NEUROTRANSMITTERS: CRITICAL AMINO ACIDS AFFECTING SEROTONIN AND DOPAMINE

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CRITICAL AMINO ACIDS AFFECTING SEROTONIN AND DOPAMINE

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Abstract

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This paper examines how amino acids from foods critically affect neurotransmitters, which, in turn, affect every area of brain and body health. The manner in which neurotransmitters can affect personality, mental health, and learning disabilities is explored in this research review. Inadequate amino acid nutrition or exposure to poisonous chemicals or drugs can directly cause nerve cells to function poorly. Resulting changes in quantities of neurotransmitters such as serotonin and dopamine can influence emotional states like anger, frustration, or depression, but can also influence energy, speed of thought, activity level, speech volume and fluency, social functioning, and memory. The primary focus of this paper is on essential amino acids, protein, and dietary supplementation. Affected disease states include alcoholism, Parkinson's disease, schizophrenia, and autism. This paper describes the effects of nutrition on the manufacture of neurotransmitters from complete amino acids critical to producing norepinephrine serotonin and dopamine in the brain.

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CHAPTER I: INTRODUCTION

Neurotransmitters: Critical Amino Acids Affecting Serotonin and Dopamine

The human body is made up of cells containing many receptors that receive incoming information about what is happening within the human body and what is happening in the body's outside environment (Wardlaw, 2003). These receptors make functional our whole body, including our eyes, ears, skin, nose, stomach, heart, and other organs and systems. The nervous system receives information through stimulation of various receptors at these, for example, organ sites, processes this information, and sends out signals for an action to be produced through the system's various branches. The basic functional parts of the nervous system of the human body are neurons. The nervous system has various kinds of neurons or nerve cells (Cohen & Swerdlik, 2010; Wardlaw, 2003). Neurons allow us to perceive what is occurring in the environment around us, engage in learning, and store information in memory. They also carry information which controls the body's voluntary and involuntary actions. This is accomplished through transmission of electrical and chemical signals. Neurons conduct electrical impulses which result in the release of chemical regulators (Wardlaw, 2003). Neurotransmitters are chemical compounds that allow nerve cells (neurons) to communicate with each other (Sahley, 2001). Some neurotransmitters are excitatory in that they cause a neighboring neuron to fire. Others are inhibitory in that they block neighboring neurons from firing. Rates of synthesis and release of neurotransmitters are mediated by the concentrations of amino acid precursors tryptophan (Trp or 5HT), phenylalanine (Phe) and tyrosine (Tyr), among others, which are transported by the blood. Precursors of these substances are generally found in our diets (Fernstrom & Fernstrom, 2007; Kotsopoulos, 2011; Parker & Brotchie, 2011; Sahley, 2001;

Shibata & Fukuwatari, 2012; Tom & Nair, 2006; Turner, 2011; Yan Bin Shen, Voilque, Odle, & Sung Woo Kim, 2012). Apart from the role of amino acids as constituents of protein, other known functions of the amino acids in the brain are as precursors for the monoamine neurotransmitters. These neurotransmitters are serotonin (5HT) and the catecholamines: dopamine (DA), norepinephrine (NE), and epinephrine (Fernstrom & Fernstrom, 2007; Sahley, 2001). The effects of nutrition can be understood by examining the actions of nutrients as they affect neurons, synapses, neurotransmitters, muscles, tissues, organs, and the body's systems (Wardlaw, 2003). Transmission of a message from one neuron to another neuron relies on neurotransmitters.

