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THE ROLE OF MACROMOLECULES IN THE METABOLISM AND HEALTH OF DIFFERENT SOMATOTYPES

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ABSTRACT

Macromolecules such as carbohydrates, lipids, proteins, and nucleic acids are large, organic molecules that are directly involved in human metabolism. Somatotyping is the classification of a person according to his body physique, and it deeply relies on the consumption of various macromolecules as well as the metabolic pathways that occur in the body, suggesting that the calories that a person takes in and the food he consumes play a vital role in determining if he is deemed fit to be an ectomorph, endomorph, or mesomorph. This article aims to identify the vital roles of the main macromolecules in metabolism and how these macromolecules affect the diet and health of each somatotype. Correlation of the relationship between metabolism and different body figures provides awareness on the macro and micro aspects of digestion as well as the risk factors that may affect one's health.

INTRODUCTION

All human beings are born with an inherited body type that is related with the composition of their body and anatomical figures. This can be referred to as "somatotypes". It is a taxonomy that originated in the 1940s through the American psychologist William Sheldon to categorize the physical figures according to their body types, namely Ectomorphic, Mesomorphic, and Endomorphic. Somatotyping gives the quantitative characteristics of the human physique. The importance of the somatotype method relies on the fact that it has been introduced in order to empirically define different aspects of the body composition: degree of fatness, musculoskeletal development and the linearity of the body. It has also recently been studied due to their relation to different diseases that may be linked to diet and lifestyle.

The three components of Somatotypes are Ectomorphs, Mesomorphs, and Endomorphs. According to the Center of Wellness Without Borders, Ectomorphs are composed of people who are slim or lean. He is usually tall and has long limbs, but with little muscle, body fat, and testosterone levels. These people have a hard time gaining weight. This means that they seem to maintain their weight and can even get away with it with a few pounds of fat. Examples in this category include the fashion models and basketball players.Mesomorphs are athletic, solid, and strong. They cannot be considered as overweight or underweight. They both gain and lose weight without too much effort. Endomorphs consist of big, high body fat, often pear-shaped, with a high tendency to store body fat. These people have a lot of adipocytes, muscle, and gain weight easily. Examples include people who are nearly overweight and obese.

Those three are the 3 types of somatotypes. However, many combinations have arised as time passed by. The common combination somatotypes include: pear-shaped ecto-endomorphs that are composed of thin, delicate upper bodies while having a greater fat storage around the hips and thighs; and apple-shaped endo-ectomorphs, with high fat storage in the mid-section and thin lower bodies.

There are many factors that may be affected by the concept of somatotypes. One very notable element is the role of various somatotypes in nutrition. This is where metabolism takes place. We all obtain our energy through the food we eat since our food is composed of macromolecules. The 4 macromolecules are Carbohydrates, Lipids, Proteins, and Nucleic Acids. First, Carbohydrate storage plays an important role as the general constituent of energy resources. Without carbohydrates, people cannot have an adequate energy deposit to attain optimal performance and recover from stress and wear-tear.

CARBOHYDRATES

Carbohydrates are composed of Carbon, Hydrogen, and Oxygen atoms in a ratio of 1 molecule of water per carbon atom. The empirical formula is CnH2nOn. They can be classified according to the number of carbons and sugars, isomerization. Carbohydrates can be digested through the use of functional enzymes in our body, absorbed via combination of glycemic index, and transported via passive and active transporters.

In a study conducted in the Warsaw University of Life Sciences-SGGW (2016), which involved 154 female students aging 21-25 years old. The study had a questionnaire composed of two parts. The first contained information on weight, height, place of residence, supplementation, self-health assessment, and physical activity. The second part was based on three-day dietary food records. The subjects were classified into their respective somatotypes: ectomorphic, mesomorphic and endomorphic. Based on the results, the women of the ectomorphic somatotype had the highest intake of dietary fiber and sucrose. They also consumed the greatest amount of protein, fats, and other vitamins like vitamins B1 , B6 , copper, and retinol. The women of the mesomorphic somatotype consumed more carbohydrates than the other girls. Those that fall under endomorphic consumed the least amount of the macromolecules, macronutrients and other selected vitamins and minerals, and yet found it hard to maintain their weight. ideal body weight, even though the food they consumed a small amount of energy, macronutrients, and selected vitamins and minerals. In addition, the fact that endomorphs consumed the least amount of carbohydrates simply reflects the low energy demand in these groups as well as the low quantity of muscle tissues that are supposed to be metabolically active (Blundel et al. 2012). Such a relationship and a lower energy intake in endomorphic people were also observed in other studies (Frackiewicz et al. 2016).

