DIETARY FAT & UTILIZATION DURING EXERCISE

OVERVIEW

- Structure and types of dietary fat
- Fats are broken down (lipolysis) to be used by the skeletal muscle as fuel.
- Fat contributes about 50% of the fuel at low – moderate exercise intensities.
- The contribution of fat to total energy expenditure increases as energy duration increases.

WHY FATS ARE IMPORTANT

Fuel for contracting muscles

Absorption of fat-soluble vitamins

Insulation for vital organs

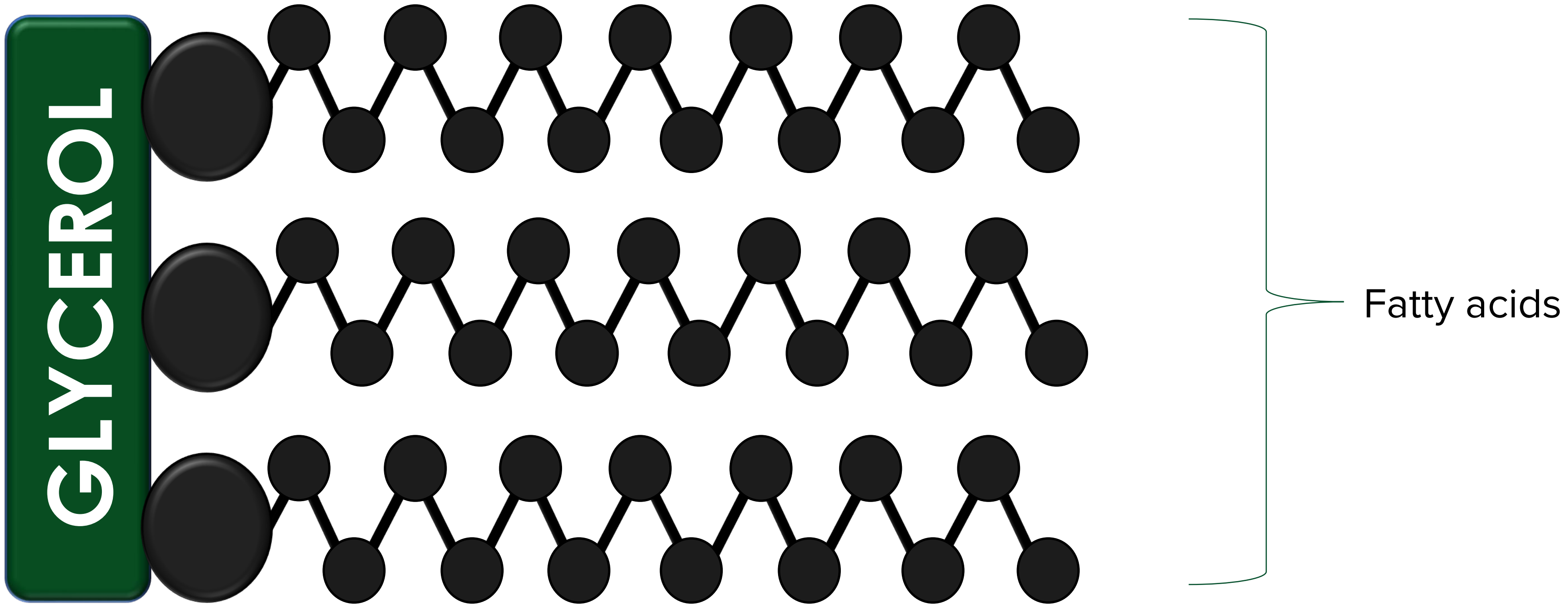
Cell-membrane structure

DIETARY FATS

TYPES OF DIETARY FAT

Triacylglycerols are the most abundant dietary lipids (90%).

There are made up of three fatty acids and glycerol back bone.



