

# Tuning Up the Mitochondria: How a Consistent Exercise Routine Improves Mitochondrial Health in Diabetics

## The Mitochondria:

Humans are eukaryotic organisms, meaning that our cells contain an organelle called the mitochondria. The mitochondria is often referred to as the “powerhouse of the cell,” as it is responsible for producing ATP (adenosine triphosphate), the short-term energy stored within the cell.

## Why is it important?

The human body’s muscle cells have a high concentration of mitochondria that produce ATP. This is released from the organelle so that the cell can use it for other cellular functions and all of our biological processes. The mitochondria undergoes the process of cellular respiration to produce ATP molecules. Cellular respiration is how we derive energy from the food that we eat from the monosaccharide, glucose, in the presence of oxygen. As the mitochondria uses oxygen in its cellular respiration process, it releases carbon dioxide as a waste product. With every exhale, carbon dioxide is released from the process of cellular respiration as a waste product. When the presence of oxygen is smaller than needed to undergo the process of cellular respiration, the mitochondria only produces a small amount of ATP in the presence of the production of lactic acid. ATP is considered the “primary energy currency for cells.” It is a small molecule, but within its bonds it possesses the potential to provide a quick burst of energy.

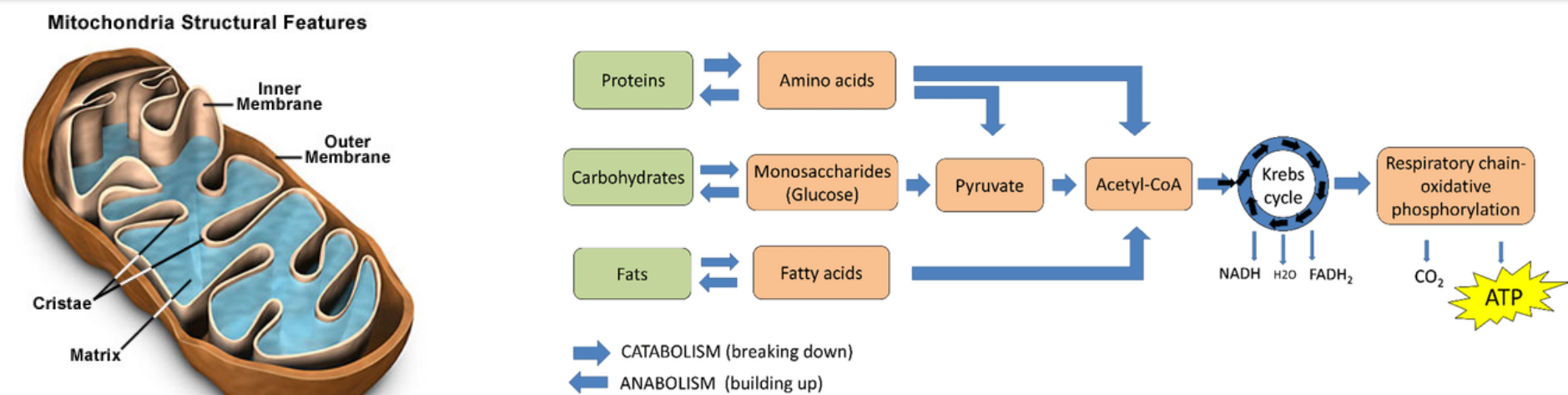


Figure 1

## Studies on Exercise Amongst Diabetic Patients

A research paper conducted by John P. Kirwan, PhD, examined the role of exercise on diabetic patients in 2017. In his research, Dr. Kirwan explains the long history of the benefits of exercise., and its affordability that makes it the desirable candidate for preventing and monitoring diabetes. Maintaining a consistent physically active lifestyle has been proven to reduce the risk of developing “glucose tolerance, insulin resistance, and type 2 diabetes. It has also been established that low cardiovascular fitness is a strong and independent predictor of all-cause mortality in patients with type 2 diabetes”(Kirwan 2017).

Additionally, Kirwan points out that integrating a strong routine of physical activeness can reduce levels of hemoglobin A1c, which when elevated are predictive of vascular complications in patients who suffer from diabetes (Kirwan 2017).