The aforementioned results provide a conclusion that somatotypes affect the consumption of carbohydrates, the main source of energy in the diet of people. Endomorphic people, who are prone to accumulation of body fat may limit their energy consumption intentionally, particularly from fats and carbohydrates to limit and prevent weight gain. On the other hand, ectomorphs have very fast metabolism due to the high presence of metabolically active muscle tissues.

LIPIDS

Somatotyping is important for the identification of body composition of humans. It allows one to determine the body composition through the degree of fatness, musculoskeletal development, and the linearity of the body. This is because somatotypes are linked to diet and lifestyle. Thus, the concept of lipid metabolism is very imperative when it comes to tackling the information related with various somatotypes, especially the endomorphs with high amount of body fat or adipocytes.

As it was previously mentioned, many factors play a role in somatotyping method, one of which is nutrition—carbohydrates, lipids, and protein. Just like Carbohydrates, people will hardly function physically and mentally without lipids such as fats and oils. Lipids are nonpolar organic compounds that are generally insoluble to water but soluble to nonpolar solvents like chloroform, acetone, ether, benzene, etc. They are all composed of a carbonyl group (-COOH). Lipids are particularly important to the body since these energy sources are very concentrated and provide more energy per gram than Carbohydrates. 1 gram of carbohydrate is equivalent to 4 kcal while 1 gram of lipid is equivalent to 9 kcal. Unlike the carbohydrates, the body can store lipids in the body, allowing for long term source of energy. However, it is still important to monitor the lipid composition of every human, as fats can be a potential risk for obesity and heart diseases.

In terms of the molecular function of Lipids, they function as membrane structural component, regulatory substances and enzyme co-factors, storage and transport form of metabolic fuel in the form of chylomicrons, protective form of cells in bacteria, plants, etc. The 4 main groups of lipids include fatty acids (saturated and unsaturated), glycerides with glycerol, nonglyceride lipids like sphingolipids, steroids, waxes, and complex lipids like lipoproteins and glycolipids. Lipids can be further be classified based on their functions as well—Fatty acyl, Glycolipids, Glycerophospholipids, Sterol lipids, and Sphingolipids.

Digestion and absorption of lipids include minor and major digestion. The former is via the triacylglycerols in mouth by the help of the enzyme lingual lipase while the latter occurs in the lumen of duodenum by the help of bile salts and pancreatic lipases. These enzymes that catalyze the breakdown of fats into glycerol and fatty acids. Lingual lipases are secreted by lingual serous glands and they hydrolyze medium and long chain triglycerides while gastric lipase hydrolyzes dietary triglycerides into monoglyceride and diglyceride. Bile salts emulsify fats and function as detergents that break large globules of fats into micelles. In the Exogenous Pathway, pancreatic lipase converts TAGS to monoglycerides, glycerol, and free fatty acids. They enter the enterocytes and are packaged into chylomicrons. These chylomicrons enter the lymph and get associated with lipoprotein B48. Lipoproteins are complex particles with a central core having cholesterol esters and triglycerides and are surrounded by free cholesterol, phospholipids, and apolipoproteins. Each chylomicron travels through the lymph, bypasses the liver, and enters the bloodstream. Once in the bloodstream, it will acquire 2 apolipoproteins which are ApoE and ApoC2. The chylomicrons then continue to circulate in the blood and encounters fat tissues. Lipoprotein Lipase will take the triglyceride into the fat in the form of free fatty acids. Cholesterol, B48 and E then remain in the chylomicrons. These remnants will be taken up by the liver through the action of ApoE attaching to the LDLr. The cholesterol will be used to make glucose, apolipoproteins, and hormones. In the Endogenous pathway, the liver is the one that makes the chylomicrons with lipoprotein B100. The C2 will function in the recognition system as it encounters the adipocytes. The VLDL remnant particle is also known as the IDL. The triglycerides carried in VLDL are catabolized in muscle and adipose tissue by lipoprotein lipase, which then releases free fatty acids. The chylomicron with ApoE will be tracked back to the liver with the receptor called LDLr and half of its composition will become LDL through the Cholesterol-Ester Transport Protein. About 80% will be reabsorbed by the liver and 20% will be deposited in the blood vessels, which can build up plaques, posing a risk to having atherosclerosis.