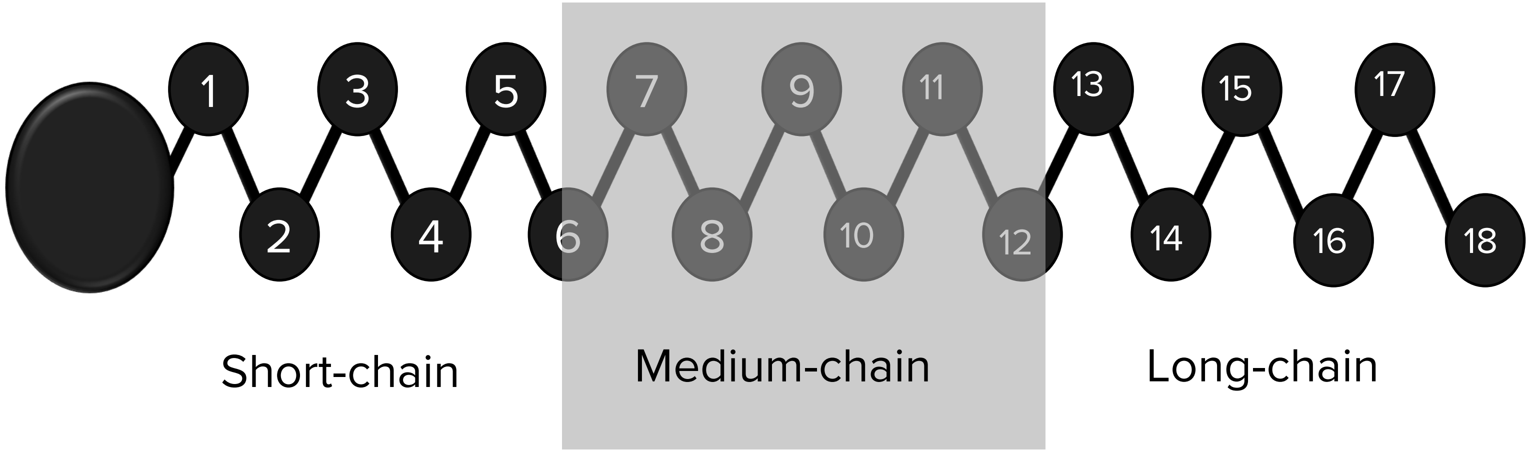
TYPES OF DIETARY FAT

Triglycerides differ in their fatty acid composition.

The most abundant fatty acids are long chain fatty acids.

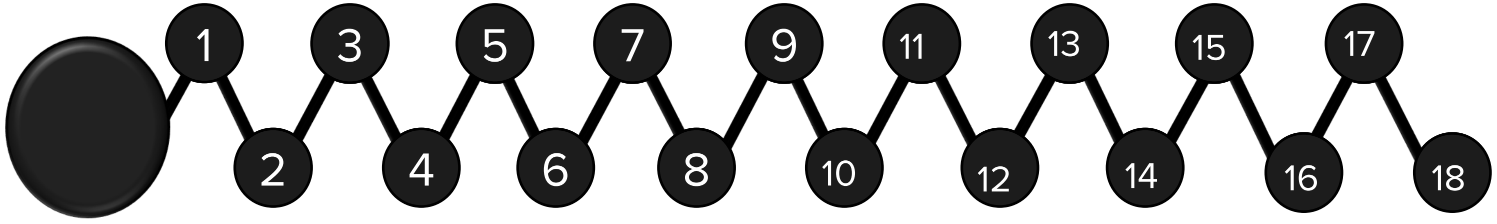
Long chain fatty acids contain >12 carbons in their structure.

# of carbons	Name
< 6 carbons	Short chain fatty acids
6 – 12 carbons	Medium chain fatty acids
> 12	Long chain fatty acids

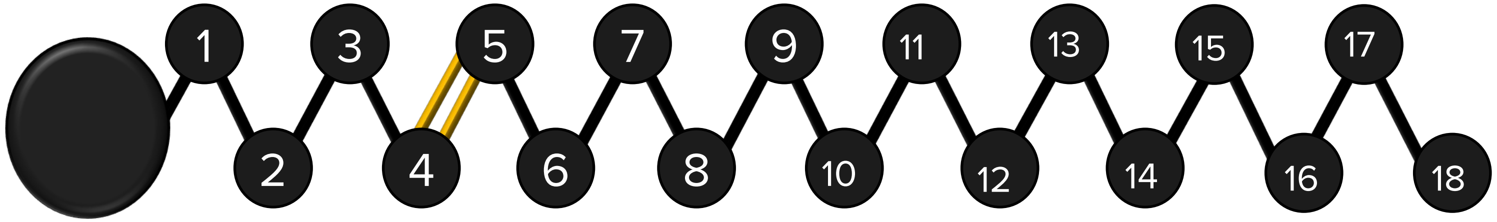


TYPES OF DIETARY FAT

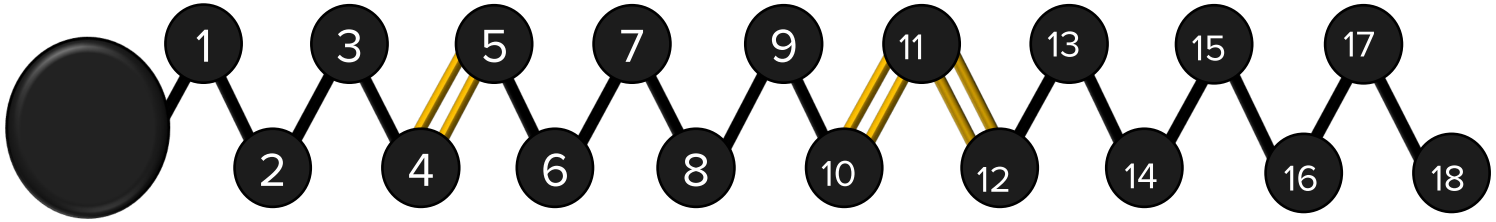
Fatty acids also differ in their structure



Saturated fatty acids have no double bonds/

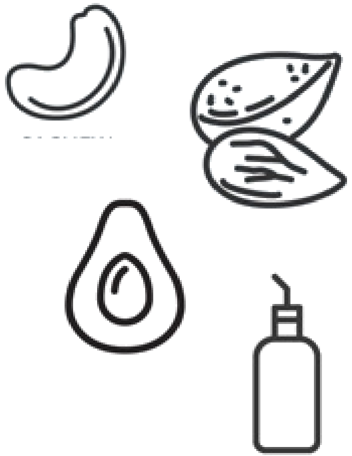


Mono-unsaturated fatty acids have one double bond/



Poly-unsaturated fatty acids have multiple double bonds.

