frontiers FOR YOUNG MINDS

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IS FAT TISSUE "PLASTIC"?

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Fat tissue, called adipose tissue, is our energy storage and it plays a vital role in the growing process. Did you know that we have three different types of adipose tissue that can convert into each other during our lives? The white adipose tissue stores fat from the foods we eat. The brown adipose tissue is responsible for heat production. And lastly, the beige adipose tissue is a form that is halfway between these two. The white and brown adipose tissues are very important to the body's functioning. But, if we eat a lot of sugar and fat, the metabolism and functions of these tissues change, which can result in diseases like obesity and diabetes. Nowadays, scientists are studying the possibility of turning white adipose tissue into brown adipose tissue, in an attempt to prevent and reverse some of these diseases.

ADIPOSE TISSUE

Is our energy storage and it plays a vital role in the growing process. Is constituted by adipocytes (fat cells), nerve cells and blood vessels.

ADIPOCYTES

Cells that compose adipose tissue, storing energy as fat.

WHAT IS ADIPOSE TISSUE?

Adipose tissue, also known as body fat, contains a type of cells called **adipocytes** (fat cells) as well as nerve cells and blood vessels. In the human body, it is possible to find three types of adipose tissue that

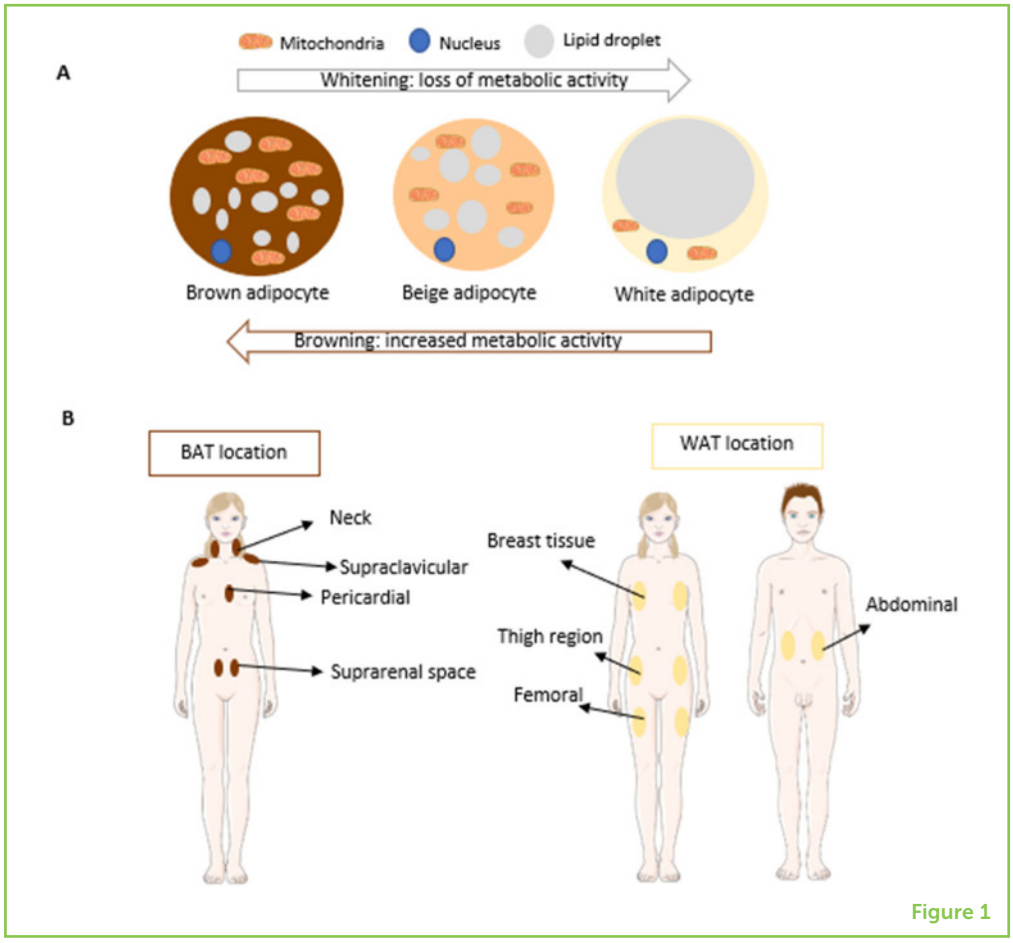

Figure 1

(A) Brown adipocytes are characterized by high numbers of cellular structures called mitochondria, which makes BAT the most metabolically active type of adipose tissue. Brown adipocytes have small fat droplets. White adipocytes store fats and contain a large fat droplet. They have lower numbers of mitochondria. Beige adipocytes are an intermediate form—more metabolically active than white adipocytes, but less active than brown adipocytes. Brown and white adipocytes can be interconverted, by processes called browning and whitening. **(B)** Locations of WAT and BAT in the human body.