Furthermore, reverse cholesterol transport starts with the work of nascent HDL that occurs in the liver and intestine (Feingold & Grunfeld, 2018). Small HDL particles can carry cholesterol and phospholipids that are found in the cells and this process is mediated by ABCA1, resulting in the formation of mature HDL. Mediator of cholesterol efflux that allows mature HDL to further acquire cholesterol from cells ATP-binding cassette transporter (ABC) A1 and scavenger receptor-BI (SR-BI). Cholesterol is then transported by the HDL to the liver directly by the interaction with hepatic SR-B1 or indirect transfer of cholesterol to VLDL or LDL. The process is facilitated by CETP. The role of cholesterol efflux from macrophages to HDL is very crucial for protection against atherosclerosis. Plasma lipoproteins can be classified based on size, lipid composition, and apolipoproteins (chylomicrons, chylomicron remnants, VLDL, IDL, LDL, HDL, and Lipoproteins. All tend to promote the formation of fatty plaques in the arteries except for HDL which is anti-atherogenic (Feingold & Grunfeld, 2018). These are proven in the study conducted in 1996 by Valkov and colleagues.

The relationship between the somatotypes and some risk factors for ischemic heart disease (IHD) was investigated. Aside from cholesterol, other factors like arterial blood pressure, body mass, and body mass index were also observed. Based on the results that they have gathered, endomorphic and mesomorphic groups showed the highest predisposition to IHD. This is due to the fact that endomorphs have high percentage of VLDL, IDL, and LDL. On the other note, there is little to no risk of IHD to the ectomorphs. The mean levels of triglycerides and low density lipoproteins (LDL) had critical values in the subjects outside the typological diagram particularly the endomorphs, while the high density lipoprotein levels were the most elevated in the subjects of ectomorphic type.

All the pathways in lipid metabolism play a major role in the modulation of somatotypes. Few studies have attempted to explore the biochemical differences between somatotypes. Another study investigated the components of the somatotypes in relation to serum cholesterol. It was found that there is a significant relationship between skinfold thickness and serum cholesterol. The higher the amount of cholesterol, the thicker the skinfold. This is the case of endomorphs who have a big percentage of body fat and less muscle mass. In the study by Gordon and colleagues (1987) where the relationship of somatotype and fasting serum lipids was observed in 242 male and 70 female young adults, the males have revealed a significant relationship between somatotype and serum lipids, while the females have shown a relatively random relationship between these variables.

Similar results were found in the study (Bolonchuk et al. 2000) that examined the body structure, functional responses at peak exercise, and nutritional status of 63 males whose age is in the range of 18-40 years, living under controlled conditions. Data were grouped by dominant somatotype to emphasize differences in body types. Dominant ectomorphs were shown to have less body weight, fat weight, and percent body fat than endomorphs and mesomorphs. The factors that are low in ectomorphs are fat-free weight (FFW), total body potassium (TBK), and body cell mass (BCM). In addition, the ectomorphs had different functional responses during peak exercise despite having the same peak power output. Respiratory parameters like respiratory exchange ratio, oxygen ventilatory equivalent, and end-exercise plasma lactate concentrations are high which indicates an exceptionally low amount of oxygen uptake as energy is concerned. These data indicate that ectomorphs have deficits in fat-free weight (FFW) and body cell mass (BCM) in comparison to endomorphs and mesomorphs, which are associated with differences in functional capacity.