DIETARY SOURCES

	Type of Fat		
	Saturated	Monounsaturated	Polyunsaturated
Dietary Sources			

TRANS FAT

Trans fats are unsaturated fatty acids therefore they contain at least one double bond in a *trans* configuration, which is different to other fatty acids.

Unlike other dietary fats trans fats are not essential for the human diet.

Animal products, such as red meats and dairy, have small amounts of trans fats. But most trans fats come from processed foods.

DAILY FAT INTAKE RECOMMENDATIONS

- Fats have many important functions in the human body and should not be excluded from the diet.
- Daily fat intake: The recommendation for adults is that 20-35% of total energy intake should be from fat.
- Saturated Fat: The proportion of energy from saturated fats be limited to less than 10%.
- Trans fats: High intakes are associated with an increase risk in heart disease and should be eaten in small quantities or avoided.
- Intake of fat by athletes should be in accordance with public health guidelines and should be individualized based on training level and body composition goals (Thomas et al 2016).

Thomas DT, Erdman KA, Burke LM. *J Acad Nutr Diet*. 2016;116(3):501-28
https://health.gov/our-work/food-nutrition/2015-2020-dietary-guidelines/guidelines/

OMEGA 3 FATTY ACIDS

OMEGA-3 FATTY ACIDS

Omega-3 fatty acids are a group of fats that are important for health. Omega-3 fats come in different forms:

Alpha-linolenic acid (ALA). ALA cannot be made in the body so must be eaten in the diet.

Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are long-chain fats that can be made from ALA in our bodies. It is these fats which are associated with health benefits such as lower risk of heart disease (Mori 2017).

Can you name some good food sources of Omega 3 Fatty Acids?

Mori TA. *Fitoterapia*. 2017;123:51-58

GOOD SOURCES OF OMEGA-3 FATTY ACIDS

Fish (Omega-3)	Non-Fish Alternatives (ALA)	Others
Salmon, Mackerel, Trout, Tuna, Sardines, Cod, Herring	**Nuts and Seeds**: Walnuts, Pumpkin Seeds **Vegetable Oils:** Rapeseed and Linseed **Soy Products**: Beans, Milk, Tofu, Edamame, Soybean Oil	Avocados Olives (oil) Chia Seeds

Mori TA. *Fitoterapia*. 2017;123:51-58

OMEGA-3 FATTY & HEAD TRAUMA

In rodent models there is large body of evidence that supplementation of Omega-3 DHA enhances resilience to brain injury.

In 2016, Oliver et al. supplemented American football athletes with 2, 4 or 6 g/day of DHA.

It was found that irrespective of DHA dose, supplementation reduced axonal damage which is a characteristic of mild traumatic brain injury.

Although data is limited, it is possible that DHA may protect against the negative effects of sub-concussive and concussive injuries.

SSE#190 GATORADE SPORTS SCIENCE INSTITUTE

Oliver J & Anzalone A. *Sports Science Exchange*. 2018;29(190):1-4
Oliver JM, Jones MT, Kirk KM, et. al. *Med Sci Sport Exerc*. 2016;48:974–82

OMEGA-3 FATTY ACIDS & RECOVERY

Omega-3 fatty acids are also have anti-inflammatory properties.

Supplementation of Omega-3 have been found to **reduce muscle soreness** following muscle damaging arm exercise.

Although the evidence is limited, this may be beneficial to athletes during a period of fixture congestion, during a tournament or a heavy training period when recovery is more important.

Jouris KB, McDaniel JL, Weiss EP. *J Sports Sci Med*. 2011;10(3):432-438

OMEGA-3 & THE INJURED ATHLETE

New research suggests that Omega-3 intake may benefit injured athletes.

McGlory et al (2019):

- Supplemented participants with Omega-3 (5 g/d) for 4 weeks. During this period subjects underwent 2 weeks of limb immobilization, followed by two weeks of return to normal activity.
- This study found a greater decline in muscle volume in the control group, compared to the Omega=3 group.
- Omega-3 ingestion maintained muscle mass during the immobilization period, attributed to higher muscle protein synthesis rates.

