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 backbone.
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.
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.
<table>
<thead>
<tr>
<th>Dietary Sources</th>
<th>Saturated</th>
<th>Monounsaturated</th>
<th>Polyunsaturated</th>
</tr>
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<tbody>
<tr>
<td></td>
<td><img src="image" alt="Saturated Sources" /></td>
<td><img src="image" alt="Monounsaturated Sources" /></td>
<td><img src="image" alt="Polyunsaturated Sources" /></td>
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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.
• 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).
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?
## GOOD SOURCES OF OMEGA-3 FATTY ACIDS

<table>
<thead>
<tr>
<th>Fish (Omega-3)</th>
<th>Non-Fish Alternatives (ALA)</th>
<th>Others</th>
</tr>
</thead>
</table>
| 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         |
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.

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.

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


• 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.
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.

Oliver JM. Journal of Athletic Training. 2019;54(1):5-6
DIGESTION, ABSORPTION, STORAGE & BREAKDOWN
Lingual lipase begins to breakdown lipids.

Lingual lipase and gastric lipase continue to breakdown lipids.

Bile salt break the large globules into small droplets.

Stomach contracts and relaxes = chyme (large lipid globules).

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

Adipose Tissue
~12 kg

Skeletal Muscle
~0.3 kg

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

Adapted example from Jeukendrup and Gleeson. *Human Kinetics*. 2004
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.
The breakdown of lipids is called lipolysis and takes place in the adipose tissue and skeletal muscle.

Enzymes involved in breaking down lipids in the adipose tissue:
- Adipose Triglyceride Lipase
- Hormone sensitive lipase
- Monoacylglycerol Lipase

Enzyme involved in breaking down lipids in the skeletal muscle:
- Hormone sensitive lipase

Lipolysis:
- Glycerol + Free Fatty Acids
- BLOOD
FAT UTILIZATION DURING EXERCISE
Fat is the primary fuel at low – moderate exercise intensities.

As exercise intensity increases above ~60-65% VO₂max 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.
An exercise test has been developed to determine substrate utilization during exercise using indirect calorimetry.

**Cycling Protocol:**

35 W ↑ every 3 min

Collection of VO$_2$ and VCO$_2$
Running Protocol

1-2 km/h ↑ every 3 min

Collection of VO₂ and VCO₂
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.
Exercise duration also influences substrate metabolism.

As exercise duration increases the contribution of fat to total energy expenditure increases.
SUBSTRATE UTILIZATION DURING EXERCISE

Energy Expenditure

% of Energy Expenditure

Exercise Time (hrs)

- MUSCLE TRIGLYCERIDES
- PLASMA FFA
- BLOOD GLUCOSE*
- MUSCLE GLYCOGEN

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