Having said all of these, taking into consideration that endomorphs have been proven to have greater storage of lipids which more or less be associated with obesity, the ability to store adipocytes via lipogenesis is of great importance in understanding this phenomenon. The Acetyl-CoA that is obtained from glycolysis creates lipids (Fat), and this occurs in the cytoplasm of adipocytes and hepatocytes. Since there's a tendency for the endomorphs to eat a lot of carbohydrates or glucose more than their body needs, their system uses Acetyl-CoA to turn excess carbohydrates into fat. From the Acetyl-CoA, 2 carbon atoms will be subsequently added and this is repeated until fatty acids are in the necessary length. ATP is consumed in the anabolic process of creating bonds; however, triglycerides and high-energy molecules will be stored in adipose tissue and will serve as a source of energy when needed. Without pyruvate, the Acetyl-CoA is the mitochondria would not be transported across the mitochondrial membrane. Through the conversion of pyruvate into oxaloacetate (OAA) and Acetyl-CoA via the enzymes pyruvate carboxylase to form the OAA and pyruvate dehydrogenase to form Acetyl-CoA, both products then are used up to combine and form Citrate. The citrate crosses the mitochondrial membrane and goes into the cytoplasm, and is consequently converted back into OAA and Acetyl-CoA. OAA will be reduced to Malate through Malate Dehydrogenase, then the Malate will be oxidized to Pyruvate. Pyruvate then crosses back across the mitochondrial membrane and prepares itself for another round of lipogenesis.

The Acetyl-CoA in the cytoplasm will be converted into Malonyl CoA which undergoes elongation for fatty acids to be created. This is what occurs in people with endomorphic somatotype, leading to accumulation of body fat and limiting their energy consumption intentionally. While ectomorphs are able to burn off excess calories with continuous movement, endomorphs do not tend to have the same value of expenditure, as far as excess fat and calories are concerned. Their profile leads to a higher possibility for energy storage and low tolerance in carbohydrates. Thus, a nutrient distribution for people under this somatotype should follow the 25-35-40 distribution for carbs, proteins and fats. This way, risks of obesity and cardiovascular diseases can be controlled and eliminated (Elliott, 2020).

PROTEINS AND NUCLEIC ACIDS

Proteins are the major structural and functional polymer in living systems (Harvey, 2011). They perform various functions that are dynamically and structurally essential. They are made up of sequences of amino acids that are linked by peptide bonds in a linear polypeptide structure. Peptide bonds are formed by condensation between the amino group of one amino acid and carboxyl group of another. Polypeptides are the intermediate products of translation in cells and form proteins when properly folded. The functions of proteins are performed in complex 3-dimensional structures, serving as antibodies, enzymes, messengers, hormones, and structural components. Proteins can be classified as essential and non-essential amino acids. The primary sources of amino acids in humans are obtained from the diet. These are called the essential amino acids, which include Arginine, Isoleucine, Leucine, Lysine, Histidine, Methionine, Phenylalanine, Threonine, Tryptophan, and Valine. On the other hand, non-essential amino acids are synthesized by the body. These are the Alanine, Arginine, Asparagine, Aspartic acid, Cysteine, Glutamic acid, Glycine, Proline, Serine, and Tyrosine (Harvey, 2011).

There are three steps in protein synthesis, namely transcription, translation, and post translational modifications. During transcription, the information in a strand of DNA is copied and transcribed by RNA polymerase to produce a new sequence of RNA, particularly messenger RNA (Harvey, 2011). This mRNA sequence carries genetic information from the genes to the rest of the cell and contains codons that code for a specific amino acid. During the first phase of transcription, the RNA polymerase looks for a promoter region on the DNA template strand and binds to the region. RNA polymerase reads the DNA template in the 3’ to 5’ direction and subsequently allows for the covalent bonding of RNA bases that correspond to the template DNA strand; Adenine to Guanine and Uracil to Cytosine. After which, dissociation of the new bases gradually happens to form a new mRNA strand which will then be synthesized in the 5’ to 3’ direction until the RNA reaches a terminator sequence. Codons are translated by ribosomes to their respective amino acids and primary structure of proteins. The process involves initiation, elongation, termination, and ribosome cycling. During translation, the ribosome binds to the 5’ cap of mRNAs before locating the protein-coding region and move down until AUG is encountered. The elongation period follows a repetitive cycle and signals to a stop as it receives a stop codon. First, a transfer RNA enters the A (Aminoacyl) site and the peptide is transferred to the P (Peptidyl) site. tRNA from the P site will then be ejected to the E (exit) site. Once the previous tRNA has left, another charged tRNA enters the A site through eEFIA.