Individuals from varied economic and educational backgrounds supplement Trp by using an amino acid supplement. The rationale to supplement is partly due to the discovery approximately 60 years ago that tryptophan is a product which metabolize into serotonin (5-hydroxytryptamine (5-HT) in the brain. Serotonin is a neurotransmitter in the brain which is believed to elevate mood, reduce stress and anxiety, improve and regulate sleep, and regulate appetite and energy (Fernstrom, 2012; Kotsopoulos, 2011; Parker & Brotchie, 2011; Sahley, 2001; Sherman, 2010; Yan Bin Shen & et al., 2012). Due to the research observation that ingesting Trp directly raises brain Trp concentrations and stimulates 5-HT synthesis and release, there is evidence to suggest the potential for Trp in improving sleep, mood, energy, and appetite. Interest in Trp has led to a considerable number of significant published studies (Fernstrom & Fernstrom, 2007; Parker & Brotchie, 2011). Researchers have examined the therapeutic use of Trp in humans under a number of behavioral and psychiatric conditions involving sleep and mood changes (Fernstrom, 2012; Fernstrom & Fernstrom, 2007). The metabolites of Trp have a critical role in the body (Moehn, Pencharz, & Ball, 2012; Parker & Brotchie, 2011).

Low levels of amino acids besides Tyr and Trp have been implicated as having a role in depressive mental disorders, as well (Parker & Brotchie, 2011). Included are the excitatory amino acids such as glutamate, aspartate, glutamine, serine, glycine, taurine, threonine, alanine, and histidine as well as the sulfurated amino acid homocysteine (Parker & Brotchie). Further, there are many clinical conditions that can benefit from the use, for instance, of the essential branch chain amino acids (BCAAs) (Tom & Nair, 2006).

The chemistry and functions of both the developing and the mature brain are influenced by a wide range of dietary factors including the essential amino acids, which are the primary focus of this paper (Parker & Brotchie, 2011, Wardlaw, 2003). Thus, how the brain functions depends on how the brain is nourished (Sahley, 2001, Wardlaw, 2003). In this paper, the focus will be primarily on the amino acids Tyr and tryptophan, because research for the last several decades has focused on these two amino acids (Parker & Brotchie, 2011). These two amino acids are important to mood, emotional state, and behavior regulation. The amino acid Trp must be supplied or augmented via diet, as does Tyr. These are available directly within a diet of healthy amino acid foods or produced through Phe which converts to Tyr in the liver and kidneys (Parker & Brotchie, 2011; Pencharz & et al., 2007). It has been commonly reported that in women, low Trp levels have an association with mild or moderate depressive conditions. Similar claims are made for Tyr and Phe that synthesize to catecholamines in the brain (Parker & Brotchie, 2011).

Statement of the Problem

The problem to be addressed is “how are neurotransmitters affected by amino acids and other nutrition”?

Definition of Terms

Serotonin: 5-hydroxytryptamine or 5-HT: 5-hydroxytryptamine, a hypothalamic neurotransmitter is synthesized in neurons from the essential amino acid Trp, which comes from dietary foods and is supplied to the brain by the blood stream (Fernstrom, 2012; Yan Bin Shen & et al., 2012).

Amino Acids: Amino acids are the building blocks of proteins, containing a central carbon atom with a nitrogen atom and other atoms attached (Wardlaw, 2003). They are formed of carbon, hydrogen, oxygen, and nitrogen. The most important function of amino acids lies in their role in maintenance of quality proteins; however, the metabolism of the three essential branched chain amino acids, or BCAAs (leucine, isoleucine, and valine), for instance, occurs largely in synthesis of skeletal muscle (Wardlaw, 2003).

Branched Chain Amino Acids: The branched chain amino acids are primary essential amino acids used by muscles for energy (Wardlaw, 2003).

Catecholamines: The neurotransmitters dopamine (DA), norepinephrine (NE), and epinephrine make up the catecholamines (Fernstrom & Fernstrom, 2007; Parker & Brotchie, 2011; Sahley, 2001).

Depression: Depression is a consequence of insufficient activity of the neurotransmitters serotonin and norepinephrine, among others, so that any deficiency in blood levels of certain amino acid precursors might contribute to depressed states. This has led to speculation that the use of a natural dietary constituent or changing one's diet to those foods rich in appropriate amino acids (Tyr and Trp) could boost neurotransmitter release and effect changes in brain function. Such supplementation could have antidepressant benefits with few to no side effects (Parker & Brotchie, 2011).

