FAT…. It's Not All That: Two Main Types of Fat in Our Bodies, Visceral and Subcutaneous Fat

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Abstract

Sixty-six % of American adults are considered to be overweight or obese. Much research is currently being conducted to learn about the different types of adiposity, the biochemical processes of adipocytes, or fat cells, the hormones secreted by these cells, health risks associated with obesity, and its contributing factors. The report below will outline how to classify obesity, the hormones secreted by fat cells (eptin, resistin, and adiponectin) and how they work in the body, the two types of fat: visceral, or intra-abdominal fat and subcutaneous fat, inflammation and health conditions, studies linking genetics to obesity, and the overall contributing factors to gaining excessive weight.

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Introduction

According to the 2003-2004 National Health and Nutrition Examination Survey [NHANES], an estimated 66% of adults, aged 20-74, in the United States can be classified as overweight or obese (Ogden, C., Carroll, M., Curtin, L., McDowell, M., Tabak, C., & Flegal, K., 2006). In addition, 17% of children ages 6-19 are considered to be overweight. Obesity can be defined as an excess of body fat where the size and number of adipocytes, or fat cells, increases, which typically is associated with considerable health risks (Myers, 2004). This report will define and outline obesity and its correlation to body fat content, the two main types of body fat, visceral and subcutaneous fat, and the risks associated with each. In addition, it will discuss the hormones fat cells secrete in the human body.

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Defining Obesity

In order to pronounce that an individual is overweight obese, health professionals use height and weight measurements to calculate a person's body mass index [BMI]. BMI can be described as a surrogate indicator of an individual's fat content. Although it does not measure fat directly, BMI is directly related to body fat (CDC, 2007a). BMI is defined as weight (kg)/ height (m)^2 (Myers, 2004). To classify adult individuals as overweight they must have a BMI range of 25.0 kg/m^2 to 29.9 kg/m^2, while an obese person is defined as having a BMI of 30.0 kg/m^2 or greater (CDC, 2007a). Although this method is a useful tool for determining overweight and obese patients, it may not be the most accurate or scientific. Some research suggests that a more precise, non-invasive and faster instrument for measuring a person's fat content is through single-slice magnetic

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resonance imaging [MRI] (Morley, 2007). This type of procedure is helping to assess children and adults who are at risk for serious health complications in research projects; however, this procedure is expensive and thus not the primary method used for determining fat content. Yet, in order to use these methods and tools, healthcare specialists must first identify the types of fat which they are measuring and where these are distributed throughout the body.

Fat Facts

A fat cell, or adipocyte, stores fat as triglyceride in the body. Triglycerides are composed of three fatty acids and a glycerol molecule. Adipose tissue is comprised of fibrous connective tissue with adipocytes that provide a source of energy to the body which protect, cushion, and insulate vital organs. Adipose tissue used to be thought of as an inactive place used only to store energy to be utilized at a later time. But, in 1994 scientists discovered that specific hormones that are useful in preventing health problems actually are secreted by fat cells. Fat, in general, is now regarded as an important part of the human body and is considered to be an active and complex endocrine organ (Gosnell, 2007).

There are two types of adipose tissue known as brown adipose tissue (brown fat cells) and white adipose tissue (white fat cells). Brown fat cells are an individual's first fat cells and are primarily found in infants. These types of cells are composed of an increased number of mitochondria, which are the energy boosters of the cell, and are used in the process of thermogenesis, in order to create heat for the body (Freudenrich, 1998-2007). As an infant continues to develop, the level of brown adipose tissue decreases, while white adipose tissue increases. These white fat cells can be considered the "typical" fat cell found within the human body. These cells are usually 20-25% larger than other body cells due to their lipid content, which is primarily made up of triglycerides and cholesterol ester. They also contain a normal sized nucleus and similar amount of cytoplasm as other cells. Yet, they appear greater in size because of the globular structure of the lipid, or fat, pushing the remaining parts of the cell outward towards the cell membrane.

