In this eBook you will learn how to control blood sugar through exercise, and gain an understanding for the importance of muscle tissue in regulating blood sugar.

Blood Sugar Control and Exercise

Using Exercise to Control Blood Sugar and Manage the Effects of Insulin Resistance

Cyrus Khambatta, PhD
Nutritional Biochemistry
Copyright Mangoman Nutrition and Fitness
# Table of Contents

About the Author .......................................................... Page 2  
The Benefits of Exercise ............................................... Page 3  
Cardiovascular Exercise ............................................... Page 3  
Resistance Exercise ...................................................... Page 4  
High Quality Muscle Tissue ........................................... Page 5  
The Muscle Supercompensation Effect ............................... Page 6  
The Difference Between Muscle Quality and Quantity ........ Page 6  
The Characteristics of High Quality Muscle Tissue ............... Page 8  
How Much Exercise is Necessary? ..................................... Page 9  
Creating an Exercise Program .......................................... Page 10 
Progressive Resistance .................................................. Page 11 
References ........................................................................ Page 12 
Photo Credits ..................................................................... Page 12
About Cyrus Khambatta, PhD  
Nutritional Biochemistry

I was diagnosed as a type 1 diabetic at the age of 22, in my senior year of college. At that time in my life I didn’t understand anything about diabetes, I only knew that it had “something to do with sugar.” In the first year of life as a diabetic, my health deteriorated rapidly, to the point where I began to seriously question whether I would be able to exercise ever again. Constant lethargy, dehydration, muscle soreness, and a lack of motivation occupied most of my waking day, which directly opposed the athletic lifestyle that I had maintained my entire life.

After the first year I finally decided to seek positive change, and launched a personal research project to learn about changing my lifestyle for the better. I changed my diet from the ground up, and in a short period of time I experienced abundant energy, quality sleep, reduced blood glucose, increased athleticism, and a significant increase in my quality of life.

I decided to study towards a PhD in Nutritional Biochemistry to understand the molecular level details of the diabetic condition, and contribute to the peer reviewed scientific literature. I received a PhD from UC Berkeley in 2012, and have since started a business as a nutrition and exercise coach for type 1 diabetics and type 2 diabetics. In only a short period of time, I have had great success with my clients, and aim to continue inspiring positive change in the lives of both type 1 and type 2 diabetics.

In the process of living as a diabetic and studying the molecular level physiology of diabetes, I have come to realize one thing: diabetes can be a very confusing condition. Therefore, my goal as an educator and coach is to provide diabetics with the tools to understand the biology of their condition in a non-technical manner, so that they can then use this knowledge to make healthy lifestyle choices for themselves. I aim to teach the fundamental principles of what it means to live a “healthy” lifestyle as a diabetic (or as a parent of a diabetic), and to inspire diabetics to take full control of their health using nutrition and exercise techniques based on scientific research.

Click here to follow me on Facebook:  
https://www.facebook.com/mangoman nutrition

Click here to follow me on Twitter:  
http://www.twitter.com/drmangoman
The Benefits of Exercise

We’ve all heard the adage that exercise is good for you. In fact, many doctors and researchers (including myself) go so far as to say that exercise is the single most powerful drug known to man. And the support for this concept is not hard to find. Exercise benefits every organ in your body, large to small. Here are a few benefits of exercise:

<table>
<thead>
<tr>
<th>Effect</th>
<th>Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased lean body mass</td>
<td>Muscle</td>
</tr>
<tr>
<td>Reduced fat mass</td>
<td>Adipose (fat) tissue</td>
</tr>
<tr>
<td>Lower resting heart rate</td>
<td>Heart</td>
</tr>
<tr>
<td>Lower cholesterol levels</td>
<td>Blood vessels</td>
</tr>
<tr>
<td>Reduced blood pressure</td>
<td>Blood vessels</td>
</tr>
<tr>
<td>Increased memory formation</td>
<td>Pituitary gland (brain)</td>
</tr>
<tr>
<td>Reduced depression</td>
<td>Brain</td>
</tr>
<tr>
<td>Improved digestive function</td>
<td>Small intestine, large intestine, pancreas, liver</td>
</tr>
</tbody>
</table>

There is a lot of confusion on what exercises to perform and how much to perform for increased health. It seems like every few years the research changes, from time-intensive cardiovascular exercise to short-duration cardiovascular exercise to high intensity interval training (HIIT).

The benefits of exercise on the human body hasn’t changed, it’s just that our understanding of how exercise affects our body is constantly evolving.