MITOCHONDRIA

Structures within cells that generate energy using the food we eat.

FATTY ACIDS

Building blocks of the fat that we eat in our diet. Fatty acids besides being a source of energy, they act as main constituents of cellular membranes. Increased levels of fatty acids are one important link between obesity, insulin resistance, and type 2 diabetes.

OBESITY

Abnormal or excessive fat accumulation leading to several diseases, like heart disease, type 2 diabetes, and certain types of cancers, including breast and prostate.

differ in function, structure, and location: white adipose tissue (WAT), brown adipose tissue (BAT), and beige adipose tissue (Figure 1A). Each kind of adipose tissue has specific traits.

BAT, which stores low levels of fat, is responsible for maintaining body temperature. BAT can do this this because it contains large numbers of **mitochondria**, which are cellular energy factories. The large numbers of mitochondria are also what give BAT its brown color. BAT is found in large quantities in newborns and young people, but the amount of BAT decreases throughout life (Figure 2). BAT eventually turns into WAT, through a process called whitening. Whitening reduces the metabolism of adipose tissue, which means that the cells burn less energy.

WAT primarily works as energy storage. The cells of WAT each contain a large fat droplet and fewer mitochondria, which makes them white in color. WAT releases substances called **fatty acids**, which are an important energy source, during periods of fasting. WAT is found in high quantities in adults, and this is the type of fat that if present in huge amounts result in overweight or **obesity**.

Figure 2

As we get older, the amount of BAT in our bodies decreases and is converted to WAT.

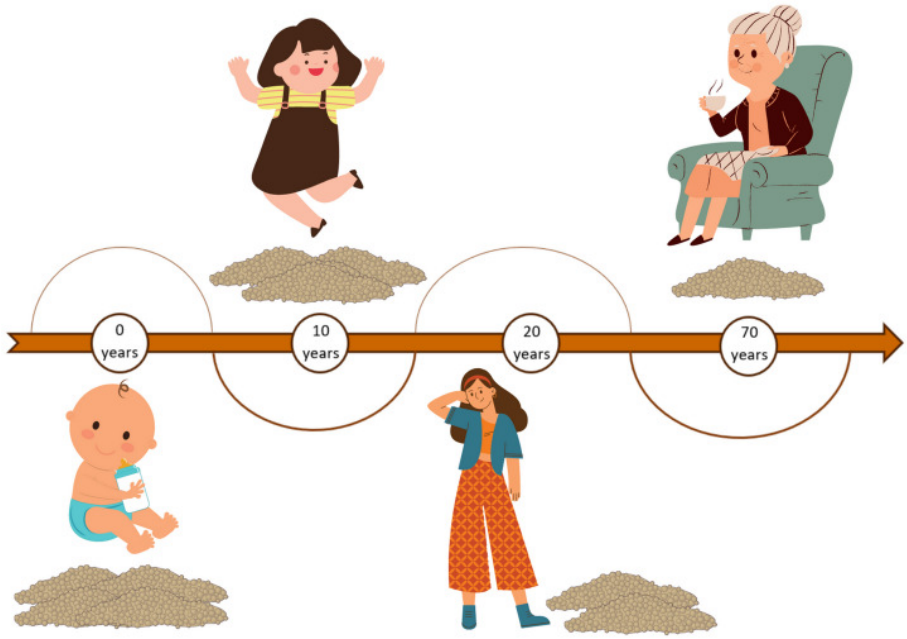

Figure 2

Beige adipose tissue is similar to BAT in function, and it can be found in small amounts in adults. Beige adipose tissue is formed from the conversion of WAT in BAT, which is called browning. During browning, energy is released in the form of heat, which speeds up **metabolism**. As we get older and lose BAT, the browning process still occurs, but at a much reduced rate. At this stage, WAT does not become BAT—instead, it turns into beige adipose tissue. Scientists are working to understand if browning can be used to turn WAT into beige adipose tissue, to fight some **metabolic disorders**, like type 2 diabetes [1].