McGlory C, Gorissen SHM, Kamal M, et. al. *FASEB J.* 2019;33(3):4586-4597

OMEGA-3 FATTY ACIDS: SUMMARY

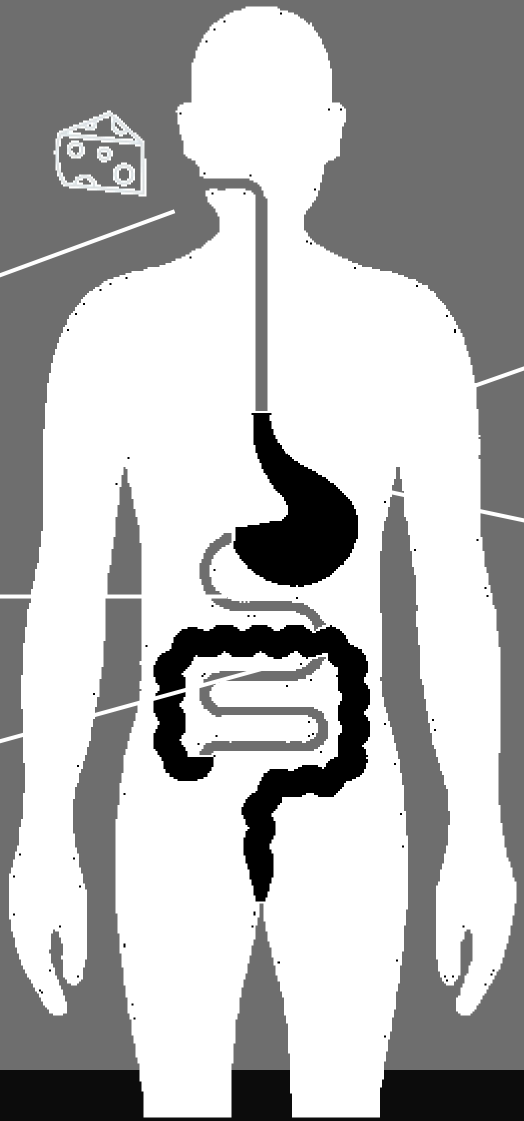
- Consumption of Omega-3 fatty acids are associated with
  - Lower rates of cardiovascular disease
  - Protection following mild head trauma
  - Preservation of muscle mass during limb mobilization
  - Antioxidant/ anti-inflammatory properties
- The Dietary Guidelines for Americans 2015–2020 recommend consuming **8 oz (227 g)** of fatty fish per week.
- However, consuming 8 oz fish/week would not contain the quantity of omega 3 fatty acids reported to be effective, particularly for potential neuroprotection.

DIGESTION, ABSORPTION, STORAGE & BREAKDOWN

DIGESTION AND ABSORPTION

Lingual lipase begins
to breakdown lipids

Lingual lipase and gastric lipase
continue to breakdown lipids



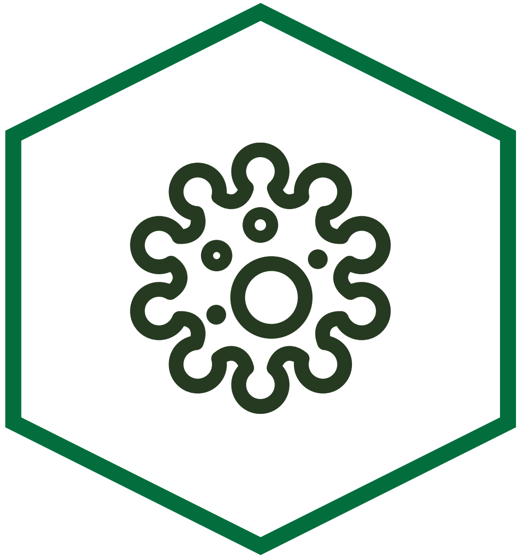
Stomach contracts and relaxes = chyme
(large lipid globules)

Bile salt break the large
globules into small droplets

Pancreatic lipase hydrolyses the
small droplets to release fatty acids
and micelles are formed

Jeukendrup and Gleeson. *Human Kinetics*. 2004

STORAGE



Adipose Tissue
~12 kg

Skeletal Muscle
~0.3 kg

Approx. amount for 80 kg man with 15% body fat

STORAGE

- The main storage form of fat in the body is triacylglycerol (TAG)
- Most fat is stored in the white adipose tissue
- TAG is also stored in the liver and skeletal muscle.
- Muscles cannot use (oxidize) TAGs they have to be broken down into fatty acids and glycerol.