Cardiovascular Exercise Defined

Cardiovascular training is sometimes called aerobic exercise. This is the world’s most popular form of exercise, mainly because it can be performed without any equipment. You don’t even need shoes. You simply need to move. It doesn’t matter how you move, just that you do it continuously to get your heart pumping fast.

The benefits of cardiovascular training are massive, and occur all throughout your body. Your heart is the muscle that performs the bulk of the work, hence the name cardiovascular. Don’t be fooled, your heart is a muscle, however it is constructed slightly differently than the muscles supporting the rest of your skeleton, mainly because it acts like a pump to circulate blood.

Cardiovascular exercise strengthens the force with which your heart contracts (also called...
cardiac output). Stronger beats mean that with each beat, your heart is capable of pumping a larger volume of blood. In addition, cardiovascular exercise increases the number and cross sectional area of the blood vessels in your heart, in order to provide your heart with larger amounts of blood.

**Frequent cardiovascular exercise trains your heart to pump more blood through the rest of the body, and to pump blood to itself. Genius.**

Cardiovascular exercise (e.g. walking, jogging, running, swimming and cycling) also strengthen skeletal muscles throughout your body. After all, those are the muscles that are doing the work. Because cardiovascular exercise can be performed for long periods of time, large muscle groups are usually the major contributors.

Simply stated, cardiovascular exercise burns calories. Lots of calories. You may have noticed the last time you did cardiovascular exercise that you got very tired and perhaps slept well that same night. Often this occurs because the amount of energy you burned in the process of moving large muscle groups was quite high. Overall, this is a great thing, especially if you are overweight.

**Losing weight starts by burning calories.**

### Resistance Exercise Defined

Resistance training is the type of movement in which your body is *resisting* an external force. The external force can be a weight set, another person, or your own body. In most cases, gravity provides the force; opposing that force is what leads to muscle growth over time.

Most people think that resistance exercise requires an expensive gym membership, spending time lifting weights or lifting heavy objects. This is a misnomer. Resistance exercise can be performed without a single weight, and can be performed using only your body as a weight (hence the term *bodyweight* exercise).

The most important thing you should know about resistance exercise is this:

**Resistance exercise preserves (and even grows) muscle mass, which is an essential aspect of becoming a diabetic health machine.** Preserving muscle mass will keep the billions of mitochondria in your muscle hungry for glucose, amino acids and fatty acids, keeping the strength of the glucose vacuum high.

In order to become a diabetic health machine it is imperative to perform exercise that preserves muscle mass, and even increases it in exchange for fat mass. When muscle tissue is given the stimulus to grow (even in small amounts), it becomes very hungry for nutrients, including nutrients that are already stored on your body. True, the nutrients you eat will feed your increasingly hungry muscle tissue, but by preserving muscle mass you also gain the ability to breakdown the fat stored all around your body.
This is great news for diabetics, for a number of reasons:

- Preserving muscle mass burns fat mass already stored on your body
- Reduced fat mass kick starts the weight loss process
- Reduced fat mass increases the action of insulin
- Increased insulin action means increased insulin sensitivity

High Quality Muscle Tissue

Imagine if we were able to separate you into a number of piles and weigh each pile separately. In one pile we might find your bones. In another pile we would find your muscle. In a third pile we would find your body fat.

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>15%</td>
<td>12%</td>
</tr>
<tr>
<td>Muscle</td>
<td>42%</td>
<td>36%</td>
</tr>
<tr>
<td>Fat</td>
<td>16%</td>
<td>27%</td>
</tr>
</tbody>
</table>

**Average Body Composition of Men and Women in the United States.** The average body composition of males and females in the United States is shown here, broken down by bones, fat, and muscle tissue. On average, males tend to be composed of a larger proportion of lean body tissue (bones and muscle), whereas women tend to be composed of a larger proportion of fat tissue.

**Why Is Muscle Tissue Important?**

Unless you are obese, your body has more muscle tissue than any other single tissue type. This is great news for you as a diabetic because muscle tissue is also the hungriest tissue in the body, and is responsible for more glucose vacuuming than any other tissue.

Muscle tissue is important for many reasons. Muscle responds to physical movement by changing shape, size, and function. This is the very nature of exercise “training.” When a muscle contracts, the fibers that comprise the tissue contract. In the process of contracting, the muscle consumes small amounts of onboard fuel. These onboard fuels are mainly carbohydrate and fat.
In response to repeated contractions, the contracting muscle fibers get depleted of their onboard fuel stores because the mitochondria are being asked to generate energy continually. In addition to using up onboard fuel, the muscle fibers undergo a series of micro-tears that are by-products of repeated contraction cycles.

