1 ml/kg BW) were performed one day before, immediately before, immediately after, one day after, and (for the 3-hr trial) two and three days after the exercise bout, always in the fasted state. First-order TG clearance constants (k_2) were calculated.

Annuzzi (1987) Metabolism 36:438

Values are mean±SEM; *P<0.05 vs immediately before (–0)

Η υποτριγλυκεριδαιμία της άσκησης μπορεί να εμφανιστεί απουσία αυξημένης κάθαρσης TG



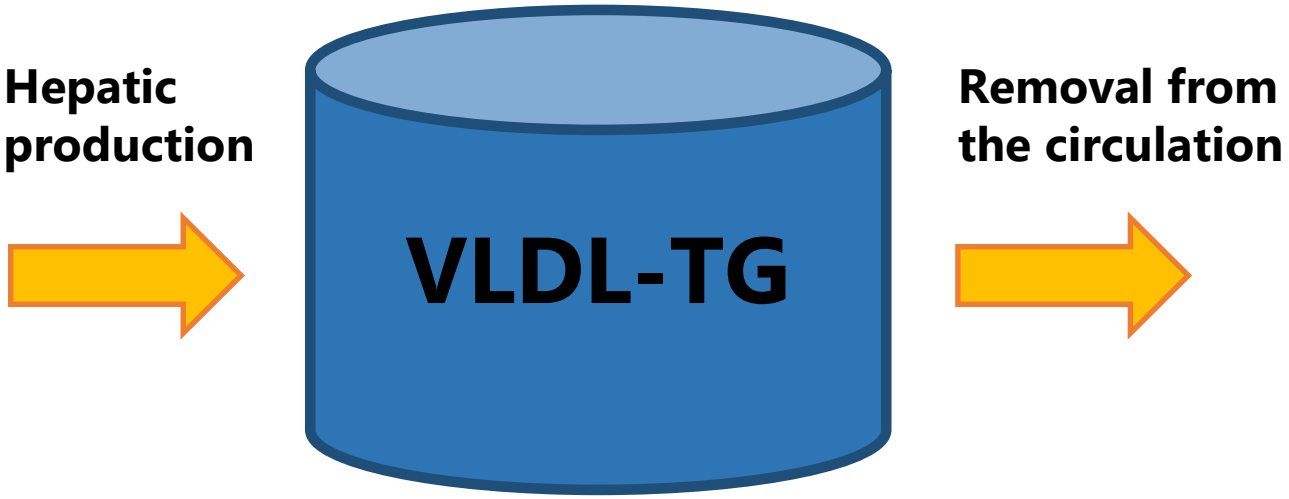


8 healthy men (aged 48.3±2.6 years, BMI 25.5±1.0 kg/m^2, VO_2max 39.0±2.2 ml/kg·min) participated in two intravenous fat tolerance tests (20% Intralipid; 0.5 ml/kg BW—0.1 g fat/kg), in random order separated by 5 days. On the previous afternoon, they completed 90 minutes of exercise at moderate intensity (walking, jogging or running on a treadmill at 60% of VO_2max), or an equivalent period of rest. First-order TG clearance constants (k_2) were calculated from post-Intralipid TG concentrations (after subtraction of fasting values) by fitting mono-exponential regression lines to the TG clearance curves (i.e. the first 20 or 25 min of the IVFTT, depending on the subject).

Gill (2001) Eur J Clin Invest 31:201

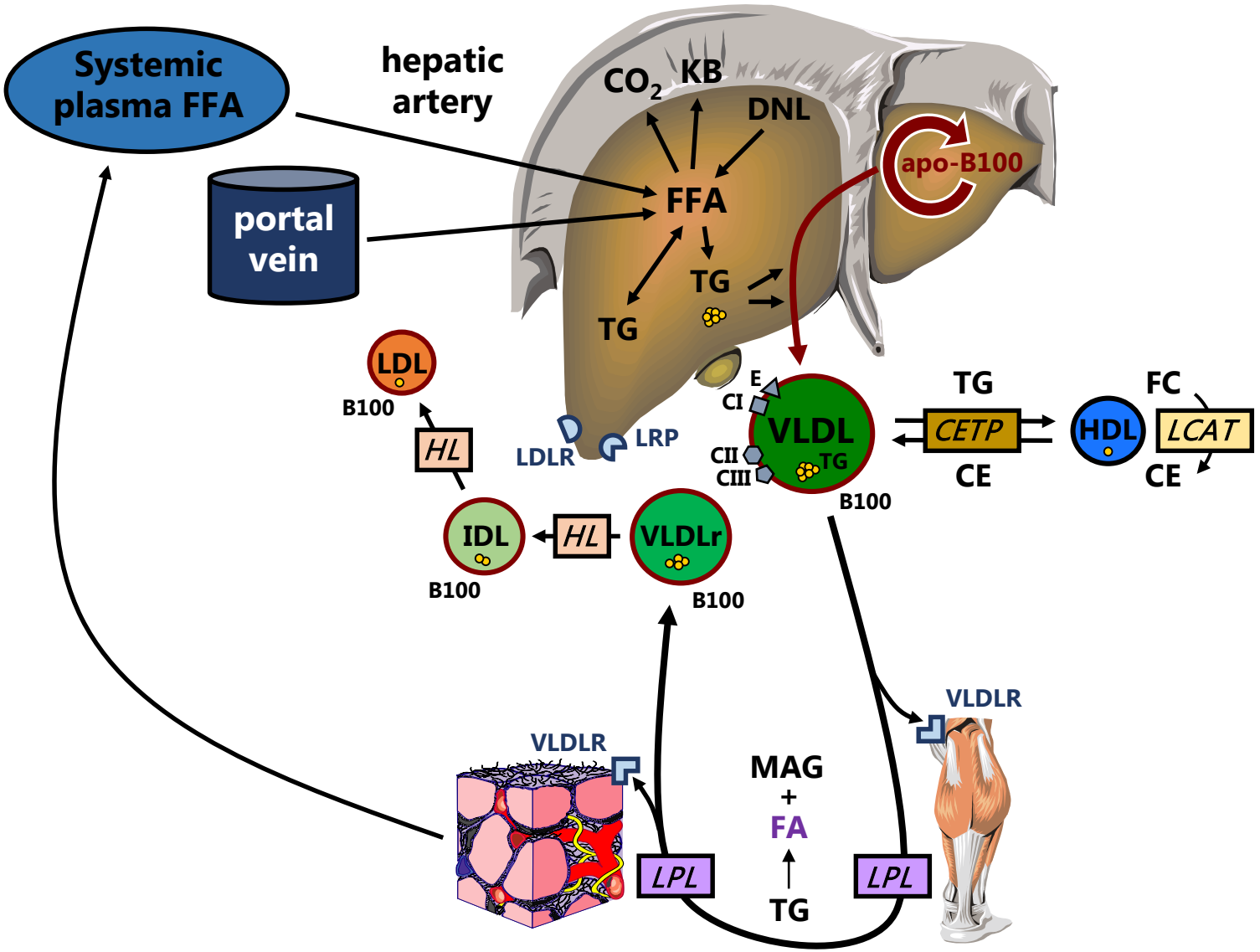
Values are mean±SEM; *P<0.05 vs Rest

Ομοιόσταση των VLDL-TG: η απλή εικόνα



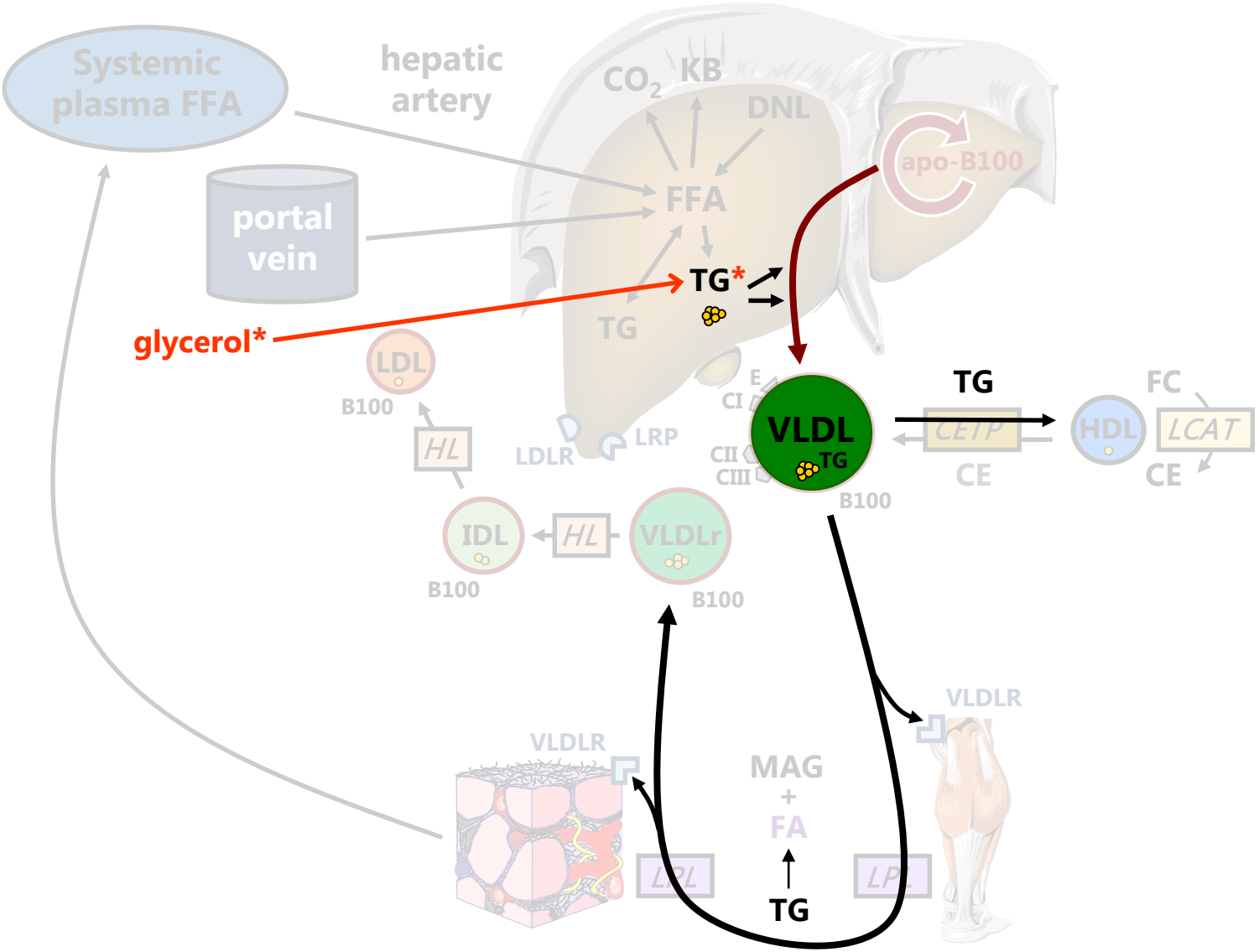
When the concentration in the bloodstream is constant (e.g. in the postabsorptive state), the rate of influx must equal the rate of efflux.