Fats and Hormones

As mentioned previously, fat is an important endocrine organ that secretes hormones. White fat cells are responsible for releasing the hormones, resistin, adiponectin, and leptin. Resistin is the hormone released to allow tissues to become less sensitive to the action of insulin and most often correlates to insulin resistance which leads to Type II Diabetes ("Resistin," 2006). After an individual with normal metabolism eats a meal, insulin is released by the pancreas and is transported to insulin-sensitive tissues, including adipose tissue. The insulin then causes these cells to internalize glucose, maintaining a normal blood sugar level. However, individuals with insulin resistance, typically those with visceral adiposity, are unable to process glucose in this way. Rather, normal levels of insulin do not trigger tissues to internalize glucose which causes the pancreas to release more insulin in the hopes of getting the cells to respond. At this point, blood sugar levels remain elevated. As a defense, the body attempts to dilute the sugar with water from cells, resulting in dehydration. Moreover, the hormone resistin is released by fat which results in more adipocytes becoming unable to absorb glucose from the blood causing overweight/ obese individuals to become more insulin resistant.

Adiponectin is another hormone released into the bloodstream exclusively by adipose tissue. It is considered to be an "insulin-sensitizing hormone" (Inukai, K., Nakashima, Y., Watanabe, M., Takata, N., Sawa, T., Kurihara, S. et al., 2004). The discovery of this hormone is relatively new; yet, early studies suggest that adiponectin is important in prevention of insulin resistance which is often associated with obesity. Obese individuals produce lower levels of adiponectin as visceral adiposity increases; therefore, these individuals are at increased risk of developing Type II Diabetes, atherosclerosis, and fatty liver disease.

The hormone leptin plays an important role in regulating body weight by modulating energy expenditure. In animal models of obesity, research suggests it is responsible for decreasing appetite by inhibiting food intake and increasing metabolism ("Leptin; LEP," 1966-2007). Metabolism can be described here as continuous chemical processes inside cells that convert fuel from food into useable energy for the body. Basically, leptin is secreted by adipocytes as a defense mechanism against starvation. As adipocytes become larger due to the accumulation of triglycerides, they produce more leptin (Bowen, 1998). So, leptin levels increase as an individual's fat mass expands. In obese individuals leptin levels are high which should decrease appetite and increase energy expenditure. Yet, during weight loss, leptin reduces the number of calories burned by the body to keep an individual from becoming malnourished. Secretion of the hormone leptin decreases as adipose cells become smaller, as when weight loss is occurring. To keep a person from "starving," appetite will increase and resting energy levels drop. This hormone is at least partly responsible for making weight loss a difficult and challenging task.

Research Suggests: Genetic Linkage

A study conducted by C. Ronald Kahn, president and director of the Joslin Diabetes Center, and associates focused on identifying the distribution of visceral and subcutaneous fat. He extracted samples of subcutaneous and visceral adipocytes and pre-adipocytes from mice. Using a molecular technique called "gene chips," he was able to identify the genes in the fat cells (Gosnell, 2007). Of approximately 6,000 different mouse genes, the expression of an estimated 200 varied between the subcutaneous and visceral fat depots. Seven of these genes studied had higher levels of expression in the intra-abdominal (visceral) adipocytes, while five had high levels of expression in the subcutaneous cells (Gesta, S., Bluher, M., Yamamoto, Y., Norris, A., Berndt, J., Kralisch, S., et al., 2006b).

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In an effort to determine whether a similar pattern occurred in humans, Kahn sought another science researcher to conduct a test using human genes. Matthias Bluher, of the University of Leipzig, examined 10 similar genes in samples of the two types of fat taken from 198 human subjects (one-third of who were normal weight, one-third of who were classified as overweight and one-third of who were said to be obese). Bluher concluded that there were differences in the levels of gene expression between visceral and subcutaneous fat depots. Based on the genetic information gained, researchers were able to predict BMI and whether the fat was located in the abdomen (visceral) or on the hips (subcutaneous) for the subjects in the study. According to Stephanie Gesta (Gesta, 2006a), researchers are still unclear about whether this genetic information is a cause or an effect of obesity. Moreover, Kahn has been quoted saying "It is pretty clear that both obesity and body shape are to a large extent genetically programmed" (Gosnell 2007).