**Frequent and repeated muscle contractions result in muscle micro-tears and depleted fuel stores.**

When the exercise session is complete, the muscle fibers enter a state of recovery in which the damaged muscle fibers are hungry for nutrients from the bloodstream to (1) replenish fuel stores, and (2) grow in preparation for the next exercise session\(^1\). Let’s look at these a little more closely.

**The Muscle Supercompensation Effect**

The way muscle tissue adapts to exercise is by supercompensating in the resting state. What this means is that the repair process not only fixes the micro-tears that occurred during the previous exercise session, it repairs itself to be stronger than it was originally so that the muscle can withstand longer durations of exercise and generate more force. This is known as the supercompensation effect, and is the main reason why exercise training over time results in muscle tissue growth\(^9,10\). If this were not the case, muscle tissue would not grow larger or become stronger over time, and you would not notice a difference in endurance, speed, flexibility or strength.

Think of a car. When the gas tank in your car gets low, you head to the gas station to refill the tank. If your car has a 15 gallon fuel tank, 15 gallons is the most fuel that you can carry at any one time. But imagine if you drove a “smart” car that adapted to the amount that you drove. Over time, the size of the gas tank would grow. Today it’s 15 gallons. Tomorrow it would be 16 gallons. Next week it would be 17 gallons. Over time, this would mean that the more you drove, the more fuel your car could carry.

The more you exercise, the larger the glucose stores become. This process does not continue forever, but strategic exercise training can increase the amount of glucose that your muscles store as glycogen.

**The Difference Between Muscle Quality and Quantity**

Most people don’t differentiate between muscle QUANTITY and muscle QUALITY. Most people think that exercise will lead to large muscles. This can be an especially large deterrent for women, who want to maintain a petite physique.

Simply exercising muscle tissue will not make it larger, unless you specifically design your exercise program to gain mass. The truth is that your muscle will respond to the type of exercise training you perform. Therefore if you want to maintain long, slender, skinny muscle, then you can easily do so by performing the right activities. Instead, if you want to gain 10 pounds of muscle and enter a bodybuilding competition, you must specifically train your body to gain muscle mass.
Take a look at the pictures below to understand this concept:

Muscle Quantity and Quality Are Not the Same. The bodybuilder on the left has a large quantity of muscle tissue, because he has trained specifically to gain muscle mass over time. The result is a large quantity of muscle and a low quantity of fat. The athletes on the right have completely different bodies than the bodybuilder on the left. Their bodies are lower in muscle quantity and definition. Which of these three athletes is most insulin sensitive?

As a diabetic, muscle quality is more important than muscle quantity.

Muscle quality is a measure of how well the muscle tissue in your body responds to glucose, whereas muscle quantity is a measure of the size of your muscle tissue.

The two do not have to be mutually exclusive, however it is important to note that you do not have to look like the bodybuilder on the left in order to have high insulin sensitivity. The truth is, you can’t look from the outside to determine which of these three athletes are the most insulin sensitive. Instead, we have to examine the muscle tissue from the inside, and make sure that the muscle is hungry for large quantities of glucose.
The Characteristics of High Quality Muscle Tissue

As far as diabetes is concerned, the most important determinant of muscle tissue quality is how well the muscle tissue responds to insulin\textsuperscript{11–13}. Therefore, the following two points are important to understand:

- **If a small amount of insulin can push a large quantity of glucose into the muscle, then the muscle is considered high quality (insulin sensitive).**
- **If a large quantity of insulin is needed to push a large quantity of glucose into the muscle, then the muscle tissue is low quality (insulin resistant).**

In the diagram:

- **INSULIN SENSITIVE**: When a small amount of insulin can push large amounts of glucose into body tissues.
- **INSULIN RESISTANT**: When a large amount of insulin is needed to push glucose into body tissues.

**Insulin Sensitivity is the Opposite of Insulin Resistance.** Insulin sensitive tissue requires a small amount of insulin in order to vacuum large amounts of glucose out of the bloodstream. Insulin resistant tissues require large amounts of insulin in order to vacuum large amounts of glucose out of the bloodstream. Making large amounts of insulin cause significant stress to the beta cells in the pancreas.
There are a number of factors which ultimately determine the quality of muscle. Not all of these factors must be present at the same time in order for your muscle to be considered high quality. In other words, strive for these muscle qualities, but don’t get hung up if you don’t possess them all.

Characteristics of High Quality Muscle Tissue

(1) Flexibility  
(2) Strength  
(3) Endurance  
(4) Vascularization  
(5) Short Time to Recovery  
(6) High Demand for Nutrients (Hungry)  
(7) Low level of inflammation

How Much Exercise Is Necessary?