Μεταβολισμός των VLDL-TG: η όχι-και-τόσο-απλή εικόνα

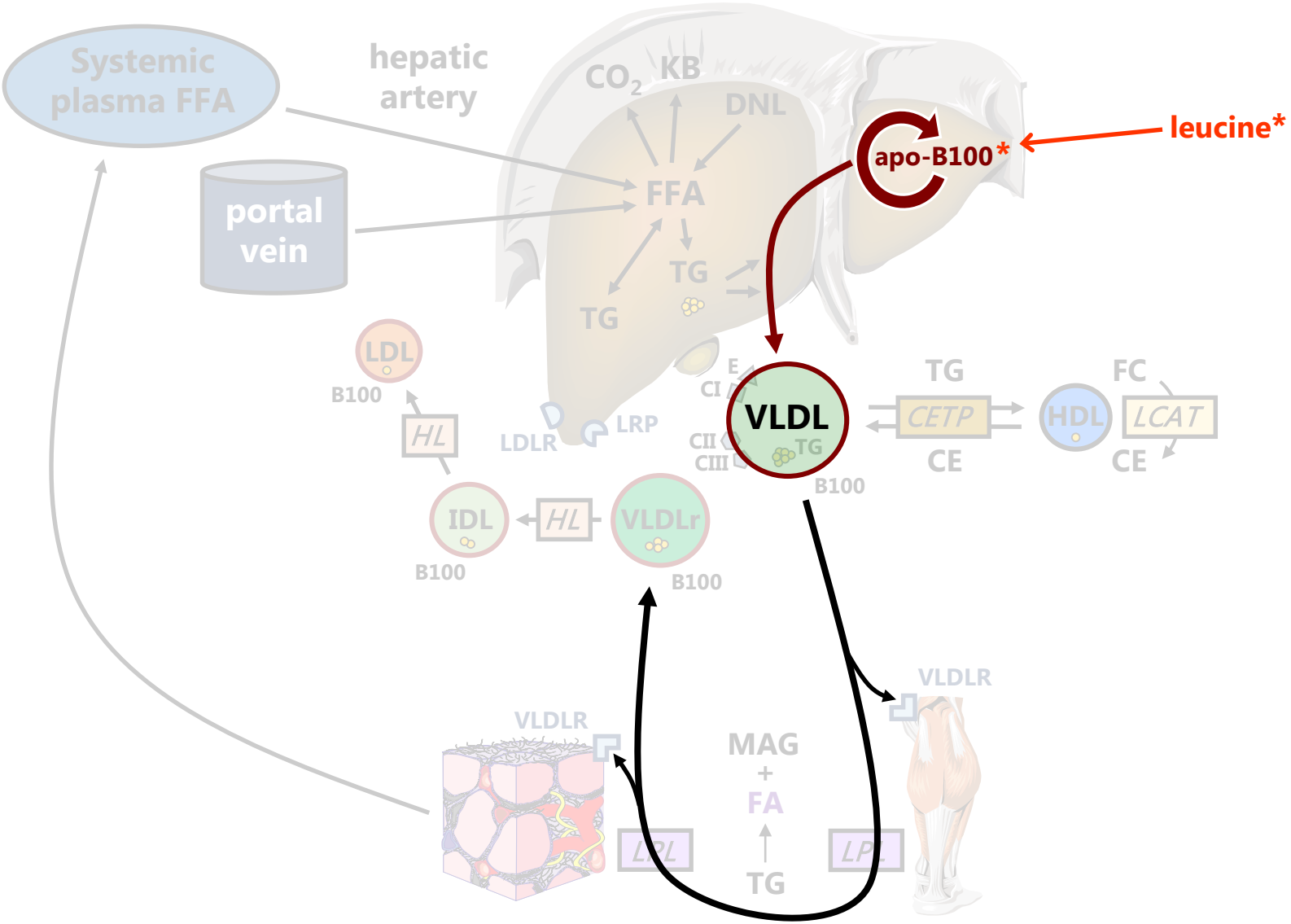


Magkos (2009) Prog Lipid Res 48:171

Μεταβολισμός των VLDL: η χρήση σεσημασμένης γλυκερόλης για την κινητική των VLDL-TG *in vivo*

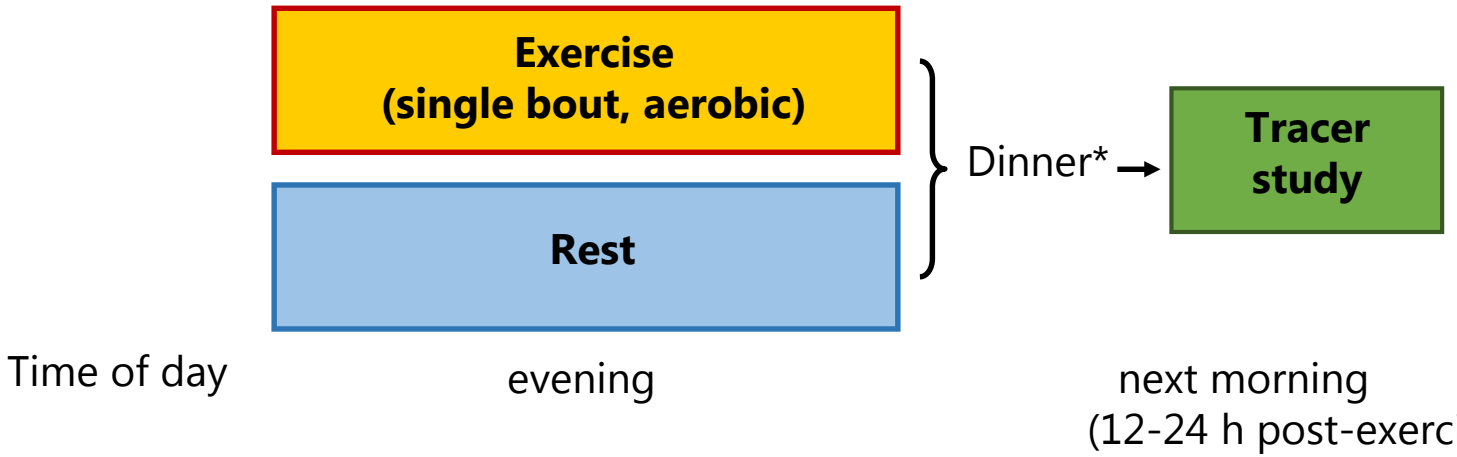


Μεταβολισμός των VLDL: η χρήση σεσημασμένης λευκίνης για την κινητική της VLDL-apoB-100 (σωματιδίων) *in vivo*



Πειραματικό πρωτόκολλο για τη μελέτη της άσκησης στην κινητική των VLDL

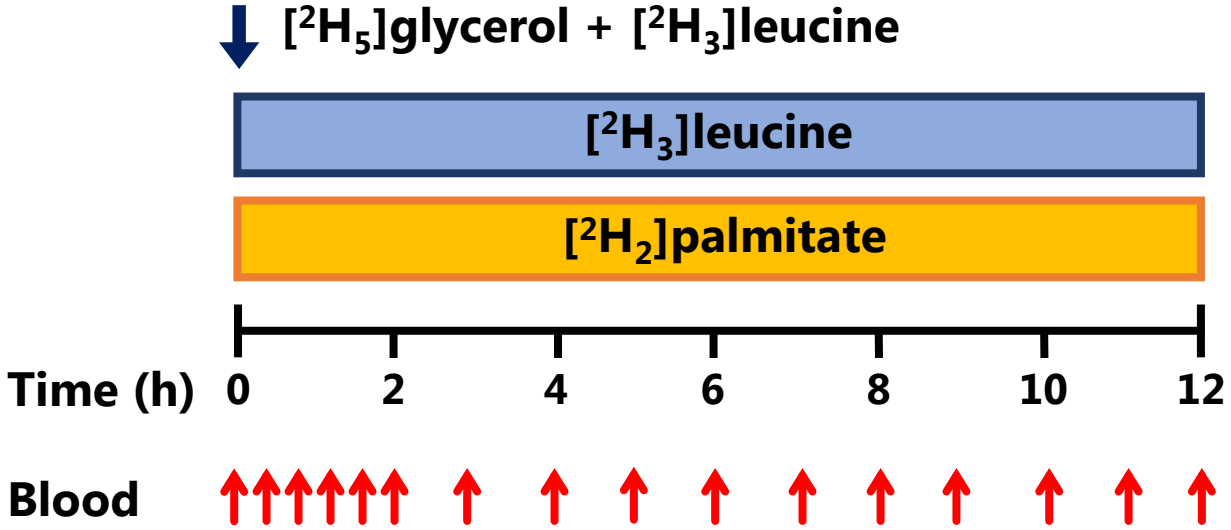
Paired cross-over design with time-matched trials