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Two types of Fat: Subcutaneous Fat

The largest adipose tissue depot in humans is found in the subcutaneous layer under the skin. It contains large blood vessels, nerves and clusters of fat cells. The adipocytes in this context store lipids (triglycerides). Subcutaneous adipose tissue is most importantly a heat insulator for the body. The amount of insulation it provides depends on the depth of this layer, which is used by the body to regulate its internal temperature through a process called homeostasis.

The subcutaneous layer of the skin is attached to muscles and bones by connective tissue. In an individual with normal weight, the attachment is typically unrestricting. However, when the adipose cells increase in size, space becomes limited and the attachment between connective tissue tightens. This results in the "dimpling" or cellulite appearance on the outer layers of the skin. This is the most visible form of fat on the human body. Yet, subcutaneous adipose tissue deposits differently for men and women. In a very general sense, men typically take on the "apple" appearance such that their fat content is displayed in their mid-sections or abdomen, a pattern known as android obesity. In current research studies, men with these types of fat deposits demonstrate higher blood pressure and increased risk of heart disease, which is being linked with visceral adiposity. One study conducted on Japanese-American men found that testosterone levels were inversely related to high levels of intra-abdominal fat. Measurements such as total body fat (TF), intra-abdominal fat (IAF), body mass index (BMI), and testosterone levels, were taken at the beginning of the study. After seven years, researchers found that the IAF content of men with low baseline testosterone levels had increased to a mean of 8.0 cm^2. In this study, they correlated a change in IAF with low levels of testosterone but found no significant correlations to a change in TF, BMI, or subcutaneous fat. As a result, researchers suggest that low testosterone levels in males may contribute to health risks associated with visceral adiposity such as Type II Diabetes and cardiovascular disease (Tsai, E., Boyko, E., Leonetti, D., & Fujimoto, W., 2000).

On the other hand, women typically deposit subcutaneous fat around the lower body- thighs, hips, buttocks. Thus, this demonstrates gynoid obesity or the "pear" shaped appearance. Although, subcutaneout fat is the most visible in the body, it is not entirely negative in its effects. In fact, Osama Hamdy, director of the obesity clinic as Joslin

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Diabetic Center, believes that subcutaneous fat is benign in its effects on health risks and is actually "good fat" (Gosnell 2007).

Two Types of Fat: Visceral Fat

As mentioned previously, adipose tissue is considered to be an active complex endocrine organ, and visceral fat is more active of than subcutaneous. Visceral fat is able to break down fats stored from the foods individuals consumed earlier by releasing fatty acids into the bloodstream (Gosnell 2007). These processes are nearly continuous in order for energy intake from food and energy expenditure to remain constant throughout the body. Visceral fat is located in the abdominal cavity which surrounds vital organs.

Some studies indicate that as fat intake, such as saturated fats, increases through dietary consumption, so does visceral obesity. However, fat intake is not the only cause of high visceral fat levels. It is also correlated with positive energy balance, that occurs when more calories are eaten than are released from daily activity. Moreover, this type of fat is associated with insulin resistance (Type II Diabetes), cardiovascular disease [CVD] and other metabolic syndromes such as: liver damage, clogged arteries, high LDL cholesterol, high triglycerides, etc.

Visceral obesity has become a major concern among health professionals. It is not easily detected on individuals using the relatively inexpensive BMI method. Rather, it is estimated through magnetic resonance imaging [MRI], which uses magnetic waves to illustrate images of the approximate fat content hidden within the abdominal cavity. Another way to estimate the percentage of this type of central adiposity is to measure waist circumference [WC] or to calculate a waist-hip ratio [WHR]. These are useful in approximating the proportionality of fat distribution around the abdomen. To an extent, health professionals are able to use this information to identify risks of heart disease and diabetes in an individual.

Inflammation

As adipose cells continually change, the secretion of the hormones leptin, resistin, and adiponectin also are modified as the number of fat cells increases, which results in an increase of pro-inflammatory markers in the body. Researchers have been able to link obesity with increased levels of pro-inflammatory markers which originate in adipose tissue, such as cytokines and C-reactive protein. CRP is thought to be an indicator of

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cardio-vascular disease [CVD] (Stienstra, R., Mandard, S., Patsouris, D., Maass, C., Kersten, S., & Mueller, M., 2007) but is also higher in obesity.