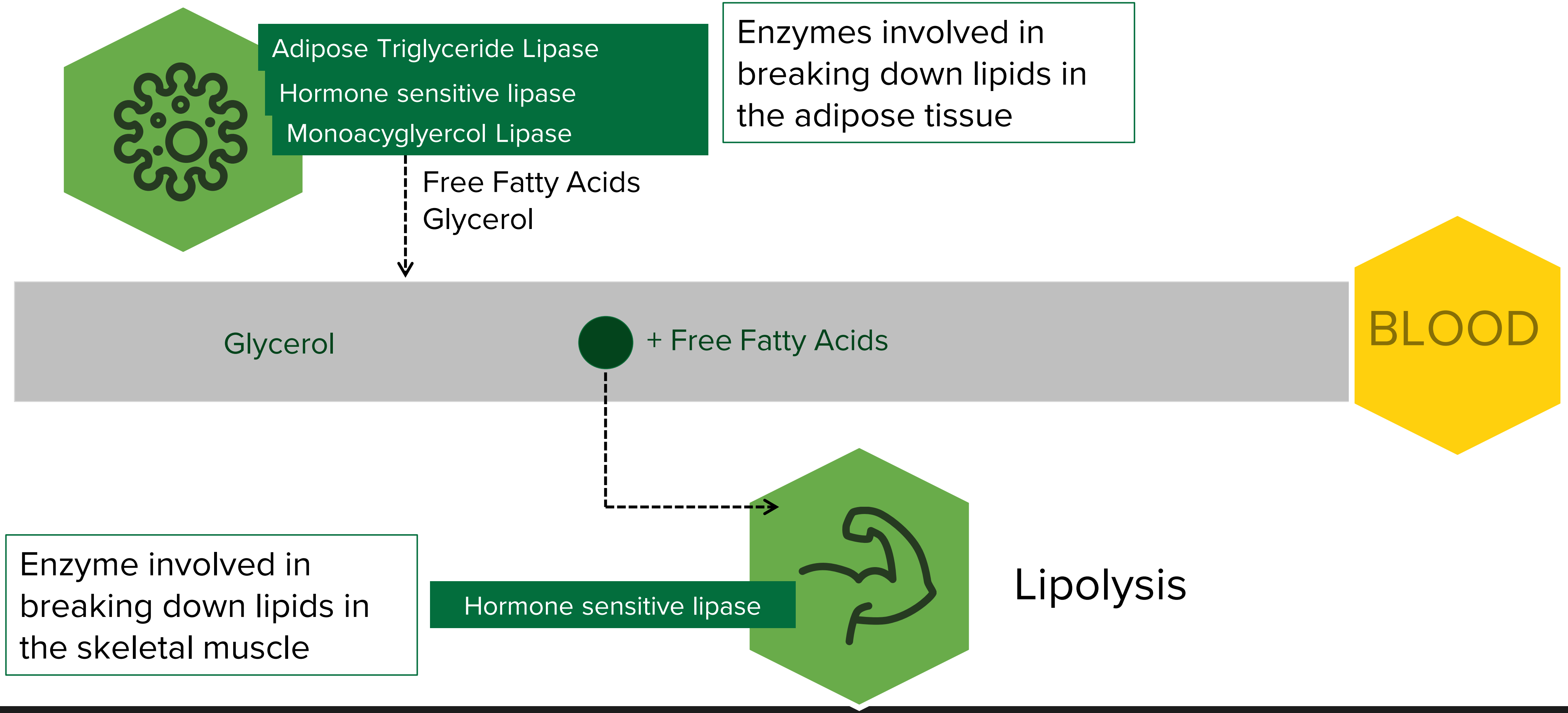
Adipose Tissue
~12 kg

Skeletal Muscle
~0.3 kg

Adapted example from Jeukendrup and Gleeson. *Human Kinetics*. 2004

LIPID BREAKDOWN

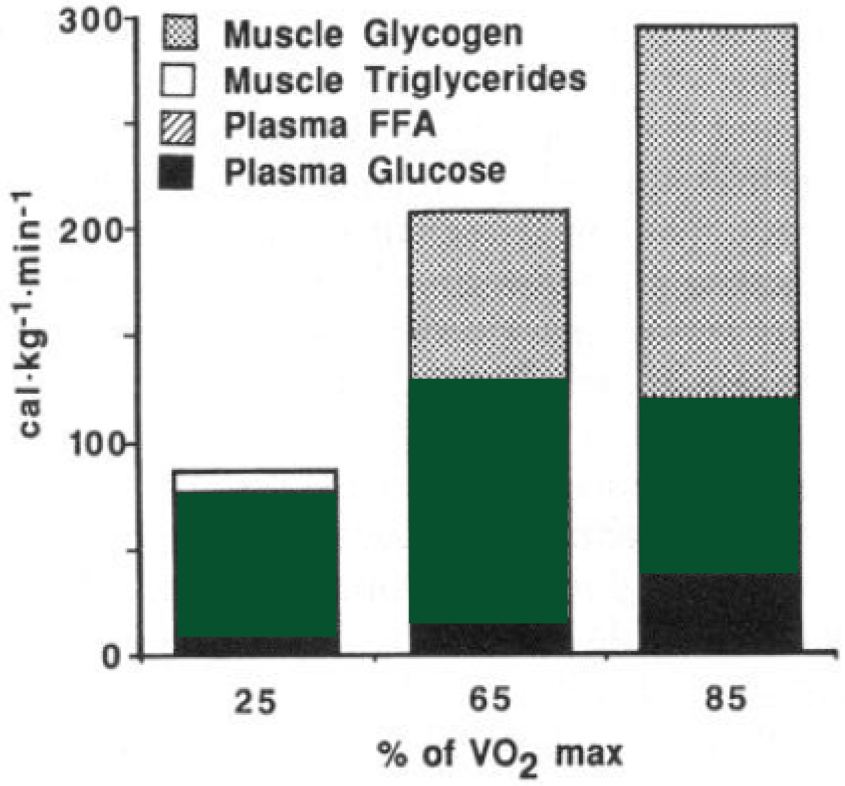
The breakdown of lipids is called lipolysis and takes place in the adipose tissue and skeletal muscle.