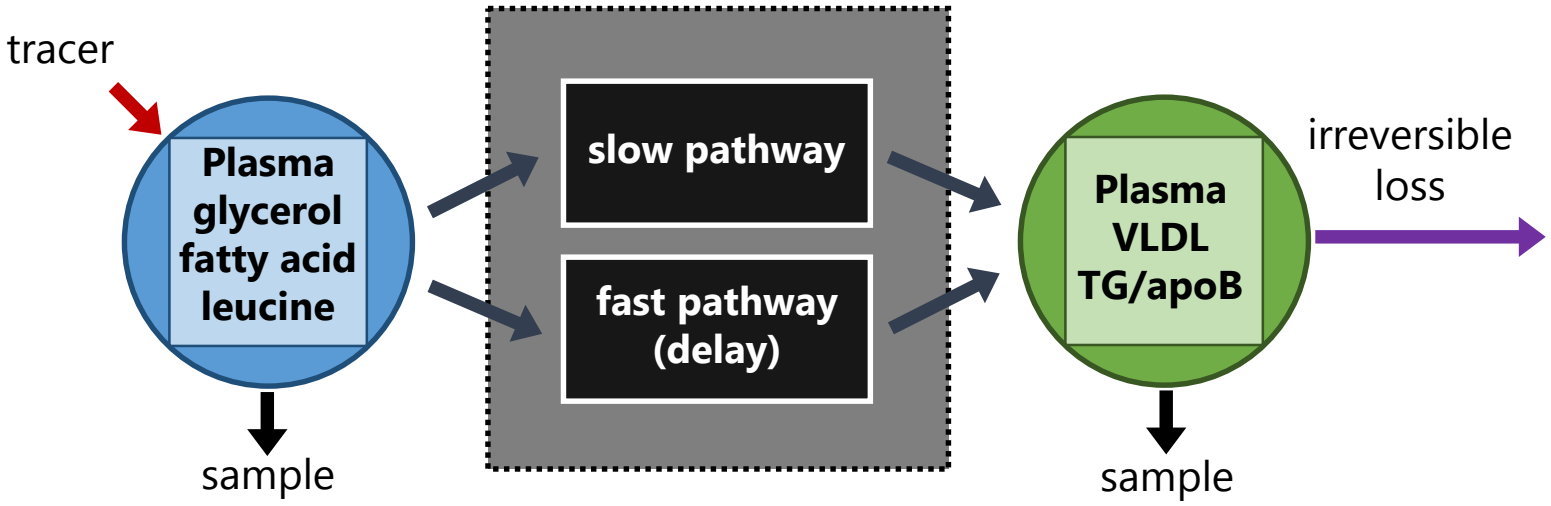


Apparently healthy, untrained, non-obese men and women

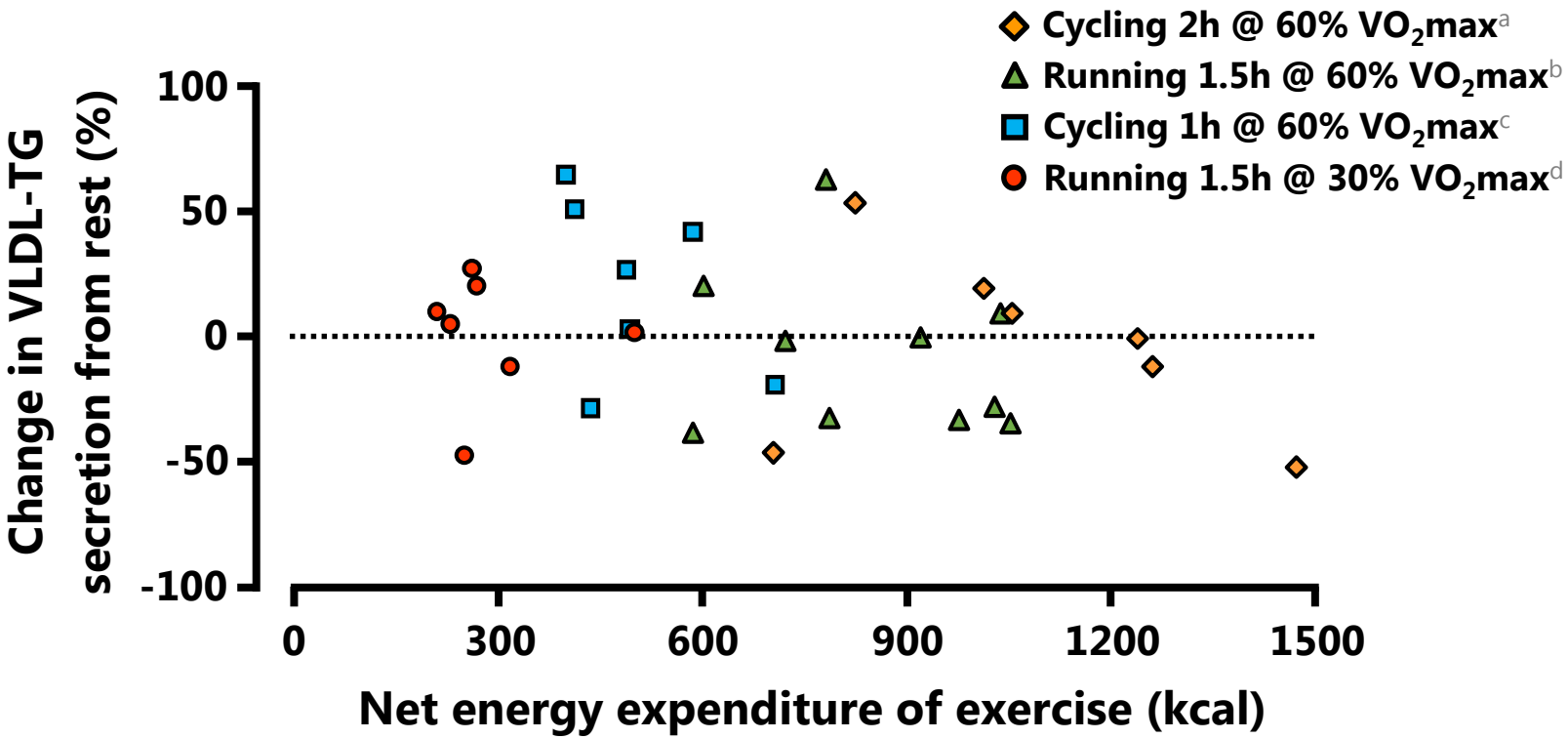
* Low fat mixed meal (note: basal hypotriglyceridemia the next morning is not the end-result of exercise-induced reduction in postprandial lipemia after dinner)

Πρωτόκολλο έγχυσης ισοτόπων και μαθηματικό μοντέλο για τη μελέτη της κινητικής των VLDL





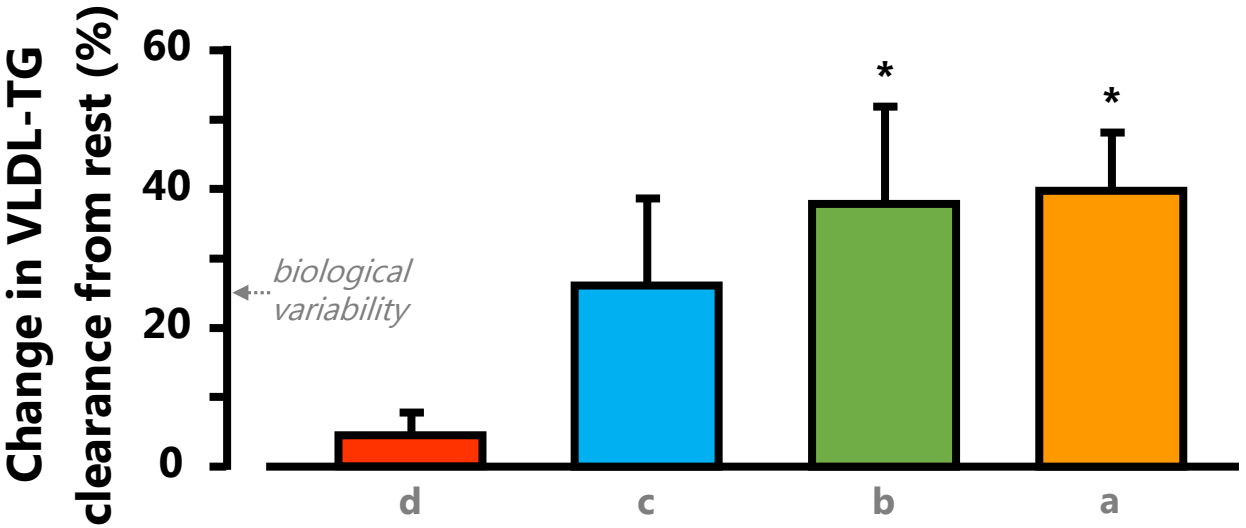
Η αερόβια άσκηση δεν επηρεάζει το ρυθμό έκκρισης VLDL-TG από το ήπαρ



[a]7 men (age ~28 yr, BMI ~22 kg/m^2) cycled for 2 h at moderate intensity; [b]10 men (age ~26 yr, BMI ~25 kg/m^2) ran for 1.5 h at moderate intensity; [c]7 men (age ~30 yr, BMI ~23 kg/m^2) cycled for 1 h at moderate intensity; [d]7 men (age ~25 yr, BMI ~24 kg/m^2) walked for 1.5 h at low intensity. Subjects were healthy and recreationally active but untrained. VLDL kinetics were assessed the day after a single bout of exercise (12–24 h post-exercise).