The metabolism of proteins begins in the stomach, wherein hydrolyzation of peptide bonds occur through the help of gastric juices (“Protein Metabolism”, 2021). Gastric juice is made up of hydrochloric acid, inorganic ions, enzymes, and a large amount of water. The amino acids are absorbed into the bloodstream and transported to the liver, going to the rest of the body. The pH of the acid in the stomach provides an environment for denaturation of dietary proteins. The unfolding of protein molecules unfold to expose their chains allows for efficient enzyme reaction. Pepsinogen serves as the main digestive component of gastric juice. It is an inactive enzyme or substance secreted by the stomach wall and converted into its active form Pepsin by gastric acid when food enters the stomach. Pepsin is secreted by gastric chief cells and breaks down peptide linkages within protein molecules by hydrolysis.

After the hydrolysis of dietary proteins, the free amino acids join the non-essential amino acids in the liver and recycled for other functions and processes. Most of the amino acids is utilized for energy and protein synthesis, as well as the synthesis of compounds that contain nitrogen, like DNA bases, neurotransmitters, and hormones. Proteins and nitrogen are degraded and excreted in the urine as urea if not used for biological function of the body (“Protein Metabolism”, 2021).

The somatotypes vary in fat and muscle that the body contains, so it can be assumed that individuals with different somatotypes have different nutritional requirements and dietary treatments as well. There have been studies that were conducted which showed the diet proportions of macromolecules in each somatotype. For instance, in the study that involved a hundred fifty-four female students in Warsaw (2016), the 3 somatotypes have been found to be taking in relatively same number of proteins, but the greatest value was found in the ectomorphic individuals, while endomorphic subjects had the least amount of dietary protein. This then indicates that protein metabolism is very optimal for people who have a slender to slim body built. It has been established that ectomorphs are well-known to have lean muscle mass and fast metabolism, while mesomorphs are typically athletic and with well-defined muscles. Mesomorphs can gain muscle and fat more easily than ectomorphs since ectomorphic individuals are prone to lipolysis so they lose fat easily and consequently cut back to having lean muscles. This is also the reason why mesomorphs are the best physique for body building.

The research done by Penggalih and Solichah in Indonesia (2019) reveals the effect that protein has on the formation of muscle. Their subjects contained 90 athletes with various calculation of dietary needs and level of activity. Around 1.7 grams per kilogram of body weight per day was provided and was labeled high protein intake in adjustment to strength training. Protein amount should be high as high-impact activity causes muscle torn and damage. Total energy for fats and carbohydrates were calculated as well. The results imply that there is a correlation between high protein intake and the significant improvement on skinfolds, particularly the subscapula and suprailiac, which just proves how the availability and intake of proteins in mesomorphs affect their overall physical structure and health. Training and exercises involving weights and cardio also affect the somatotype and health of mesomorphs. Moreover, in endormorphic individuals, there has been an observation that the least amount of protein intake is found in women with soft, round bodies and large bones (Raschka et al., 2013). The reason for this low protein value lies in the fact that endomorphs tend to have lower plant protein intake than animal protein intake, having a ratio of 2:1 instead of 1:1.

ROLE OF METABOLISM IN SOMATOTYPES

Application of the metabolic integration of all macromolecules in somatotyping is very imperative. The human body is a unique machine with a specific set of dietary requirements, exercises, and refueling. For endomorphs, the key is to consume food with low glycemic index so spikes in blood sugar can be prevented. They have been proven to be more sensitive to insulin and carbohydrates, thus it is just enough for these people to have proteins and fats served on the table as part of their diet. Examples include fish, healthy oils, avocado, and peanuts. These can help in regulation of hunger and energy level without compromising the spike in glucose level (Height, 2019). To be able to maintain good health and minimal weight gain, endomorphs are advised to have a proper way of living by fasting and incorporating regular trainings in their daily activities as these practices will allow increased proteolysis and lipolysis of fat reserves.

Moreover, for Mesomorphs that thrive within the spectrum of nutrition, it is recommended for them to have a good balance of the 3 macromolecules to stay in check and energized. As it was previously mentioned, they tend to gain muscles fast thus one way to one way to sustain this natural inclination is by having ample protein sources from both animals and plants, for this provides an ideal framework for their nutrient profile and physical flexibility. In terms of working out, moderate to heavy lifting weights and endurance training with varying periods of rest may be helpful to prevent loss of muscle mass (Height, 2019).