FAT UTILIZATION DURING EXERCISE

SUBSTRATE METABOLISM & EXERCISE INTENSITY

Contribution of fat sources to total energy expenditure



Fat is the primary fuel at low – moderate exercise intensities.

As exercise intensity increases above ~60-65% VO_2max there is a shift in energy substrate utilization- fat oxidation decreased and carbohydrate oxidation increases.

The study here by Romijn et al. (1993) tested subjects on three occasions and used muscle biopsies to determine fuel utilization.

SSE#205

GATORADE SPORTS SCIENCE INSTITUTE

Spriet L & Randell R. *Sports Science Exchange*. 2020;29(205)1-6

Romijn JA, Coyle EF, Sidossis LS, et. al. *Am J Physiol*. 1993;265:E380-91

ASSESSMENT OF SUBSTRATE METABOLISM

An exercise test has been developed to determine substrate utilization during exercise using indirect calorimetry.

Cycling Protocol:

Collection of VO_2 and VCO_2

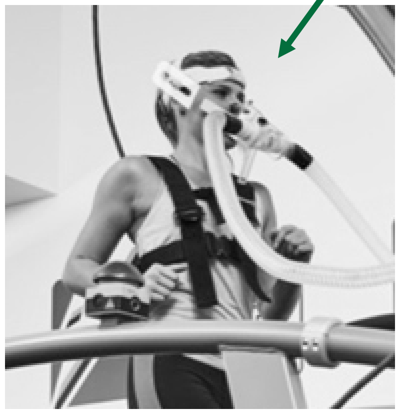
35 W ↑ every 3 min

Achten J, Gleeson M, Jeukendrup AE. *Med Sci Sports Exerc*. 2002;34(1):92-97

ASSESSMENT OF SUBSTRATE METABOLISM

Running Protocol

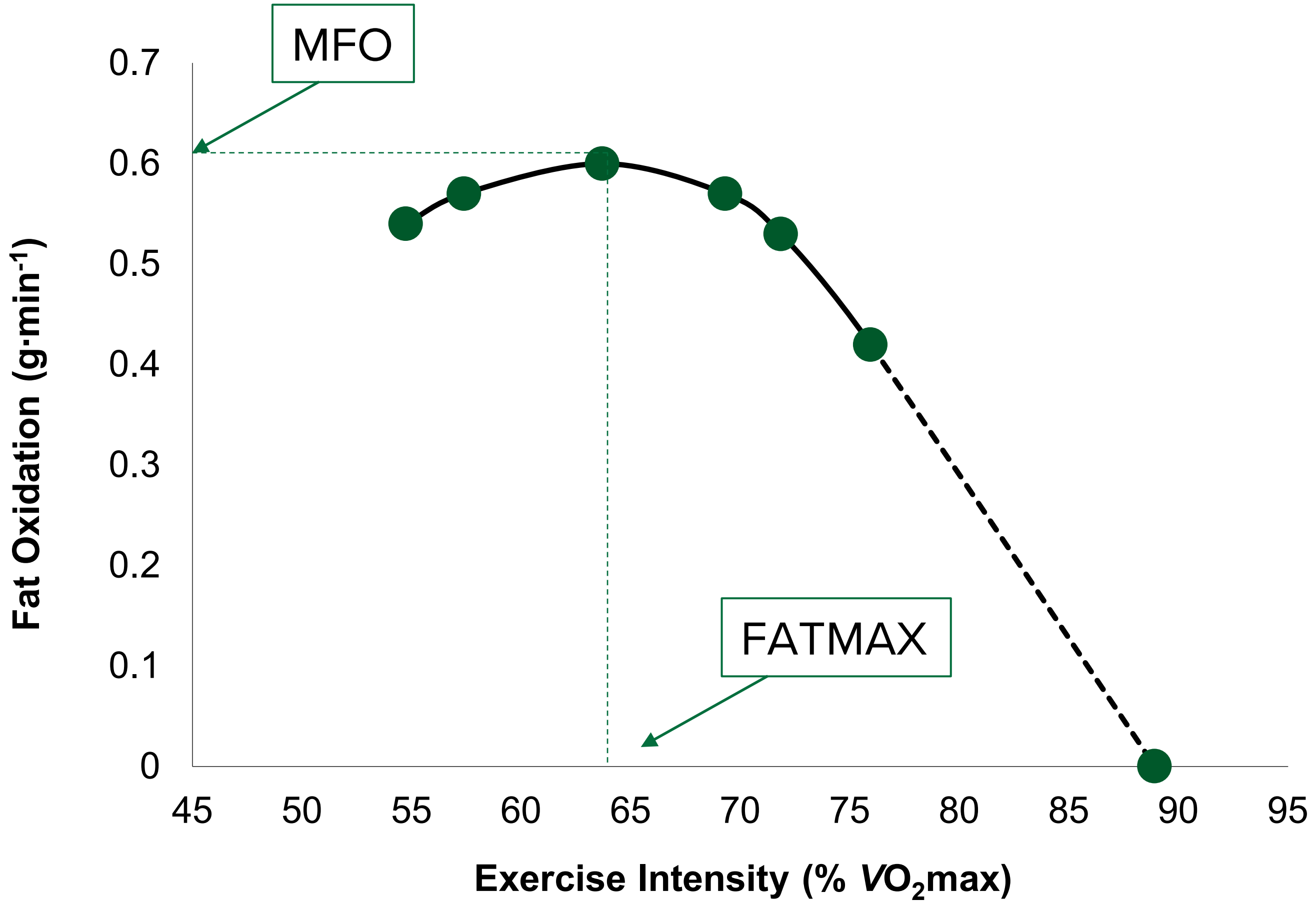
1-2 km/h ↑ every 3 min



Collection of VO_2 and VCO_2

Venables MC, Achten J, Jeukendrup AE. *J Appl Physiol*. 2005;98(1):160-167

ASSESSMENT OF SUBSTRATE METABOLISM



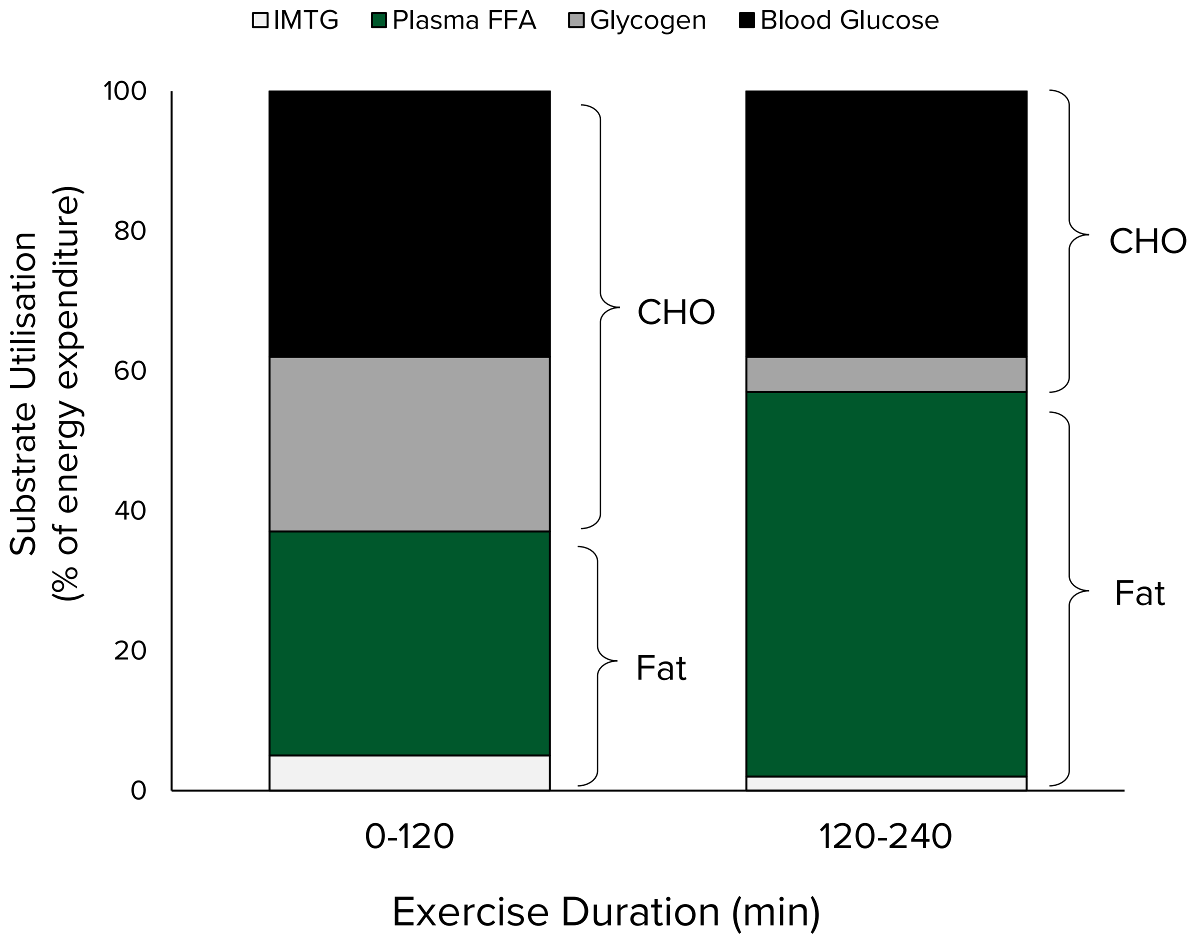
Using the collected VO_2 and VCO_2 values, fat and carbohydrate oxidation rates can be calculated using stoichiometric equations (Jeukendrup and Wallis (2005)).

Using this method **maximal fat oxidation rates (MFO)** and the **exercise intensity** at which it occurs **(FATMAX)** can be calculated on an individual basis.