[a]Magkos (2006) Am J Physiol Endocrinol Metab 290:E355; [b]Tsekouras (2007) Metabolism 56:1037;
[c]Magkos (2007) Am J Physiol Endocrinol Metab 292:E1568; [d]Magkos (2008) J Appl Physiol 105:1228

Η αερόβια άσκηση αυξάνει το ρυθμό κάθαρσης VLDL-TG με τρόπο rise-to-plateau

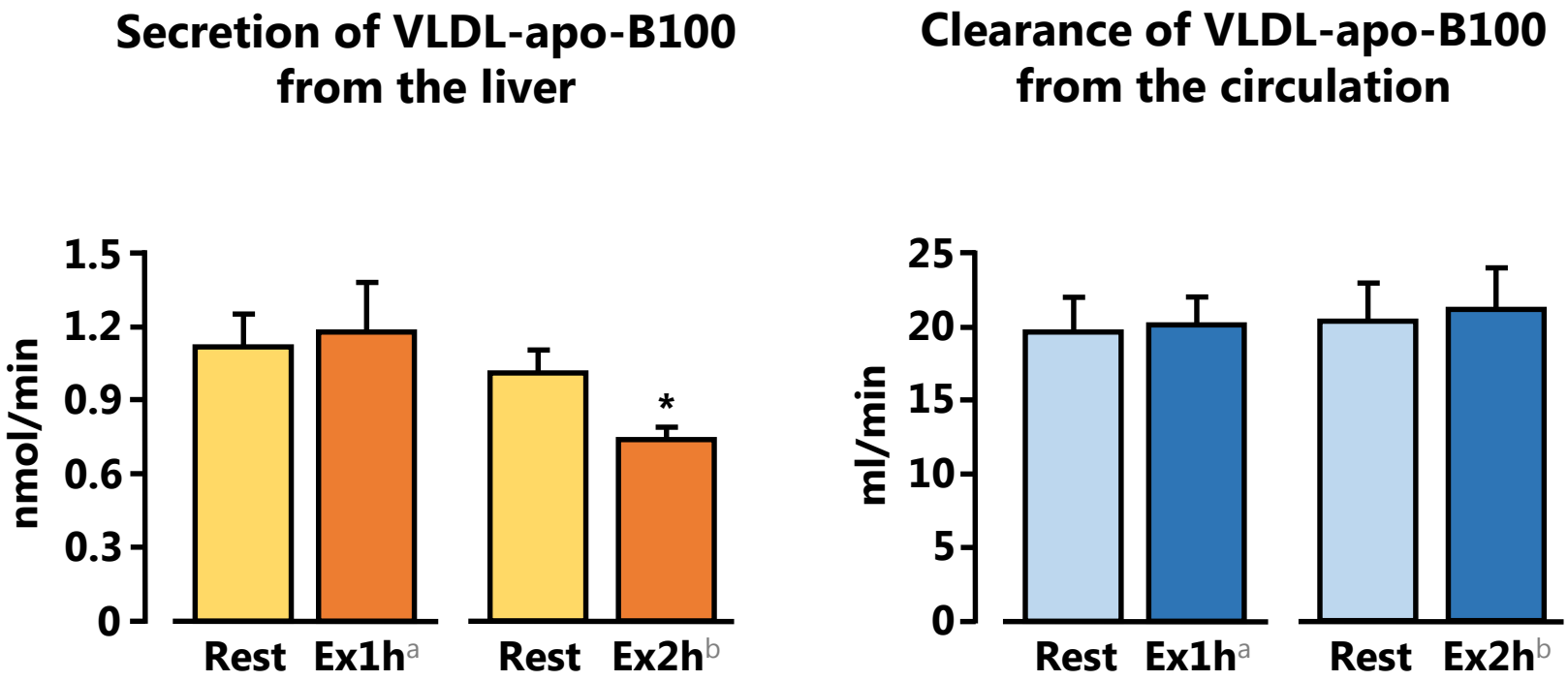


	d	c	b	a
Mode of exercise	**Running**	**Cycling**	**Running**	**Cycling**
Duration and intensity	**1.5h @ 30%**	**1h @ 60%**	**1.5h @ 60%**	**2h @ 60%**
Net energy expenditure (kcal)	**289 ± 38**	**503 ± 41**	**848 ± 56**	**1079 ± 101**
***P*-value vs rest**	**0.345**	**0.090**	**0.027**	**0.007**

[a]7 men (age ~28 yr, BMI ~22 kg/m^2) cycled for 2 h at moderate intensity; [b]10 men (age ~26 yr, BMI ~25 kg/m^2) ran for 1.5 h at moderate intensity; [c]7 men (age ~30 yr, BMI ~23 kg/m^2) cycled for 1 h at moderate intensity; [d]7 men (age ~25 yr, BMI ~24 kg/m^2) walked for 1.5 h at low intensity. Subjects were healthy and recreationally active but untrained. VLDL kinetics were assessed the day after a single bout of exercise (12–24 h post-exercise).

[a]Magkos (2006) Am J Physiol Endocrinol Metab 290:E355; [b]Tsekouras (2007) Metabolism 56:1037;
[c]Magkos (2007) Am J Physiol Endocrinol Metab 292:E1568; [d]Magkos (2008) J Appl Physiol 105:1228

Η αερόβια άσκηση μειώνει το ρυθμό έκκρισης VLDL-apoB-100 (δηλ. VLDL σωματιδίων) από το ήπαρ



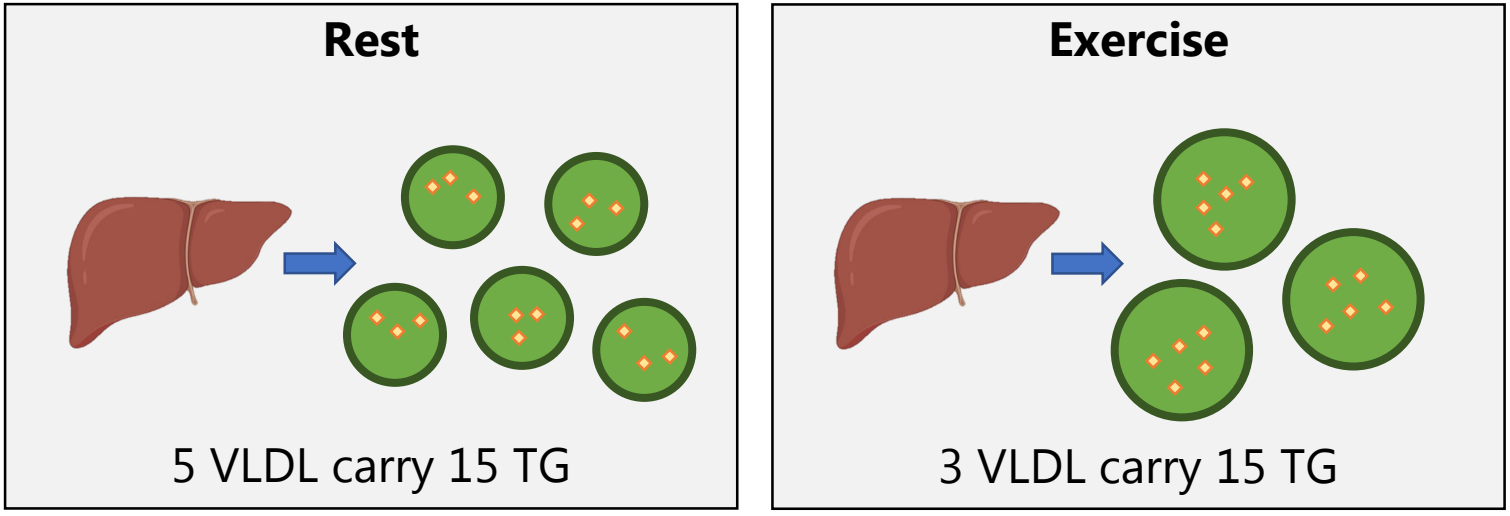
[a]7 men (age ~30 yr, BMI ~23 kg/m^2) cycled for 1 h at moderate intensity; [b]7 men (age ~28 yr, BMI ~22 kg/m^2) cycled for 2 h at moderate intensity. Subjects were healthy and recreationally active but untrained. VLDL kinetics were assessed the day after a single bout of exercise (12–24 h post-exercise).

[a]Magkos (2007) Am J Physiol Endocrinol Metab 292:E1568
[b]Magkos (2006) Am J Physiol Endocrinol Metab 290:E355

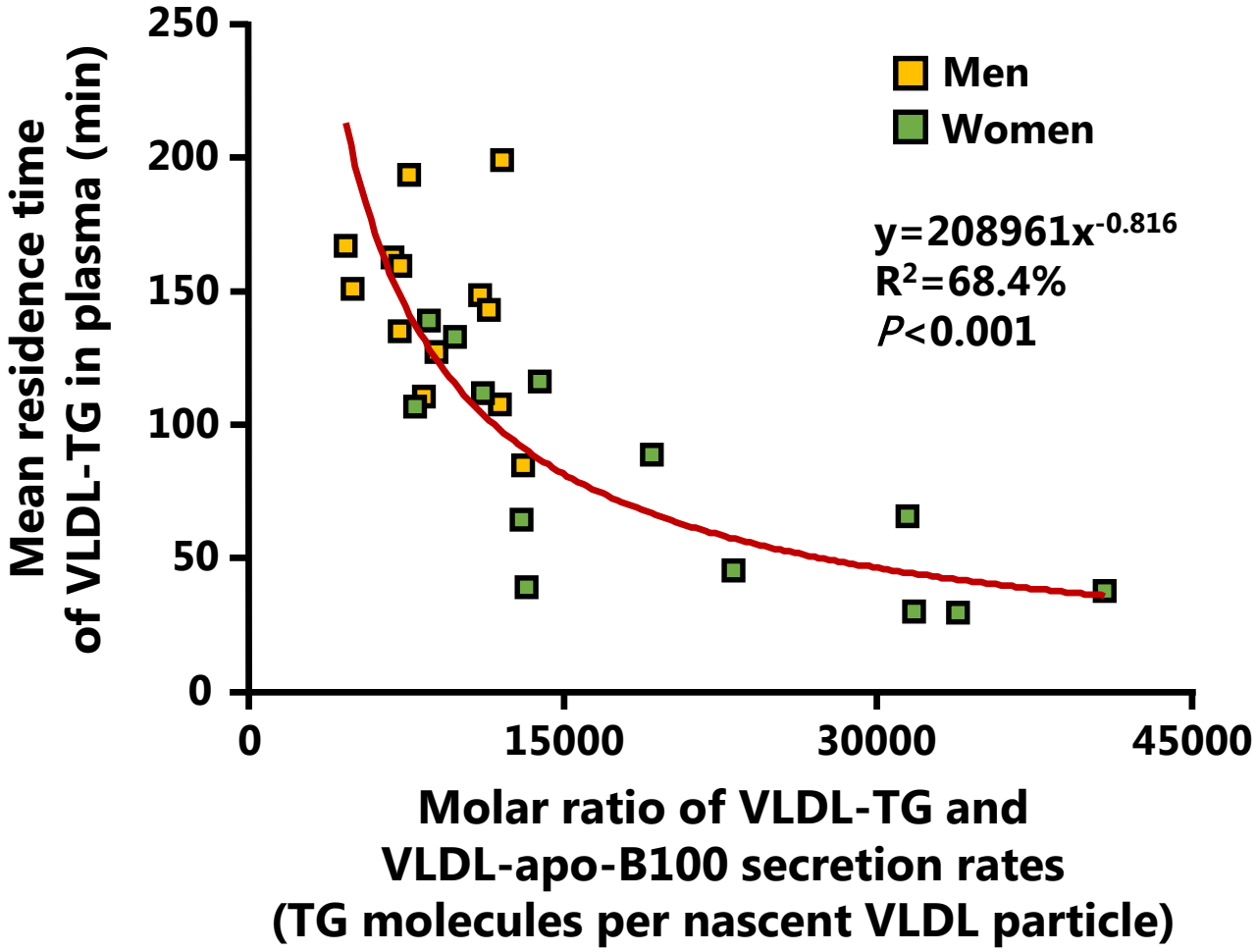
*P<0.05 vs rest

Το γεγονός-κλειδί μετά την αερόβια άσκηση

The liver after exercise secretes the same number of TG in fewer VLDL particles than after rest, hence it packs more TG per VLDL particle. This means that it secretes TG-richer and thus also larger VLDL particles!