The question how much exercise is necessary to be healthy? is an age old question that modern science has now attempted to tackle. Researchers have investigated the effects of exercise type, duration, intensity, and frequency, and have come up with a wide range of answers to describe the optimal exercise program. It’s great that we’ve put our best and brightest to the test. The problem is that there doesn’t seem to be a consensus.

Studies show that the people who get the best results were the ones that exercised for 5 hours per week on average, and split their workouts 50-50 between cardiovascular and resistance exercise.

Aim to Exercise for 5 Hours Per Week  
For Optimal Blood Sugar Control

Most people think that only doing aerobic exercise will get the job done, and that resistance training is only for bodybuilders. This mentality could not be farther from the truth.

By performing only cardiovascular exercise, you run the risk of losing muscle mass. That’s because cardiovascular exercise does not stimulate the muscle to grow nearly to the extent that resistance training does. Therefore, your body will hold on to exactly the amount of muscle required to do aerobic exercise, and nothing more. The worst part is that muscles not directly involved in the exercise itself will get smaller over time and lose both their strength and their hunger. And if you’re overweight, then losing muscle mass will certainly not help you lose weight.
If you are overweight, losing muscle mass by performing ONLY cardiovascular exercise will stunt your ability to lose weight.

**The Exercise Double Whammy**

Performing either aerobic or resistance exercise in isolation doesn’t have nearly the effect of the two together.

By supplementing cardiovascular exercise with equal amounts of resistance exercise, you get the exercise double whammy: ravenously hungry muscle tissue and an incredibly strong heart.

**Ease Yourself into an Exercise Program**

One mistake that many people make is trying to hit the 5-hours-of-exercise-per-week target immediately. This can be a huge mistake, especially if you have not exercised recently. When it comes to exercise, consistency is the key to achieving the body you want and developing a consistent muscle hunger that will keep your blood sugar in check. So depending on your current state of physical activity, use the following table as a guide for increasing your exercise frequency to the 5-hours-per-week goal:

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise 1 hour</td>
<td>Exercise 2 hours</td>
<td>Exercise 3 hours</td>
<td>Exercise 4 hours</td>
<td>Exercise 5 hours</td>
</tr>
<tr>
<td>30 min resistance</td>
<td>1 hour resistance</td>
<td>2 hours resistance</td>
<td>2 hours resistance</td>
<td>3 hours resistance</td>
</tr>
<tr>
<td>30 min cardio</td>
<td>1 hour cardio</td>
<td>1 hour cardio</td>
<td>2 hours cardio</td>
<td>2 hours cardio</td>
</tr>
</tbody>
</table>

**If You Do Not Currently Exercise**

If you do not exercise at all, start by achieving 1 hour per week of exercise divided between 30 minutes of resistance exercise and 30 minutes of cardiovascular exercise. You can perform them as individual sessions on separate days.

**If You Currently Exercise Even A Little**

If you’re already exercising regularly, then find the column that best describes the total number of hours that you perform. As an example, if you perform 2 hours of exercise per week on average, then locate the column that says “Week 2: exercise 2 hours.” That’s your starting point. Start by performing 2 hours of exercise this week, divided between 1 hour of resistance exercise and 1 hour of cardiovascular exercise. Next week, add 1 more hour of total exercise. The following week, add 1 more hour. Repeat this process until you achieve 5 hours of total exercise, divided between 3 hours of resistance exercise and 2 hours of cardio exercise.
Progressive Resistance

When it comes to exercise, the name of the game is *progressive resistance*. I’ll define the term as follows:

*Progressive Resistance*: the method of gradually increasing the difficulty of an exercise session by increasing either the duration or intensity.

Incorporating progressive resistance into your regimen means that on a weekly basis, you challenge yourself to work slightly more than the week before. So if today you can run a mile in 8 minutes and 30 seconds, next week aim to run a mile in 8 minutes and 20 seconds. The following week aim to run a mile in 8 minutes and 15 seconds. Changing your workout goals by seemingly tiny amounts like this continually challenges your muscle tissue to remodel, grow, and adapt to increasing levels of stress.

By incorporating *progressive resistance* into your workout regimen, you will not only achieve a better body in a shorter period of time, but begin to reverse the effects of insulin resistance quickly. By continually challenging muscle tissue all throughout your body, you not only maintain high quality muscle tissue over time, you stimulate the muscle tissue to continuously vacuum glucose out of the bloodstream to satisfy a large appetite.
References


Photo Credits


Telstar Logistics / Foter / CC BY-NC

CelebMuscle / Foter / CC BY-NC-SA

Pensiero / Foter / CC BY-NC-ND