Lastly, for ectomorphic subjects with a tendency to burn fat stores faster, a good source of carbohydrate sources in the diet and a combination of evenly divided portions of protein and fat will be beneficial. Frequent small feeding that amounts of five to six small meals in a day is also recommended. Examples include eating whole grains, nuts, meat, vegetables, and fruits. Since their body is most likely well-designed to endurance exercises, building strength and muscles is suitable, with some cardio workouts from time to time.

INTEGRATION OF METABOLISM

In relation to the metabolic integration of all macromolecules, the regulation of metabolism differs depending on which metabolic state the body is in. As the macromolecules are digested into absorbable forms of glucose, TAGs, and amino acids, interconversion normally occurs. Carbohydrates can be converted to lipids and proteins, lipids can be converted to carbohydrates, and proteins can be converted to carbohydrates, lipids, and amino acids.

First, Acetyl-CoA can be converted to lipids from glucose via lipogenesis which requires ATP and NADPH. It happens through the G3P and DHAP pathways. Conversion of glucose to non-essential amino acids (NEAAs) is involves the use of glycolysis intermediates, wherein 3-phosphoglycerate is converted into serine, which in turn is converted to glycine and cysteine. Pyruvate can be converted into alanine. TCA Cycle Intermediates also help via the formation of alpha-ketoglutarate to glutamate and formation of oxaloacetate to aspartate and asparagine. During well-fed state, Acetyl-CoA is used as precursor for Fatty Acid synthesis, cholesterol synthesis, and steroid synthesis. Fatty acids from the diet and acetyl CoA are esterified to glycerol- 3-phosphate (G3P) to produce TAGs.

Secondly, although FAs cannot be directly converted to carbohydrates, those fats with odd-numbered carbon chains are convertible to glucose through the ß-oxidation, carboxylation, and rearrangement of succinyl-CoA into a glucogenic TCA intermediate. Glycerol in the liver that comes from other tissues (RBCs, muscles) is phosphorylated to G3P by glycerol kinase, and subsequently reduced to

DHAP to undergo gluconeogenesis.

Most importantly, the conversion of amino acids to glucose via gluconeogenesis involves the 6 glucogenic families of amino acids. Glucogenic as well as Ketogenic intermediates enter in the kreb cycle for conversion. Certain amino acids are also precursors for non-essential AA synthesis, such as Methionine to Cysteine, Glutamate/alanine to Glycine, and Phenylalanine to Tyrosine. Moreover, it has been stated that the body undergoes three metabolic states, depending on the duration between meals. The Well-fed State is 2-4 hours postprandial and the major hormone for it is Insulin. For Early Fasting (> 4 to < 18 hours without food) and Fasting State (> 18 hours but < 3 days without food), the major hormones are Glucagon & Epinephrine. This is similar with the Starving State where the fasting is even prolonged.

In the regulation of somatotypes in well-fed state, glycolysis, PDH reaction, and glycogenesis are stimulated. HMP & pathways generating NADPH are also stimulated, whereas fatty acid synthesis and glycogenolysis is inhibited. In the early fasting state, glycogen stores are mobilized and gluconeogenesis in the liver is stimulated. Glycogen synthesis and fatty acid synthesis are inhibited since large amount of glucose in the liver releases to bloodstream and maintains glucose levels. Having said this, hepatic glycogenolysis also occurs, as the brain is still dependent on glucose as a sole energy source. In the fasting state, the fuel reserves would be glycogen from the liver and muscles, TAGs, and tissue proteins. Since fasting is usually one of the recommendations for endomorphs, the tendency for their metabolic profile is that they will utilize their protein, as it will be converted for glucose synthesis. This is where glucogenic amino acids enter gluconeogenesis. Glycogen stores start to deplete, therefore, their bodies rely solely on hepatic gluconeogenesis from lactate, glycerol, and alanine. Acetyl-CoA does not proceed into the TCA cycle since oxaloacetate has been used up in gluconeogenesis. This leads to accumulation of Acetyl-CoA and further formation of ketone bodies and Acetoacetyl-coA. The last metabolic state, Starvation, is the metabolic profile of each metabolic organ when somatotype individuals have not consumed any meal beyond three days. It favors beta-oxidation of fatty acids, ketone body synthesis, and gluconeogenesis in the liver, and complete oxidation of glucose and ketones in the brain. Proteolysis in the muscles is decreased whereas lipolysis in adipocytes is continuous.