Ο ρυθμός απομάκρυνσης TG από τον πυρήνα μεγαλύτερων και πλουσιότερων σε TG VLDL είναι ταχύτερος



Basal VLDL kinetics were assessed in 26 healthy lean subjects (13 men and 13 women) matched for age (~29 yr) and BMI (~22 kg/m^2).

Magkos (2007) J Clin Endocrinol Metab 92:1311

Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 1.0

Reduced hepatic VLDL-apoB-100 secretion (fewer particles)

⇩

Secretion of larger and TG-richer nascent VLDL

⇩

Accelerated whole-body LPL-mediated clearance of VLDL-TG

⇩

Reduced plasma TG concentration

Exercise-induced hypotriglyceridemia is the net result of **changes in lipid metabolism in the periphery** (increased VLDL-TG clearance rate), which are not driven by changes in skeletal muscle LPL activity but rather, are **initiated by remote changes in protein metabolism in the liver** (decreased VLDL-apoB-100 secretion rate). This highlights not only the interaction between lipid and protein metabolism, but also the co-operation and co-ordination of different organs in the integration and regulation of metabolism at the whole-body level in humans.

Πως μειώνει η άσκηση την παραγωγή VLDL-apoB-100 από το ήπαρ;

Increased insulin sensitivity (muscle+liver)

Devlin (1987) Diabetes 36:434
Mikines (1988) Am J Physiol 254:E248

↓

In humans, acute hyperinsulinemia decreases hepatic VLDL-apoB-100 secretion

Lewis (1995) J Clin Invest 95:158

So, increased insulin action on the liver the day after exercise may be responsible for the decrease in hepatic VLDL-apoB-100 secretion rate.

Πως μειώνει η άσκηση την παραγωγή VLDL-apoB-100 από το ήπαρ;

Increased insulin sensitivity (muscle+liver)

Devlin (1987) Diabetes 36:434
Mikines (1988) Am J Physiol 254:E248

↓

In humans, acute hyperinsulinemia decreases hepatic VLDL-apoB-100 **and VLDL-TG** secretion

Lewis (1995) J Clin Invest 95:158

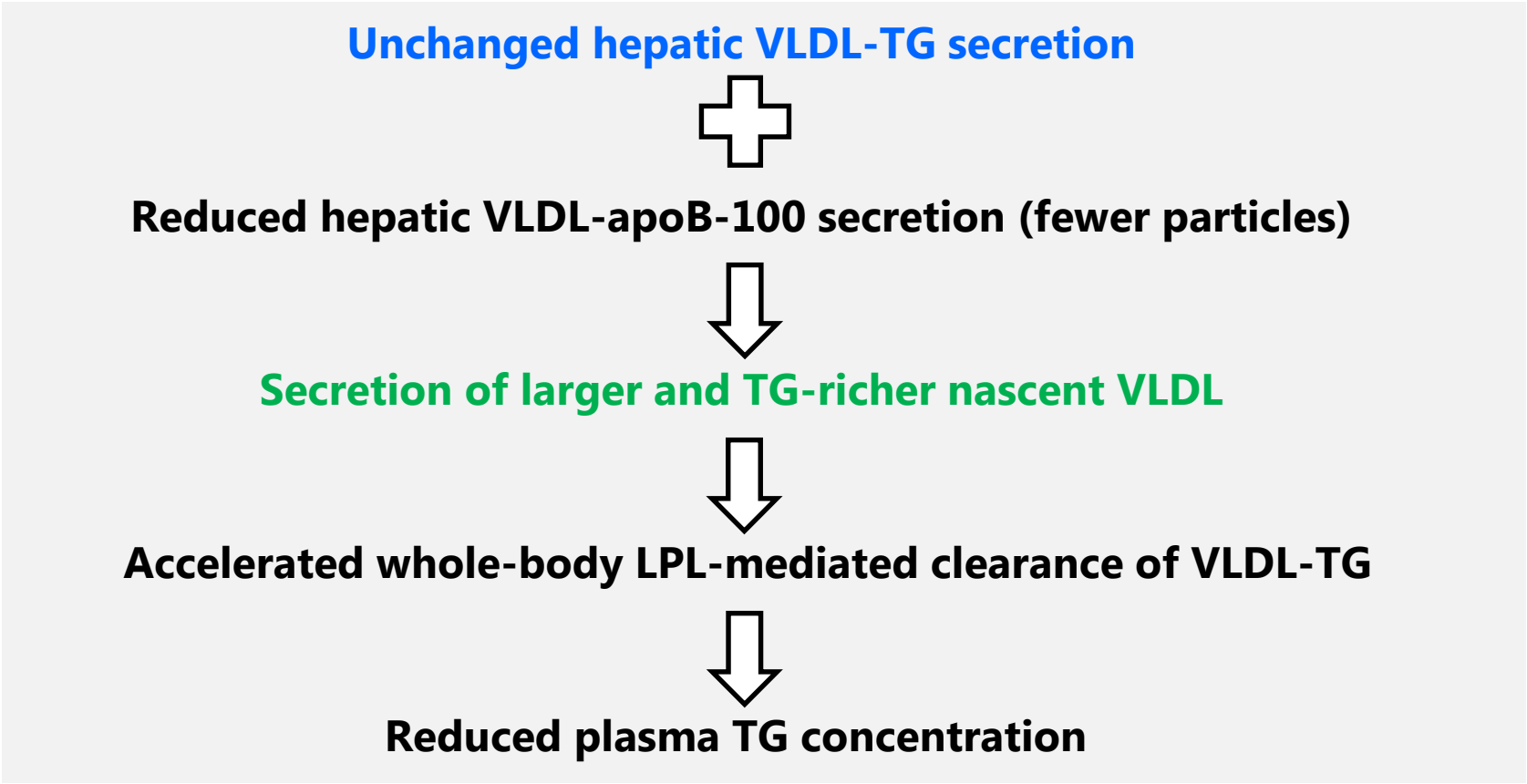
So, increased insulin action on the liver the day after exercise may be responsible for the decrease in hepatic VLDL-apoB-100 secretion rate.

…

But then again, insulin also inhibits VLDL-TG secretion from the liver in animals and humans, thus improved hepatic insulin sensitivity alone cannot explain the exercise-induced changes in VLDL-TG metabolism.

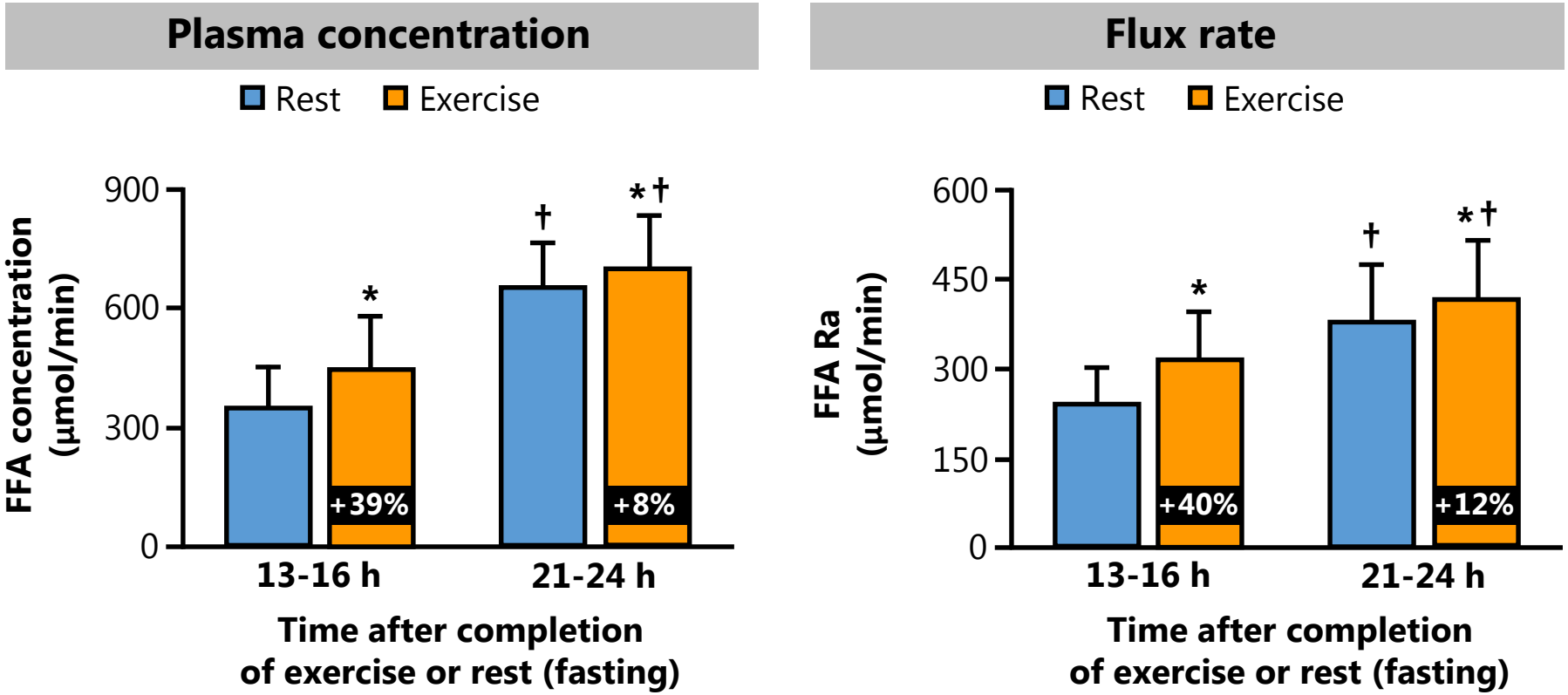
Lewis (1995) J Clin Invest 95:158
den Boer (2006) Am J Physiol Endocrinol Metab 291(6)E1360

Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 1.1



Γιατί δε μειώνει η άσκηση και την παραγωγή VLDL-TG;

Η αερόβια άσκηση αυξάνει τη διαθεσιμότητα ελευθέρων λιπαρών οξέων την επόμενη ημέρα



Stable isotope-labeled palmitate infusion ([2,2-$^{2}H_2$]palmitate for 12 hours) was used to examine free fatty acid metabolism in 27 healthy untrained men and women (aged 28.9±1.4 years; BMI 24.7±0.8 kg/m^2) between 13-16 hours and 21-24 hours after a single bout of moderate-intensity endurance exercise (1 or 2 hours of cycling at 60% of VO_2max) performed in the previous evening, and after a time-matched resting trial (in random order, approximately 4 wk apart).

Magkos (2009) Metabolism 58:1248

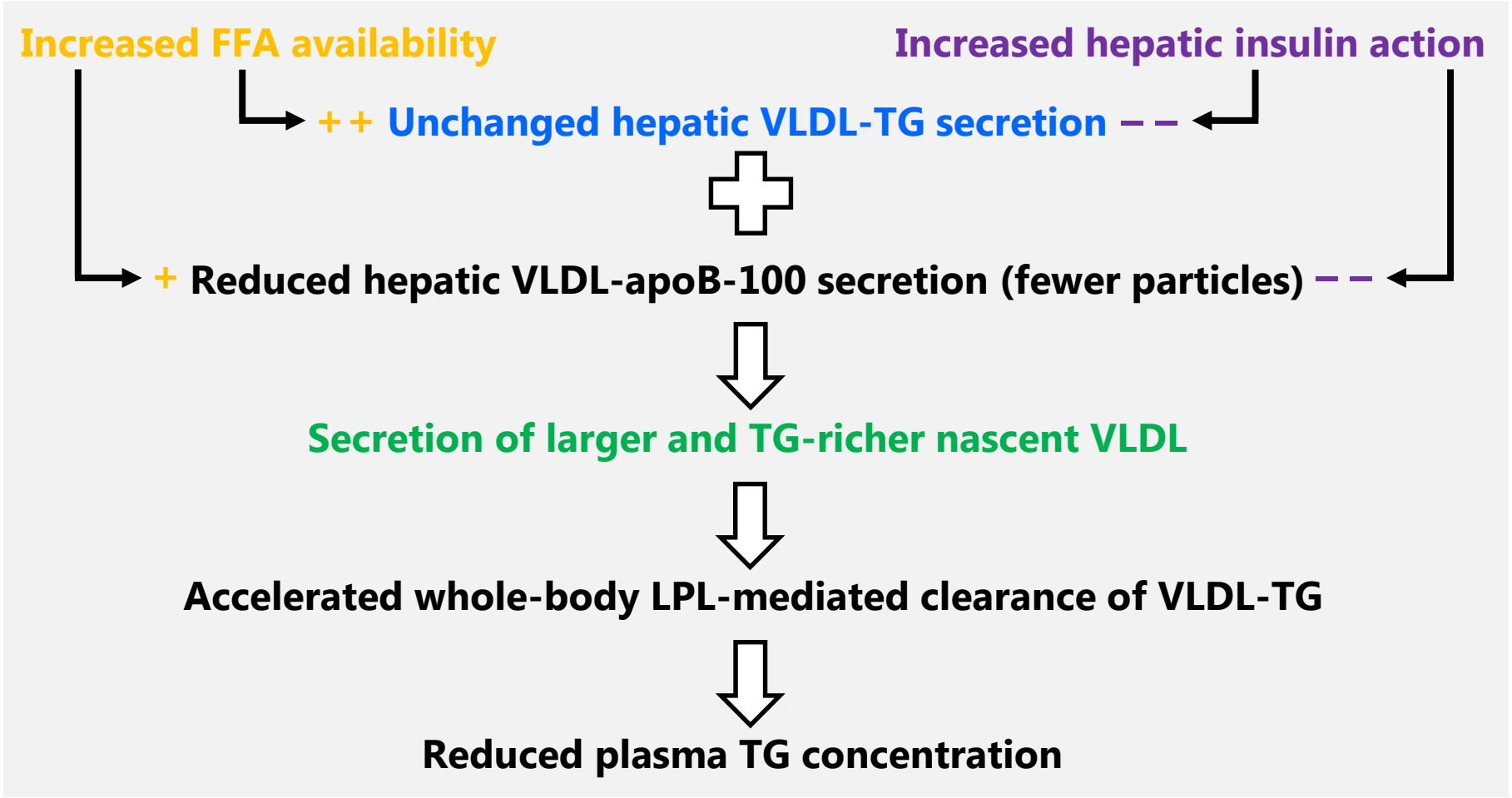
Values are mean±SEM; *P<0.05 vs Rest; †P<0.05 vs 13-16 h

Δράση της ινσουλίνης και των FFA στους ρυθμούς παραγωγής VLDL-TG και VLDL-apoB-100 *in vivo*

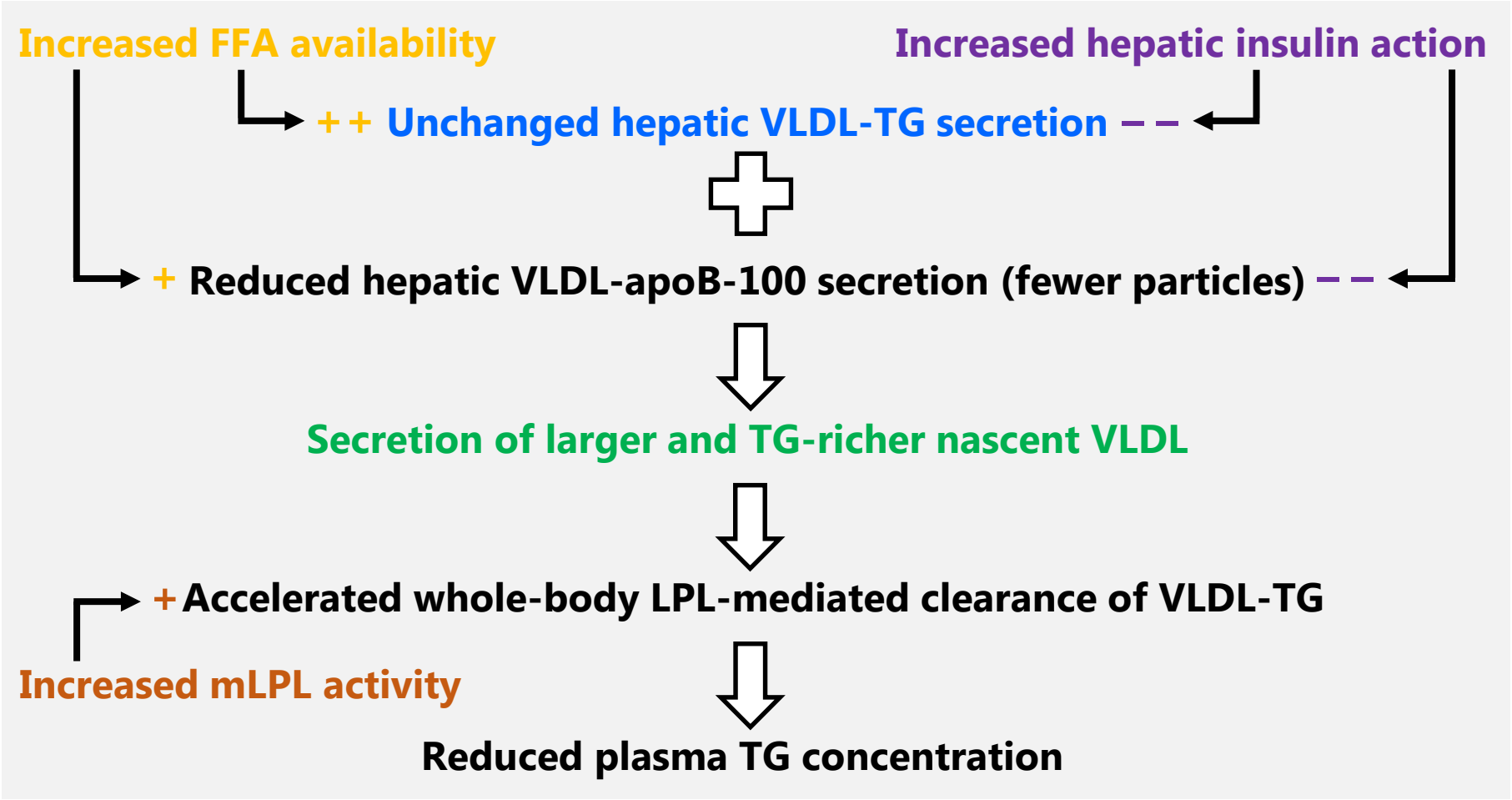
	VLDL-TG secretion	VLDL-apoB-100 secretion
Insulin alone	↓↓	↓↓
FFA alone	↑↑	↑