A 2007 research experiment published by the National Library of Medicine involving 60 type two diabetic adults confirms this. Over the span of six months of aerobic exercise and training, all 60 in the experimental group had undergone rigorous programming where they were supervised by a physician. Each session included a warmup, aerobics activity, and a cooling down period. During physical activity, the heart rate of the participants were reviewed under a polar heart rate monitor. At the end of the six month training session, 56 of the 60 adults who completed the experiment were found to have a reduction in their HbA1c levels, fasting plasma glucose, insulin resistance, and systolic blood pressure compared to the less harsh activity conducted performed by the control group.

A decline in insulin resistance, rather, creating insulin sensitivity, allows for blood glucose levels to lower, as membrane embedded glucose transport proteins within the membrane of the cells are allow for the glucose to enter the cell and assist in cellular work. In doing so, the proper amount of ATP is produced by the mitochondria in the presence of oxygen as an end product of cellular respiration.

## Diabetes

### Different Types of Diseases and Their Effects on Mitochondria Processes:

#### Type I Diabetes:

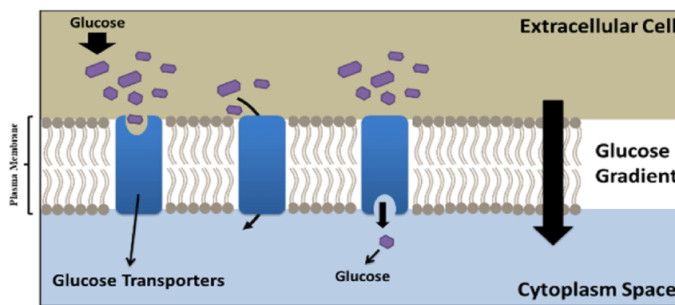
When a person has type one diabetes, it means hat the insulin their pancreas produces is immediately attacked. Unlike type two diabetes, the insulin made by the pancreas is effective, and can be used to activate glucose channels within cells to allow for the glucose to flow in and continue with its cellular functions. However, the insulin produced by the pancreas is attacked immediately as if it were an invader. This, causes the glucose located in the bloodstream to continue to grow. Your body tries to excrete the build up of glucose from the bloodstream through alternative methods. Your kidneys try to remove the glucose through the urinary system. Frequent urination leads to excessive thirst, and overtime can lead to unanticipated weight loss.

#### Type II Diabetes:

To have type two diabetes means that the insulin your pancreas produces is ineffective. There is an insulin resistance, meaning that it is unable to allow any glucose from entering the cell to assist the mitochondria in the production of ATP. Instead, glucose levels in the blood continue to rise. This results in many symptoms such as feelings of fatigue, increased thirst, frequent urination, blurred vision, frequent infections, and unanticipated weight loss. Still, people can live up for a long time until they are diagnosed as they show no symptoms. If an individual continues to not show any symptoms over an extended period of time without being properly diagnosed and treated, high glucose levels can cause impairment on vision, the urinary system, nervous system, and the cardiovascular system.

### How does this affect levels of ATP production?

Type one and type two diabetes re both considered mitochondrial diseases, meaning that they result in abnormalities onto the mitochondria that prevent it from producing the anticipated amounts of ATP. This can be especially dangerous when patients are unaware that they have diabetes, as it can be years until they are diagnosed since they do not show any symptoms. According to a 2016 research study by Kimberley L. Way, insulin resistance has shown to significantly increase the incidence and prevalence of cardiovascular disease in individuals with type two diabetes.



\* This is a visual presentation of glucose transporters embedded within the plasma membrane of the cell. The glucose enters from the extracellular cell, through the membrane embedded proteins, into the cytoplasm space within the cell. Glucose is then broken down in a cycle called glycolysis while in the cytoplasm. From there, the pyruvate molecules, a product of glycolysis, enter the mitochondrion.

## The Takeaway

The purpose of the mitochondria and its cellular functions is to produce energy, ATP, which is needed to power the chemical reactions of the cell. Building a resistance towards insulin, that’s purpose is to activate glucose channels, leaves a buildup of glucose in the bloodstream, causing a sequence of symptoms. When untreated, which is common as the patient could not show any symptoms, can lead to damage to the nervous system, urinary system, and heart disease. The integration of a consistent physical routine helps prevent the formation of diabetes, as well as create insulin tolerance in people who already have diabetes in order to produce ATP at a more adequate level.

Maintaining a consistent workout regimen will help with the production of ATP to carry out the chemical reactions of the cell. It is important to remember that

## References

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