Dopamine: The amino acids Phe and Tyr are precursors of the catecholamine neurotransmitters dopamine, norepinephrine, and epinephrine (Parker & Brotchie, 2011).

Glutamine: Glutamine is classified as a non-essesscial amino acid in part because of it being the most abundant amino acid in plasma but recent research now regards glutamine as a semi-essential amino acid due to its many benefits to healing on the body when in abundance (Wardlaw, 2003).

Hippocampus: A shortened explanation is that the hippocampus is a short term memory center of the brain which stores some memories and is especially important in transferring memories into long term storage (Sahley, 2001). Also, the hippocampus and the hypothalamus are closely interconnected in the brain (Beck & Pourie, 2011).

Multiphoton Laser Imaging: Modern technology that allows researchers to look into the living brain at the microscopic level and investigate synapses and glial cells (Ottersen, 2011).

Nervous System: The nervous system, with its two branches, is the major regulatory system that controls a large variety of the bodies' functions (Wardlaw, 2003, Cohen & Serdlik, 2010). It detects sensation, controls movements, and controls physiological and intellectual functions (Wardlaw, 2003).

Neurology: The branch of medicine that focuses on the nervous system and its disorders is neurology and it has many subspecialties (Cohen & Swerdlik, 2010).

Neuron: Neurons are elongated branched nerve cells. The human body contains about 100 billion neurons or nerve cells. (Wardlaw, 2003; Cohen & Swerdlik, 2010; Amen, 2008). The nervous system consisting of the central nervous system of the brain and spinal cord and the

peripheral nervous system of the neurons that convey messages to and from the rest of the body are actively involved with billions of neurons for the nervous system's function (Cohen & Swerdlik, 2010).

Neuropsychologists: Neuropsychologists study the nervous system (both central and peripheral nervous system) and how it relates to human behavior using tools such as the neuropsychological assessment, which is the evaluation of the brain and nervous system functioning as it relates to behavior (Cohen & Swerdlik, 2010). One of many subspecialties of neurology focuses on brain behavior relationships with more biochemical and less behavioral emphasis and is called behavioral neurology (Cohen & Swerdlik, 2010).

Neuropsychology: A branch of psychology focusing on relationships between brain functioning and behavior. Formally it was a specialty area within clinical psychology, it has become a specialty having its own certifying bodies and training regimens (Cohen & Swerdlik, 2010).

Neurotransmitters: A compound or chemical made by a nerve cell that allows for communication between it and other nerve cells or neurons (Wardlaw, 2003) (Newsholme & Blomstrand, 2006). Neurotransmitters carry impulses from one neuron to another (Sahley, 2001).

Peptide Bond: A peptide bond is a chemical bond formed between amino acids in a protein by the acid from one amino reacting with another amino acid to form the peptide bond (Wardlaw, 2003).

Physical Fatigue: Physical fatigue is the inability to maintain power output in the form of energy and motivation (Newsholme & Blomstrand, 2006).

Postsynaptic Neurons: Chemicals bind to a receptor on the postsynaptic neuron resulting in a change in the membrane which either enhances or inhibits the initiation of electrical activity in the postsynaptic neuron (Newsholme & Blomstrand, 2006).

Serotonin: Serotonin comes from the precursor amino acid Trp or 5HTP (Sahley, 2001). Hypothalamic serotonin (5-hydroxytryptamine -5-HT) is involved in the stress response which benefits human's response to stress by reducing secretion of stress hormones and further alleviating aggressive behaviors. It also regulates mood and appetite (Yan Bin Shen, Voilque, Odle, & Sung Woo Kim, 2012).

State: The term state refers to a transitory exhibition and is indicative of a relatively temporary predisposition (Cohen & Swerdlik, 2010).