As fat cells increase in size, they can become filled with macrophages. Macrophages are parts of the body's immune system and attempt to rid the body of infection. In obesity, the macrophages secrete interleukins, or toxins, into the body. As a result, these toxins can cause damage to the liver and arteries as well as play a role in contributing to insulin resistance and ultimately Type II Diabetes. Yet, it remains unclear how the infiltration of macrophages directly affects white adipose tissue to result in insulin resistance and other health problems. Stienstra et al. (Steinstra et al, 2007) believes that the modified hormone secretions may have an impact on the processes. Furthermore, scientists are beginning to view obesity as a state of low-chronic inflammation.

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Factors that Contribute to Obesity

There are many factors which contribute to obesity. The CDC (CDC, 2007b) suggests multiple contributing factors to obesity such as, energy imbalance, genetics, environment, behavior, socioeconomic status, and culture. Energy imbalance may perhaps be the most scientifically logical explanation for obesity. In regards to weight gain, energy imbalance refers to the amount of energy that is consumed by an individual is greater than the amount of energy being expended. In other words, overweight/ obese individuals are eating more calories than they are burning in specific time period. Although this is a reasonable rationalization, energy imbalance is not the only factor linked to obesity.

Scientists are on the cutting edge of relating genetics to obesity. Studies have been conducted in order to identify specific genes in the human genome that are responsible for fat deposition. Although still inconclusive, these studies indicate there is a direct correlation between genes and obesity. Some scientists suggest that there are certain genes which predispose the deposition of either visceral or subcutaneous fat. Hence, this is an area that is currently being investigated in order to learn more about how to manage and prevent obesity.

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Environmental, behavioral, and social factors all influence the predisposition for excessive weight gain. Environments can be classified as the places in which people live and work. An example of a causal factor of obesity might include living long distances from work and driving or using alternative transportation, all the while remaining sedentary during the commute and limiting overall energy expenditure. As technology continuously advances, more and more individuals perform daily tasks sitting down (i.e.: computers) which also contributes to less energy burned. Behavioral aspects coincide with environments and energy imbalance. For instance, some individuals may be less likely to engage in physical activity such as leisurely walks if they live or work in environments with high crime or no safe places to walk on such as a lack of sidewalks. In addition, making choices to eat fast foods for convenience or because of limited alternative options or eating larger portions to satisfy hunger can be attributed to behavioral decisions that are related to the environment.

Socioeconomic status may also contribute to obesity. Foods high in saturated fats, which tend have high caloric percentages, are relatively inexpensive. Some studies suggest that those individuals with low income levels may be at a disadvantage when purchasing higher cost nutrient-rich foods such as fresh fruits and vegetables. As well, limited education about nutrition may have an affect on the potential to gain weight. In addition, the costs of gym memberships may deter more poverty stricken people from joining physical activity clubs.

Since obesity has been on the rise for the past several years, scientists are still conducting research in other areas which include trying to link certain cultures to having a predisposition for becoming obese. As well, they are investigating how lack of sleep affects individuals and their weight and how the use of medications, such as steroids or antidepressants plays a role in weight gain.

Conclusion

This report has defined obesity and its correlation to body fat content by specifically outlining the two main types of body fat: visceral, intra-abdominal fat, and subcutaneous fat, underlying the skin. When learning about these two main types of fat it was important to assess the risks associated with each. Some of the most common risks linked to obesity are associated with visceral fat tissue and include insulin resistance, Type II Diabetes, cardiovascular disease, fatty liver, atherosclerosis, and high cholesterol.

In addition, it discussed the hormones secreted by adipose tissue in the human body. The three main hormones produced by adipose tissue are leptin, resistin, and adiponectin. Leptin is an appetite suppressant and is produced by the body to regulate body weight by modulating energy expenditure. Resistin enables cells to become less sensitive to the action of insulin. Adiponectin is an insulin-sensitizing hormone.

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In conclusion, the information set forth in the above paragraphs is continually changing as new studies are being conducted to discover the most current information. Much of what we know about obesity and the adiposity associated with it are relatively new and under investigation. As obesity trends continue to increase in America, the race is on to educate individuals about the health risks associated with adiposity. Education is important in helping scientists and health professionals "move" such a sedentary society to live a healthy lifestyle.

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