Visualizing the Difference in Cellular Power Output Between Untrained and Trained Humans

Israel Defense Forces - 4th Annual Ground Forces Race (10K race: Feb 6, 2011)

Assume 2 runners from this group (each pictured on the next page) weigh the same as each other and each has equal body fat and muscle mass. Despite his 'fit' appearance, assume runner B worked a desk job for the last year and quit exercising altogether. Today, he's running with his buddies.

Imagine runner A and B running at the same pace.

This means each runner's leg muscles produce the exact same power ouput, i.e. each 'body' pushes the same mass at the same speed.

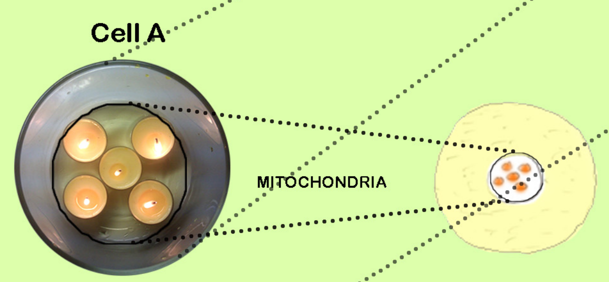
In the cells below (and in the two runners compared above) **total power output is identical** - but the contribution of energy from each section of the cell toward the total power output is not equal. More specifically, cell B uses a greater percentage of glycolsis to produce the equivalent power as cell A. **

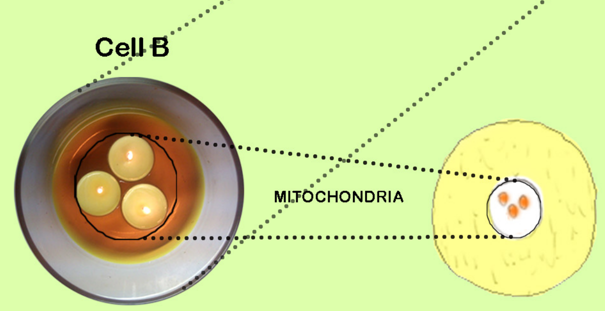
It happens that a cell with a 'smaller firebox' (cell B has less mitochondria) can produce the same power output as a cell with more mitochondria. But it makes up for the loss of oxidative power supply with an alternative source.

In this case, cell B must rely on more glycolysis to produce the equivalent power produced by cell A, as indicated by the darker yellow color in the cytosol of cell B.

The downside is more lactic acid is produced in cell B, (or in any runner who has a lower lacate threshold), also indicated by the darker yellow color in the cytosol of cell B.

Thus, runner B is in danger of 'hitting the wall' or depleting his muscles of glycogen much sooner than runner A!



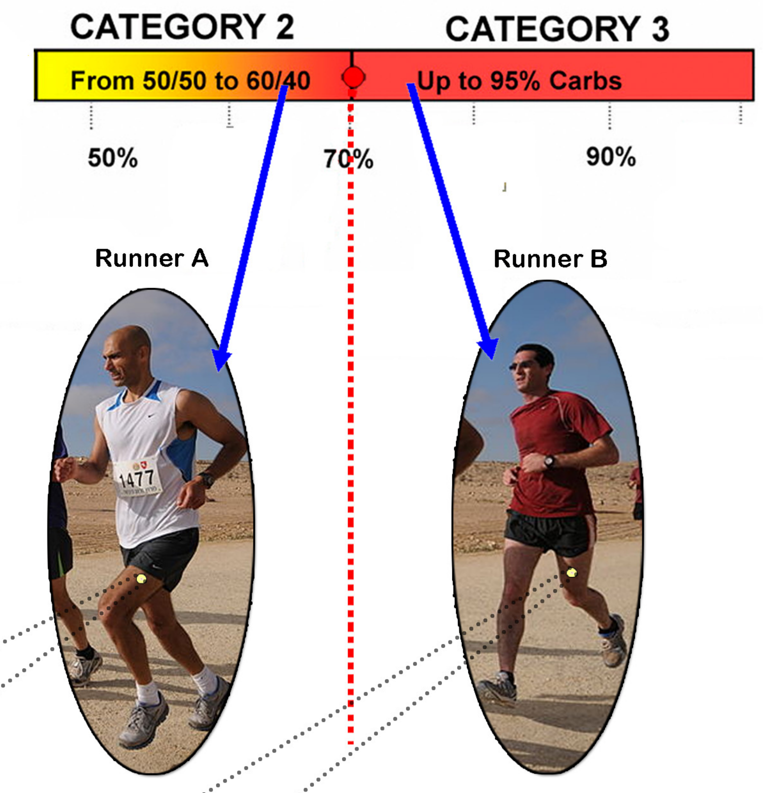


IMPORTANT TO KNOW: Oxidative metabolism = aerobic metabolism = power supplied from 'combustion'

** A 'small fire' utilizes less fuel and consumes less oxygen comparitively to a bigger fire. Cell A has a 'bigger firebox' - and therefore can produce more power from glucose aerobically or oxidatively.

Hence, cell A (runner A) relies less on glycolysis to sustain the power required for his current pace, and conversely, cell B (runner B) must resort to glycolysis because his mitochondria is 'too small' for burning greater quantities of glucose oxidatively, compared to runner A.

Variation of Glucose Utilization & The 'Firebox' Adaptation



Runner B must rely on glycolysis to sustain the pace, while runner A can rely on combusting glucose anaerobically in the mitochondria. The 'cost' to produce this equivalent power amounts to 19 times more glucose utilized! **

Thus, runner A will spare his muscle glyocgen stores.

Runner B is working in the 'Red Zone' even though he runs the same speed as runner A. Thus, B depletes glycogen at a faster rate than runner A - due to his cells operating in the 'Crazy Glycolysis' zone.*

*Runner B requires 19x more glucose to produce the equivalent energy.

In terms of eating the equivalent glucose from food, B must eat a much greater amount of carbohydrate compared to A! Considering the fact runner A must eat less carbohydrate to replace the 'less lost' gluocose energy, this means a greater percentage of his total caloric intake MUST consist of a greater percentage of fat.**

** See pie charts in the Carb Continuum Volvelle.

Lesson: The body **selectively depletes either fat or carbohydrate** according to intensity level, and the conditioned state of your cells.

Anaerobic glycolysis: 1 glucose produces 2 ATP's Note: ATP has ***purposely* not been explained yet, details later.

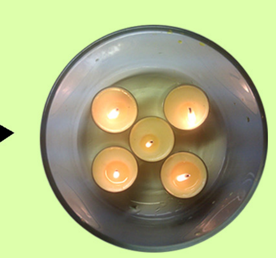
**Aerobic combustion of glucose produces 38 ATP's. Thus, 19x more energy is produced per glucose molecule, and this 'spares' glycogen from being 'wasted' during 'crazy glycolysis'.

IMPORTANT TO KNOW: Mitochondria are actually enzymes.

Trained people create a 'larger firebox' through training! The adaptation adds more mitochondrial enzymes, aka increases the density of mitochondria as shown below.

A primary adaptation resulting from endurance exercise is an increase of mitochondrial enzymes, or a 'bigger firebox'. This allows for greater oxidative combustion of glucose and fat.

This adaptation 'spares carbs' since 19 x less glucose is utilized to produce the equivalent power if glucose is used oxidatively rather than glycolytically. Glycolytically means without O_2, in the cytosol.



So... as exercise intensity increases, the trained person can 'throw' more carbs into the firebox to be utilized oxidatively, whereas the untrained person must utilize and literally 'waste' carbs in the cytosol (the primitive part of our cells) to produce the equivalent power.