Lewis et al (1995) J Clin Invest 95:158

Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 2.0

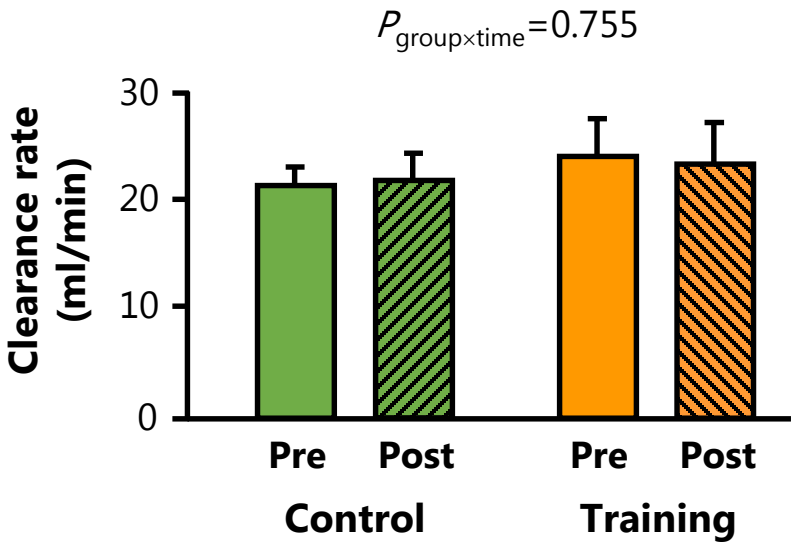


Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 2.1

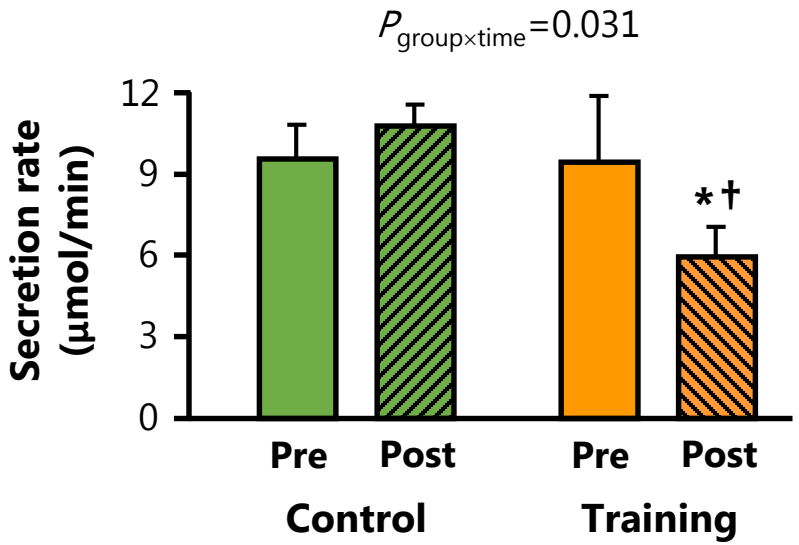


Η χρόνια αερόβια άσκηση (προπόνηση) μειώνει τα TG λόγω μειωμένης έκκρισης VLDL-TG

Plasma clearance of VLDL-TG



Hepatic secretion of VLDL-TG



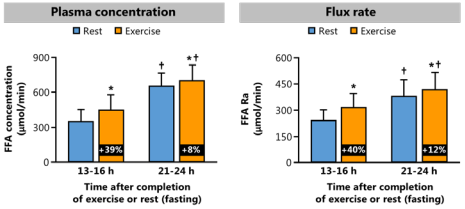
Healthy untrained men were randomly assigned to a **non-exercising control** group (n=8) or an **exercise training** group (n=8; 1 dropout). Training involved 2 months of supervised high-intensity interval exercise (3 sessions/wk; running at 60|90% of VO_2max in 4-min intervals for a total of 32 min; gross energy expenditure: 446±29 kcal). VLDL-TG kinetics were measured in the basal postabsorptive state before and after the intervention (**~48 h after the last exercise bout** in the training group). Training decreased fasting plasma VLDL-TG concentration by 28% and increased VO_2max by ~18% (both $P<0.05$), but did not alter body weight and body composition and did not affect **fasting FFA concentration**. No significant changes in VLDL-TG concentration and kinetics occurred in the non-exercising control group.

Tsekouras (2008) Am J Physiol Endocrinol Metab 295:E851

Mean±SEM; *$P<0.05$ vs Baseline; †$P<0.05$ vs Control

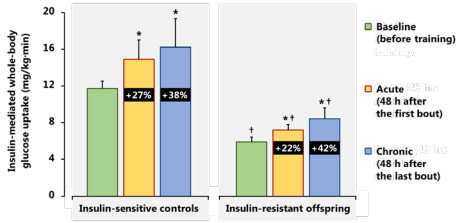
Αερόβια προπόνηση και ινσουλινο-ευαισθησία, διαθεσιμότητα FFA και κινητική VLDL-apoB-100

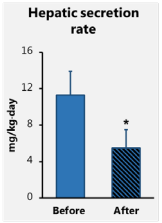
Aerobic training does not affect basal plasma FFA availability 36-72 hrs after the last bout



Sial (1998) Am J Physiol Endocrinol Metab 274:E785
Horowitz (1999) Am J Physiol Endocrinol Metab 277:E325
Horowitz (2000) Am J Physiol Endocrinol Metab 279:E348
Friedlander (1998) Am J Physiol Endocrinol Metab 275:E853
Friedlander (1999) J Appl Physiol 86:2097

Aerobic training increases whole-body insulin sensitivity (muscle and probably also liver) 36-72 hrs after the last bout



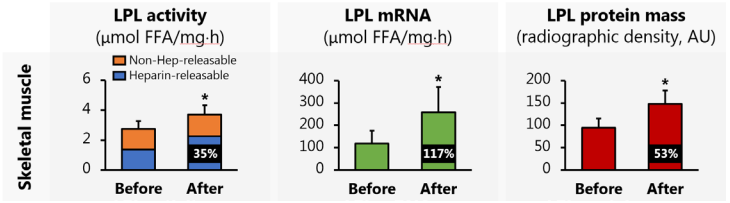


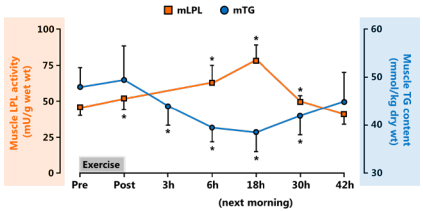
Perseghin (1996) N Engl J Med 335:1357
Burstein (1985) Diabetes 34:756
Mikines (1988) Am J Physiol 254:E248
Steenberg (2019) J Physiol 597:89
Ross (2000) Ann Intern Med 133:92

Aerobic training decreases hepatic VLDL-apoB-100 secretion rate 72 hrs after the last bout

Alam (2004) J Clin Endocrinol Metab 89:688

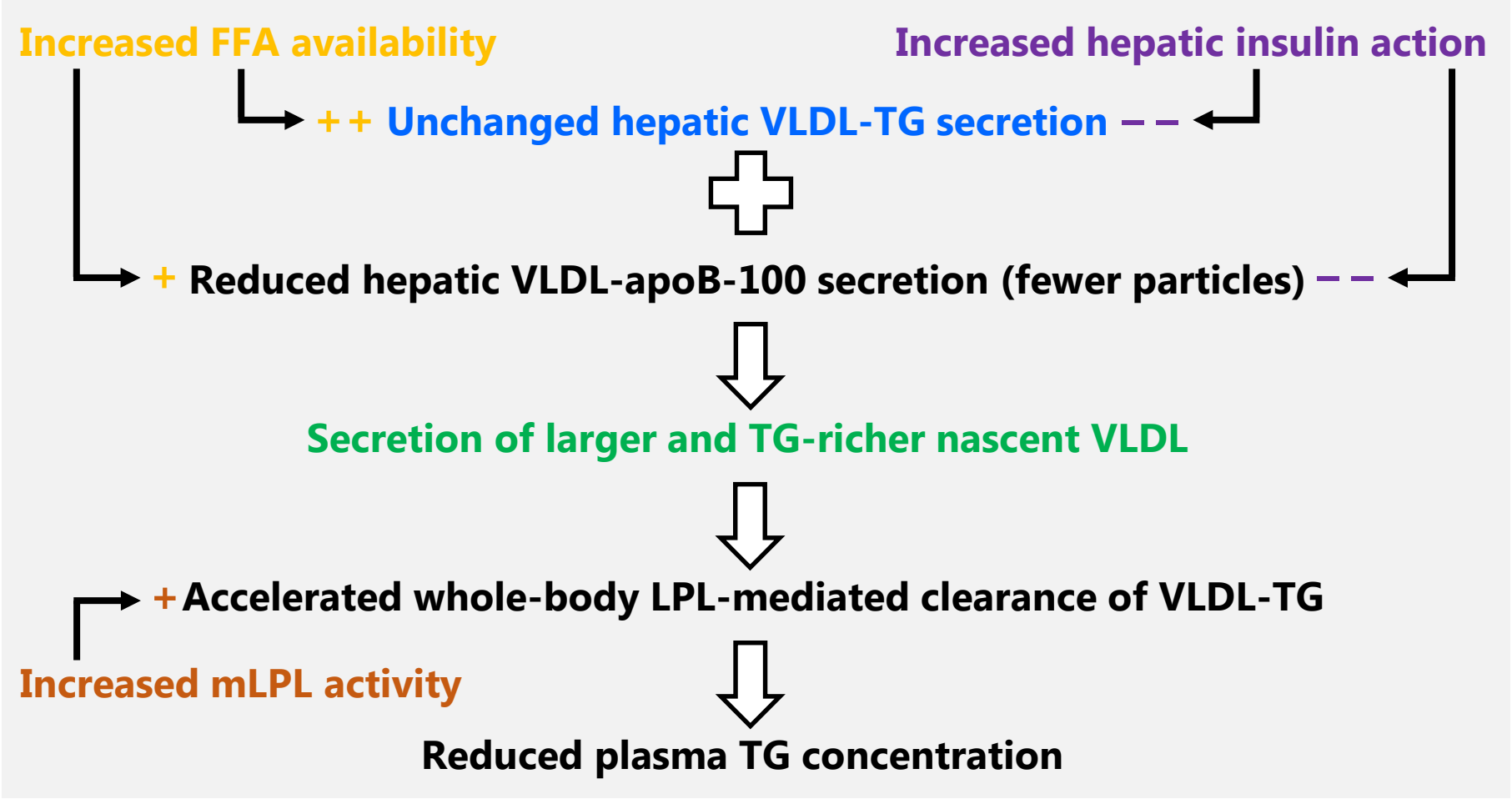
Aerobic training increases muscle LPL activity only when measured within 24 hrs from the last bout