Control in the portion of consumption is recommended for endomorphs when they want to reduce body fat. This helps them avoid excess calorie consumption that shifts to lipogenesis. Given that endomorphs find it difficult to lose fat, submitting themselves to calorie restriction, fasting, or starvation may not be the perfect formula. An effective diet that incorporates regular exercise into their daily schedule produces greater improvements holistically in their health.

Somatotyping offers a great avenue for rating and classifying the human morphology, and it was evident how intake of macromolecules indeed has a huge impact to each somatotype. Other factors outside the spectrum of macromolecules are also involved in the determination of somatotypes. One of which include the nucleic acids or genetic expression. Genetic factors explain individual differences through examining inherited gene compositions that make up an individual. In the study by Silventoinen and colleagues (2021), the data were analyzed via genetic twin modeling that is reliant on the different genetic relatedness of monozygotic and dizygotic twins. Genetic variation involves how the loci affects the trait and correlates to the twin pairs. It was found that the distribution of endomorphic subjects skewed to the right (0.88 parameter), while the distributions for mesomorphic and ectomorphic ones were relatively normal. Mesomorphs had a skewness parameter of 0.38 and ectomorphs had a value of 0.08. The gathered results suggested that boys had mesomorphic measurements and they had wider diameters in humerus and femur, whereas girls were leaning to endomorphism with thicker skinfolds in triceps, subscapular, and calf. Ectomorphic measurements were evident in adolescent girls. The heritability was estimated to range from 0.8 to 0.93. Somatotype physique was also correlated to the individual's physical fitness, and data revealed that ectomorphs had greater motor ability and endurance in cardiorespiratory in comparison to endomorphs and mesomorphs. However, higher muscular strength was associated to the latter two. This then implies that many individuals are prone to certain tasks required in specific exercises and may also have higher progress to respond to sports and workout.

Furthermore, in examining the DNA compositions of all somatotypes, there was a cross-sectional study that discussed the relation of the genotypes RR, RX and XX of the alpha-actinin-3 gene (ACTN3) to the physical built and sports abilities of each somatotype. According to Guereca and his colleagues, the ACTN3 genotypes are associated with the somatotype in athletes regardless of the sports they play. The study involved 31 sport participants in which the DNA from leukocytes in the blood were taken. Data on the anthropometric measurements of fat and muscle mass were also obtained and computed. It was found that both male and female carriers of the RR genotype produced greater mesomorphic traits, followed by the RX genotype carriers. For male carriers, the genotype XX has been found to be responsible for ectomorphy. On the other hand, for female carriers, the genotype XX presented greater endo-mesomorphic somatotype. In addition, those men with RR and RX genotypes presented a balanced mesomorph somatotype, while female carriers exhibited borderline results of endomorphic and mesomorphic somatotype.

Conclusion

In the human body, all metabolic pathways are inextricably intertwined and all the macromolecules are interconvertible with one another. Carbohydrates can be converted to lipids and proteins, lipids can be converted to carbohydrates, and proteins can be converted to carbohydrates, lipids, and amino acids. Hence, having a balanced diet of these important macromolecules is important.

Although nutritional benefits of daily consumption are maximized in all somatotypes, each somatotype has different dietary requirements, exercises, and refueling. Endomorphs need to consume food with low glycemic index to regulate their blood sugar levels. Since they are more sensitive to insulin and carbohydrates, they need to eat adequate amount of proteins and fats. Practicing proper fasting with regular weight lifting and endurance training also helps them improve their lifestyle. Mesomorphs tend to accumulate more muscle and fat easily, making them fit for body building. Ectomorphs do not have the same value of expenditure as they are prone to lipolysis and they burn off excess calories with minimal movements. It is recommended for ectomorphs to have small frequent feeding for optimizal metabolism and to make time for exercise to build their strength and muscles.

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