Synapse: The space between one neuron or cell and another neuron or cell. When the signal must bridge the gap or synapse between the branches of different neurons, the message is converted to a chemical signal which is called a neurotransmitter (Wardlaw, 2003).

Tryptophan: L-Trp or Trp (or its metabolite 5-HTP) is an indispensable amino acid for protein metabolism and is a precursor for neurotransmitters including serotonin (5-hydroxytryptamine-5-HT) and tryptamine, as well as for niacin and melatonin (Fernstrom, 2012; Moehn, Pencharz, & Ball, 2012; Parker & Brotchie, 2011).

Tyrosine: Tyosine is one of the constituents of amino acid protein from the aromatic amino acid Phe. It synthesizes catecholamine neurotransmitters within the brain (Sahley, 2001; Parker & Brotchie, 2011). Further, Tyr is the precursor of the catecholamines and thyroid hormone (Pencharz, Hsu, & Ball, 2007). Epinephrine is also synthesized from the amino acid Tyr and Phe

(Sahley, 2001). Tyramine is converted to dopamine, which has many central effects (Newsholme & Blomstrand, 2006).

Significance of the Study

This small study is a research review pulling together experimental and quasi-experimental research related to the role of amino acids and other substances in brain functioning. Nutrients directly affect neurons, and neurons directly produce neurotransmitters, enhancing transmission of chemical impulses to every part of the human body and every function of the body. Therefore, nutritional state has a direct link to the body's disease or wellness state, which is fluid and changeable. A diseased state, an emotional state, or a physiological state is changeable under different conditions. This study points to dietary alterations which could positively influence brain and body health and functioning.

Purpose of the Study

The purpose of the study is to review recent and historic literature on neurotransmitter health and amino acid therapy on some disease states and health or wellness.

Method of Approach and Delimitations of Research

The author undertook a data collection and literature review of relevant peer reviewed journal articles, popular press books, and academic books focusing on neurotransmitters and nutrition (primarily amino acids). The influence of diet on neurotransmitters, and thereby affect, function, and mood was examined and findings were summarized. Several search engines were utilized. A brief review of the history of amino acid therapy on neurotransmitters and many definitions were included in the report.

One limitation is that this paper is not a work of original laboratory research itself. No survey or experiment was conducted or model run but only an examination, description, and summary of peer reviewed research studies from primarily scholarly journals.

CHAPTER II: REVIEW OF LITERATURE

Historical Discoveries and Literature Review

The mind-body continuum can only be understood when humans understand that the body is an ever changing energy system that can be affected by, and also affects, the energy around it. The brain requires a lot of energy to carry out all of its complex processes (Sahley, 2001). It is important to remember that humans are made out of energy and sustained by energy. Bodies are ever changing fields of energy and vibration, not static physical structures like pillars or walls (Amen, 2008).

In the brain, there are two ways information transmits: electrically and chemically (Newsholme & Blomstrand, 2006). The quality of brain function is dependent on neurotransmitters, which constitute the chemical language of the brain (Sahley, 2001). Some (5-HT) neurons in the brain have been shown to be involved in neuronal circuits that control a variety of functions including sleep, mood, energy, stress, movements, and appetite (Fernstrom, 2012; Fernstrom & Fernstrom, 2007; Yan Bin Shen, et al., 2012; Amen, 2008). Therefore, balance in humans' neurotransmitters is crucial to health and wellness. Further, there is no physical disease that does not have components that are mental, emotional, or psychological, or spiritual as well (APA, 2013; Amen, 2008). Balance is critical in all these areas.