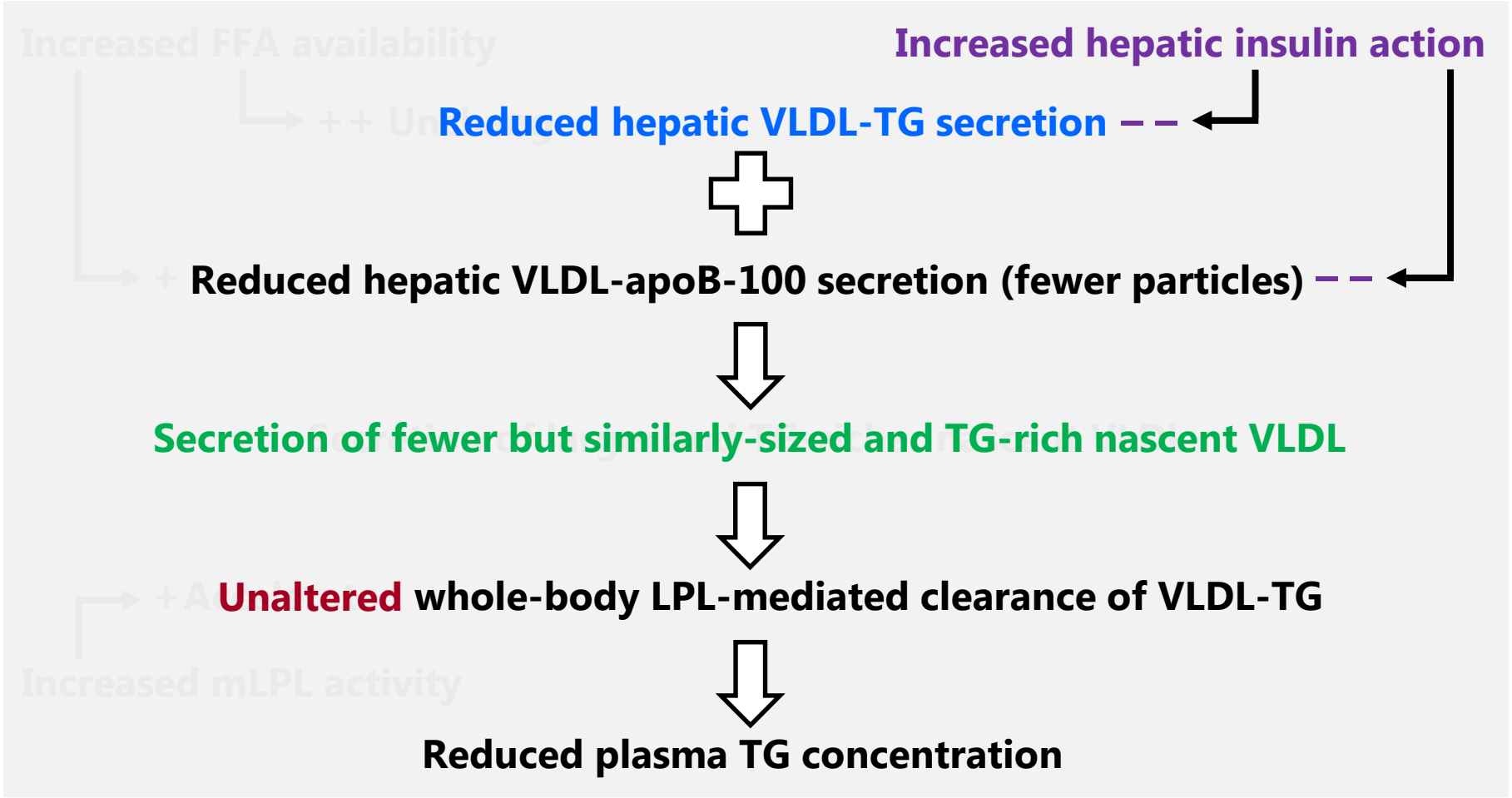


Seip (1995) Am J Physiol 268:E229
Nikkila (1978) Metabolism 27:1661

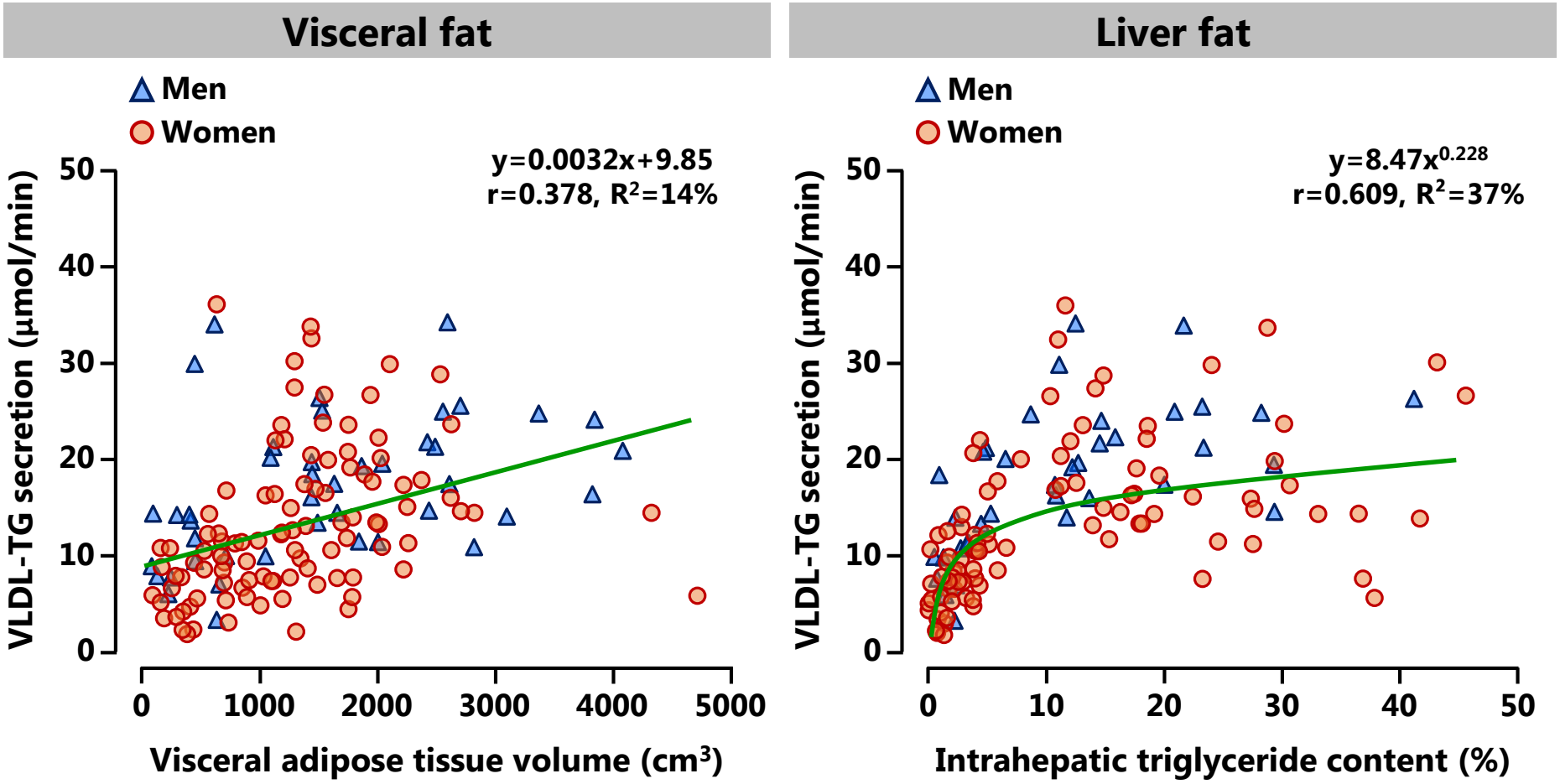
Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 2.1



Μηχανιστικό μοντέλο της υποτριγλυκεριδαιμίας της άσκησης 2.1plus



Αλλαγές στο σπλαχνικό και ενδοηπατικό λίπος μετά από την προπόνηση μπορεί επίσης να εμπλέκονται



Basal VLDL-triglyceride kinetics (12-h tracer infusion), VAT volume (MRI) and IHTG content (MRS) were assessed in 233 men (n=89) and women (n=144), aged 18–55 years, with a BMI of 19–45 kg/m^2.

Mittendorfer (2016) J Clin Endocrinol Metab 101:4151

Both $P<0.01$

Περίληψη: οι μηχανισμοί της υποτριγλυκεριδαιμίας της άσκησης

- **Μία συνεδρία αερόβιας άσκησης σε μέτρια ένταση μειώνει τη συγκέντρωση TG την επόμενη ημέρα λόγω επιταχυμένου ρυθμού απομάκρυνσης VLDL-TG από ολόκληρο το σώμα.**
- **Η επιτάχυνση του ρυθμού απομάκρυνσης των VLDL-TG οφείλεται στην έκκριση από το ήπαρ λιγότερων VLDL αλλά μεγαλύτερων σε μέγεθος και πλουσιότερων σε περιεκτικότητα σε TG.**
- **Οι αλλαγές στη δράση (και στη συγκέντρωση) ινσουλίνης, στη διαθεσιμότητα FFA, αλλά και στη δραστικότητα της LPL στο μυ εμπλέκονται στο μεταβολισμό των VLDL ανάλογα με την «ποσότητα» της άσκησης και τη χρονική διάρκεια από το τέλος της άσκησης.**
- **Η αερόβια προπόνηση μειώνει τη συγκέντρωση TG λόγω επιβραδυμένου ρυθμού έκκρισης VLDL-TG από το ήπαρ. Πιθανοί λόγοι: απουσία αυξημένης διαθεσιμότητας FFA σε συνδυασμό με αυξημένη ινσουλινοευαισθησία και πιθανόν η ελάττωση του σπλαχνικού και του ενδοηπατικού λίπους.**

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