METABOLISM

Group of biochemical reactions in the cells of our bodies to transform food into energy.

METABOLIC DISORDERS

Group of conditions based on alterations in biochemical reactions that alter usage of food to obtain energy.

WHERE IS ADIPOSE TISSUE FOUND?

The three types of adipose tissues are found in different locations in the body. The greatest portion of WAT is found right underneath the skin and surrounding the organs [2]. As you have probably noticed, men and women have different body shapes. This is influenced by the regions where each gender accumulates fat. Women have more WAT in the thigh and breast regions, while men have more abdominal fat. These differences in the distribution of WAT between males and females play a role in the risk of developing certain diseases and cancers (breast cancer, for example, which appears mostly in women). BAT disappears from most body regions as we grow up, but some remains—primarily in the upper back, shoulders and neck (Figure 1B).

CAN ADIPOSE TISSUE GROW?

During adulthood, the adipose tissue can expand, due to the formation of new blood vessels that supply nutrients and oxygen to the growing adipocytes. But WAT and BAT grow in different ways. WAT growth needs a change in the blood vessel network to supply the new adipocytes with oxygen and nutrients to avoid the dysfunction [3]. On the other hand, BAT needs lots of blood vessels, to supply it with the oxygen and nutrients it needs to produce heat [4].

We are sure you know what happens when people eat more than they need, or if they have unhealthy eating habits. When people gain weight, the big problem is that the adipose tissue expands and grows incorrectly. This leads to obesity and adipose tissue dysfunction. The adipose tissue starts to release substances that cause inflammation, just like when you get a cold and your throat gets inflamed [5]. This inflammation can increase the risk of developing metabolic disorders like type 2 diabetes, which we will describe below.

IS ADIPOSE TISSUE GOOD OR BAD?

Have you ever been told not to eat too many candies or too many burgers? The reason for this advice is that too much sugar and too much fat are dangerous for our bodies. However, we need to consume a balanced amount of sugar and fat to survive. The same is true for adipose tissue—too much or too little adipose tissue can cause severe health effects. Too little adipose tissue causes a dangerous loss of body weight. This leads to a lack of vitamins and minerals that are soluble in fat, which can cause vision problems, hair loss, and weakness. Also, the BAT that we have in the neck is used to produce heat to keep us warm when we are in cold weather.

But when we eat too much unhealthy food, excessive fat will accumulate throughout the body. In contrast to the BAT, the WAT that accumulates around the abdominal organs like the liver, intestines, and pancreas, and even the fat that accumulates below the skin, does not have the capacity to keep us warm. Instead, accumulation of WAT can lead to obesity. Obesity currently affects more than 1 billion adults worldwide, and it can lead to heart disease, type 2 diabetes, and certain types of cancers, including breast and prostate [4].

How does obesity lead to these diseases? We cannot cover all the details in this one article, but let us look briefly at the example of type 2 diabetes, which is a metabolic disease that affects how the body uses sugar. Normally, a hormone called insulin stimulates the body's cells to take up sugar from the blood, which the cells use for energy. When there is too much WAT, too many fatty acids are released from the adipocytes. An excess of fatty acids results in **insulin resistance**, which means the cells no longer respond to insulin by taking up sugar from

INSULIN RESISTANCE

The inability of cells to respond properly to insulin, which normally promotes the uptake of sugar from the blood into cells.

Figure 3

Unhealthy habits, such as eating too many foods with high fat and sugar content and/or not getting enough exercise, lead to an increase in WAT and to the whitening of BAT, because the adipocytes have to store high amounts of fat. However, studies in rats and mice indicate that exposure to low temperatures and a healthy diet might increase the amount of BAT [1].