In recent times, mind and body scholarly research has confirmed what the ancient healing traditions have held as true for a very long time: the body and the mind are a unit. The truth is that our bodies are like DNA "holograms" in which every part contains information about the whole. New research has even shown that a gas known as nitric oxide is produced by the lining of every blood vessel in the body during such activities as exercise, sex, and positive

meditations. Everything, therefore, is a chemical reaction. Humans' minds and daily thoughts are part of this "energy" and these cognitions have a well-documented effect on human bodies. For instance, psychological and emotional factors influence physical health greatly because positive and negative thoughts are always accompanied by biochemical reactions in our bodies. For example, low-levels of serotonin, which contribute to depression and are correlated to negative thinking, also have adverse effects on our physical health (Wardlaw, 2003).

Interest in inherited disorders that affect dopamine and serotonin and their metabolism in the brain have led to studies of these compounds' synthesis within the brain (Hyland, 2007). The many neurotransmitters used by firing nerve cells are made from common nutrients found in foods that contain amino acids.

Human DNA in the body's cells stores genetic information and specifies 20 different chemical versions of amino acids in the genetic code that living organisms use (Georgia State University, 2014; Wardlaw, 2003). To explain further, the genetic code has 20 standard or common amino acids that are manufactured from protein-containing foods (Wardlaw, 2003; Berg, 2002). These amino acids can regulate protein synthesis in a variety of tissues and they aid in the repair of tissue (Brosnan & Brosnan, 2006; Layman & Walker, 2006; Tom & Nair, 2006). Hydrophobic essential amino acids are those which also include Phe and methionine (Brosnan & Brosnan, 2006). Furthermore, large neutral amino acids (LNAA) alter aromatic amino acid concentrations in the brain, from blood concentrations commonly seen in transport across the blood brain barrier. Their circulating concentrations can influence the brain uptake of precursor amino acids for neurotransmitter synthesis. These molecules consequently affect brain function by influencing the formation and release of monoamine transmitters (Brosnan & Brosnan, 2006; Fernstrom & Fernstrom, 2007; Parker & Brotchie, 2011).

These 20 basic amino acids are used for making or building proteins and are present in healthy foods that contain protein (Berg, 2002; Wardlaw, 2003). The human body needs to use 20 different types of amino acids to function (Wardlaw, 2003). All are important to the body functioning; nevertheless, 11 amino acids are called nonessential or dispensable. Human cells can produce these 11 amino acids as long as the right ingredients are present in the body and as long as nitrogen is present. Nine amino acids are considered essential nutrients for adults. These are the nine amino acids the body cannot make that must be obtained from food with protein in our diets and these amino acids are called indispensable or essential amino acids (Wardlaw, 2003).

Combinations of these amino acids produce every essential protein needed for the body's homeostasis or healthy balance (Wardlaw, 2003). Most school children learn that needed amino acids are the building blocks of proteins (Wardlaw, 2003). The body creates these proteins, which are necessary for life (Georgia State University, 2014). Simply said, amino acids (from healthy protein food) link together to form peptide bonds, which are short chains or chemical links, and then they form proteins (Berg, 2002; Webster, 2003; Wardlaw, 2003). The body can synthesize many different proteins by bonding together the 20 different types of amino acids with peptide bonds (Wardlaw, 2003). Human DNA contains coded instructions for protein synthesis from which specific amino acids are placed in the protein. Amino acids are added one at a time to the polypeptide chain as directed by these instructions (Wardlaw, 2003). Amino acids are the breakdown products of "proteins" from food (e.g., meats, dairy, and plant proteins). Some amino acids are not readily available in the human diet and thus need to be, and can be, supplemented in a concentrated form (Berg, 2002; Webster, 2003). Therefore, amino acids are critical for life as they are building blocks to the synthesis of proteins, affecting both structural