SSE#206 GATORADE SPORTS SCIENCE INSTITUTE

Jeukendrup and Wallis. *Int J Sports Med*. 2005;26:28-37

SUBSTRATE METABOLISM & EXERCISE DURATION



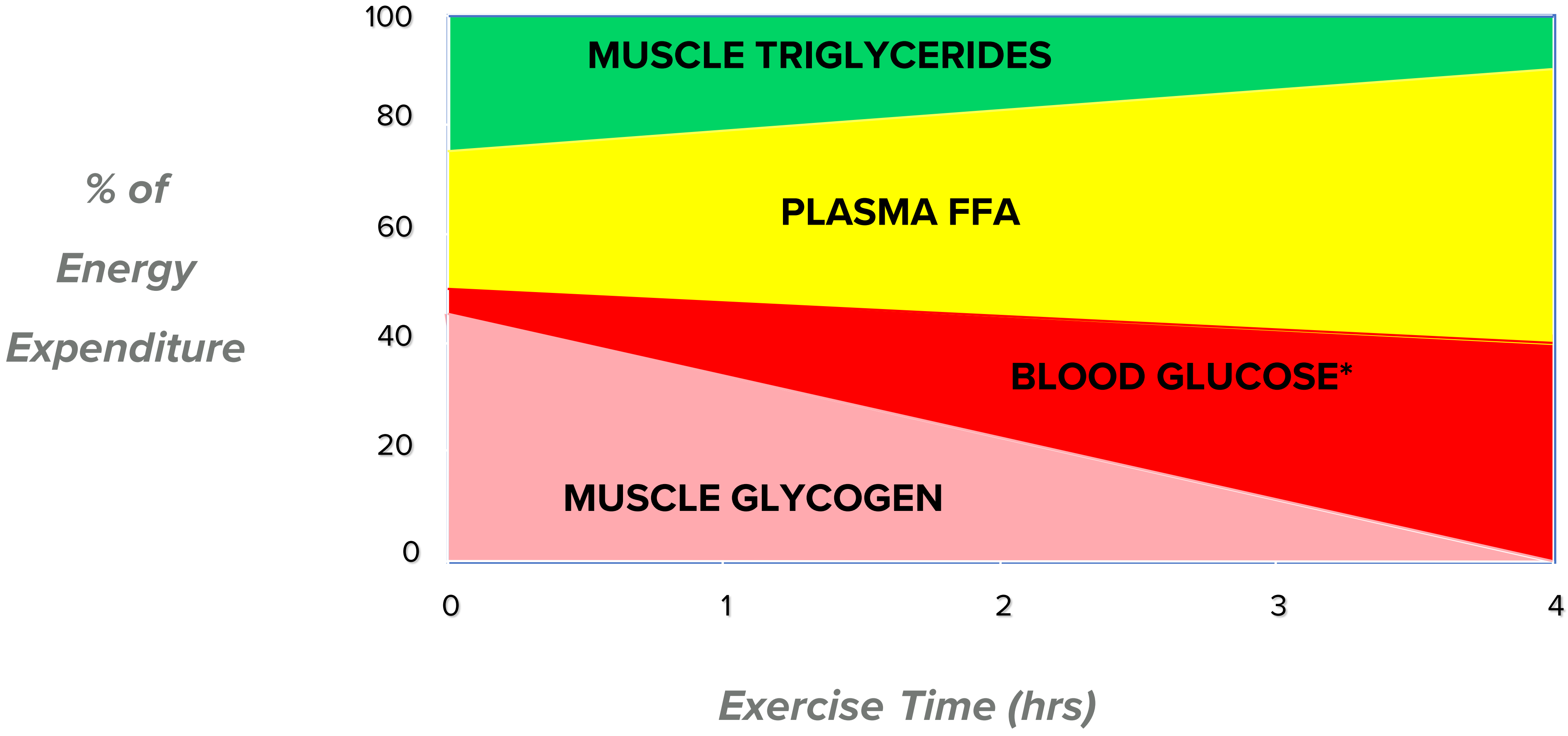
Exercise duration also influences substrate metabolism.

As exercise duration increases the contribution of fat to total energy expenditure increases.

SSE#205

Spriet L & Randell R. *Sports Science Exchange*. 2020;29(205)1-6
Watt WJ, Heigenhauser GJF, Dyck DJ, et. al. *J Physiol*. 2002;541(3):969-978

SUBSTRATE UTILIZATION DURING EXERCISE



Coyle EF. *Am J Clin Nutr*. 2000;72(2):512S-520S

KEY TAKEAWAYS

- ✓ Fats have many important functions in the human body and should not be excluded from the diet.
- ✓ Fats can be categorized depending on the amount of carbon atoms in their structure as well as the numbers of double bonds.
- ✓ Fat intake should make up 20-35% of energy expenditure.
- ✓ Omega-3 intake may be beneficial for athletes
- ✓ The majority of fat is stored in white adipose tissue
- ✓ Fats are broken down (lipolysis) to be used by the skeletal muscle as fuel.
- ✓ At low-moderate exercise intensities, fat is the predominant fuel source. As intensity increases, fat oxidation decreases
- ✓ Assessment of maximal fat oxidation rates is called FATMAX

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