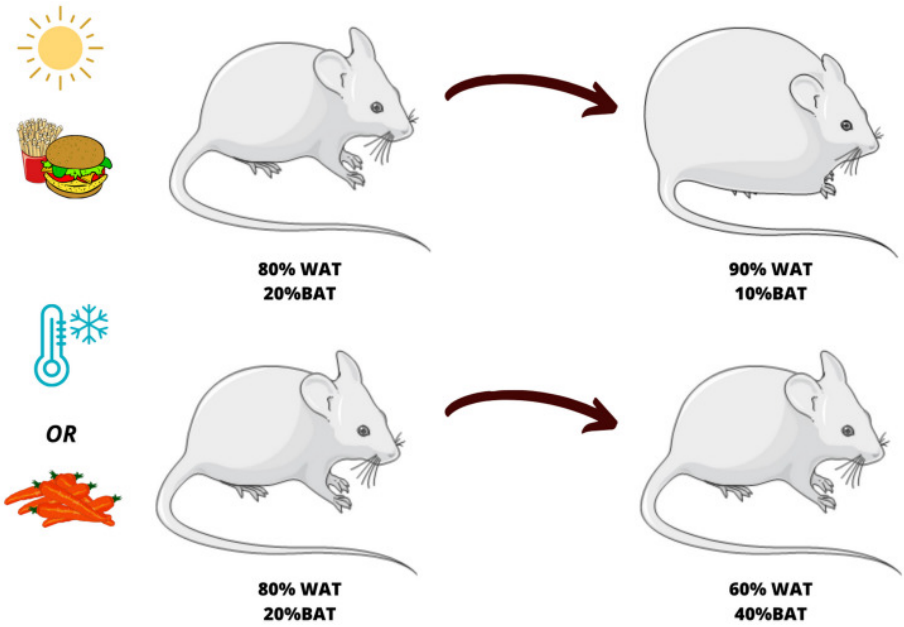

Figure 3

the blood, resulting in blood sugar levels that are higher than normal. Type 2 diabetes is dangerous because eventually the high levels of sugar in the blood lead to disorders of the circulatory, nervous and immune systems.

BROWN ADIPOSE TISSUE AS A WEAPON AGAINST OBESITY AND DIABETES

One of the biggest challenges of this century is discovering how to reduce the number of people who are obese and suffer from obesity-related disorders like type 2 diabetes. This challenge has become even more important during the Covid-19 pandemic. Obesity increases the risk of severe illness and hospitalization due to Covid-19 infection.

As we explained, BAT helps to keep the body's temperature constant when the air temperature is low. When we are exposed to cold temperatures, molecules in the skin relay a signal to the nervous system, which then releases a substance that causes BAT to burn fat [6]. This produces heat and increases metabolism. Studies using mice exposed to low temperatures and given high-calorie diets showed interesting results. Due to the browning of WAT stimulated by the cold temperatures, these animals developed high amounts of beige fat and did not gain weight. Scientists are currently trying to develop therapies based on these results, to stimulate the browning of white adipocytes to fight obesity in humans (Figure 3).

BAT may also help us fight type 2 diabetes. Recent studies showed that BAT plays an important role in insulin sensitivity. When BAT activity is increased, this promotes a decrease in blood sugar levels, because the cells of the body become more sensitive to insulin and thus can increase their uptake of sugar from the blood [7]. Researchers found that people with active BAT have lower blood sugar levels than people without active BAT [1].

WHY CAN WE SAY ADIPOSE TISSUE IS PLASTIC?

During our lives, our adipose tissue is constantly interconverting between WAT, BAT, and beige adipose tissue. That is why it can be considered a "plastic" tissue—it is changeable. When too much whitening occurs, it leads to obesity and the metabolic disorders that affect a huge percentage of the world's population. Do you know anyone who suffers from obesity or type 2 diabetes? Chances are, you do! It is clear that having an excess of WAT is toxic for our bodies, just like excess plastic is toxic for our planet. Scientists are trying to stimulate the "good" plasticity of adipose tissue, to promote browning and hopefully reduce obesity and cure metabolic disorders. But, in the meantime, we can all play a part by embracing healthy eating habits and getting lots of exercise, to keep our bodies functioning properly.

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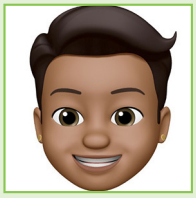

NAVIN, AGE: 15
I am interested in the medical field and aspire to become an anesthesiologist in the future. I enjoy reading and drawing cartoons. I have been playing ice hockey and love being on the rink. Tennis, swimming and cross-country is also my favorite sports. I love eating anything that is vegetarian. I want to contribute to my community in any way I can and make a positive change.

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I love science and am especially into medicine. I am passionate about health and wellness. I enjoy reading and watching heist movies. I love spending time in labs, researching and learning. I had like to learn more languages; right now, I can speak three. I hope to travel to more countries in the future!

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