and metabolic processes (Parker & Brotchie, 2011). Healthy bodily processes cannot occur without amino acids because the body processes require the proper proteins to function (Georgia State University, 2014; Rainbow Acres). Therefore, all these proteins from amino acids in healthy food play a very important role in maintaining health and make up a big part of a balanced diet (Turner, 2011). Both nonessential and essential amino acids are present in healthy foods with protein but if human populations do not eat enough essential amino acids their bodies first struggle to conserve what essential amino acids they have and then eventually the body progressively slows production of new proteins until at some point in the cycle the body breaks protein down faster than it can manufacture it. When this happens, the body's health deteriorates. For instance, researchers now suggest that some non-essential amino acids assume a more essential status when the body cannot readily generate them, as in some illnesses and in childhood. Arginine, considered non-essential overall, is essential for infants and growing children. Glutamine assumes an essential status in bodily injury cases, especially in the period after intestinal surgery. The amino acid glutamine is needed during metabolic stress and critical illness, and it is important for immunity. In glycogen-depleted athletes the proportion of lean body mass falls and glutamine is useful. Some studies show decreased occurrence of upper respiratory tract infections in athletes with use of glutamine and it promotes muscle growth and preserves lean body mass. Tyramine is needed in abundance if there are liver problems, as after much use of prescription medicines and in those struggling with drugs and alcohol. These non-essential amino acids could be reclassified as semi-essential. The common essential amino acids are histidine, isoleucine, leucine, lysine, methionine, Phe, threonine, Trp, and valine. All require healthy diets rich with protein.

The human body must maintain reserves of nutrients or humans would have to graze on food continually. Short term storage of carbohydrates in muscle, the liver, and the blood provides a reserve of glucose and amino acids. Vitamins and minerals are stored in the liver. When the body lacks a nutrient it needs for function it takes it from where it is stored, for instance, calcium from bones and protein from muscle. Amino acids are required for the synthesis of hormones and enzymes, as well (Wardlaw, 2003).

Recent published research shows protein, especially plant protein, (which would be present in such foods as soy, nuts, peas, and beans) and lean animal meats, should constitute 50% of the diet for healthy function and healthy weight of an adult human (Layman & Walker, 2006; Wardlaw, 2003). Typical diets of mixed proteins, like rice and beans, supply an average of 50% of protein as essential amino acids. Many recipes and food dishes mix vegetables, rice, potatoes, animal meats, nuts, grains, and beans. Foods that contain all nine essential amino acids in about the proportions a body needs are considered high quality complete protein foods. But when incomplete or low quality protein foods (that lack one or more essential amino acids) are eaten together they can make a complete amino acid meal. The research work of Layman from the University of Illinois at Champaign, brings the American Food Guide Pyramid into question as to its validity even with the food pyramid's newer changes (Wardlaw, 2003).

Professionals still hotly debate the merits of increasing proteins at the risk of heart attacks, organ failure, and taxing the liver. However, large amounts of certain carbohydrates can cause the same damage. Additionally carbohydrates can cause increased weight gain, infections such as yeast or candida, diabetes, edema, and increased uptake into the cells when a person is exposed to poisons from commercial sprays (Wardlaw, 2003).

No one debates the depletion of the nutrients in our American soils since the 1930s. This calls in to question the nutritional quality of grains we consume, as well as of the nutritional content of meat from grain-fed or grass-fed animals. In addition, animals raised for meat are often dosed with hormones or antibiotics prior to slaughter. Even in the absence of these issues, complete plant proteins are a healthier choice for our bodies (Layman & Walker, 2006). Further, a mix of plant protein products, other than grains, will contain enough of the nine essential amino acids to constitute a healthy diet (Wardlaw, 2003). This is good news for vegetarians. It should be noted that plant proteins found in grains are low in one or more of the nine essential amino acids due to nutrient depletion in soils. This is true around the world, but particularly in the US. Therefore, a diet predominately composed of grains, unless the grain is fortified like in cereal, does not match the body's needs for essential amino acids. Dietary proteins that contain ample amounts of all nine essential amino acids are called high-quality complete proteins.

Amino acids derived from protein intake are precursors to brain chemicals called neurotransmitters, such as serotonin. Serotonin is a natural antidepressant-like chemical produced in the brain (Fernstrom, 2012). To produce serotonin and raise serotonin levels in the brain requires the amino acid Trp, found predominately in foods such as turkey, chicken, fish, beef, goat, sheep, dairy (milk) products, eggs, soy, green peas, beans, potatoes, peanut butter, and raw nuts (Turner, 2011, Amen, 2008). These same foods help build neurons and maintain nerve cell membranes and myelin as lean proteins and healthy needed fats (Amen, 2008). Generally, Trp is deemed an essential amino acid, with currently a RDA in the United States of 0.35 grams for a 155 pound individual (Fernstrom, 2012; Yan Bin Shen & et al., 2012). An average male consumes about 100 g of total protein or 1g of Trp (Fernstrom J., 2012). We must keep in mind that RDA recommendations are based on minimum levels to prevent deficiencies leading to

disease states. The RDA recommendations do not represent what are needed for optimum levels of metabolic potential, health, wellness, and balance (Layman & Walker, 2006).

It is now possible at the microscopic level to analyze structure, physiology, and pathophysiology in the living brain of humans or mice (Ottersen, 2011). For instance, a laser beam can easily penetrate the thin cranium of a mouse, enabling previously hidden processes to be visualized. Advancements in imaging, e.g., multiphoton imaging, have brought about many changes in how scientists from various fields view the human brain and the working of complex human systems. Recent research has revealed that the brain is more malleable than was previously thought. Thus, currently, any discussion of the impact of nutrition and environment on the brain is based on the premise that the brain has been discovered to be malleable. Likewise, recent advances have shown that brain synapse populations turn over at high rates and it is now thought this turnover is commonplace. Also, synaptic receptors can be seen on imaging as continuously on the move (Ottersen, 2011). The knowledge that synapses, receptors, and neurotransmitters are structurally more soft-wired and have greater plasticity than previously believed emphasizes the necessity to explore the impact of nutrition, exercise (movement), and sleep on brain function and structure and, in addition, the mind-body disease states (Halson, 2014; Ottersen, 2011; Amen, 2008).

Further, the scientific community has published many articles encouraging the use of amino acid therapy to treat illness and psychological disorders, such as drug and alcohol dependency, depression, and anxiety (Cruz et al., 2008; Fernstrom, 2012; Fernstrom & Fernstrom, 2007). In cases of some disease states like depression, anxiety, and drug addiction, healthy diet has not been present (Fernstrom, 2012; Moehn, Pencharz, & Ball, 2012; Shapiro, Fraser, & Seguin, 2012; Turner, 2011). The disease state of drug addiction, in particular, has been shown to be adaptable to change through nutrition and “environment” in varied therapies. Nutrition and

intravenous nutrition, supplementation, exercise, positive thinking, and positive influence through mentoring and counsel have been seen to be helpful and mutually interactive (Cruz, Bajo, Schweitzer, & Roberto, 2008; Ottersen, 2011). There has been a long, well-documented history regarding using amino acids for depression and other mental issues related to brain chemistry imbalances (Fernstrom, 2012).

Discovered in the early 1900s, amino acids were used therapeutically up to the late 1980s by some practitioners. Some physicians used amino acids as a mainstay for treating emotional conditions, particularly depression. The use of pharmaceutical medications has nearly eliminated this natural treatment option, especially in America. Ironically, pharmaceutical drugs have been developed to simulate and stimulate serotonin in the brain; therefore, stirring up serotonin in the brain's synapses for improved firing of neurons for better emotional health from drug therapies. But drugs cannot produce any more new serotonin or neurotransmitters in the brain's synapses. They can only stir up what is already there.

Furthermore, amino acids have been used in clinical tests to treat a variety of serious illnesses and conditions (Newsholme & Blomstrand, 2006). This is because the amino acid Trp from food converts to the neurotransmitter serotonin and the amino acid Tyr from food converts to the neurotransmitters dopamine, norepinephrine, and epinephrine (Wardlaw, 2003). Thus, various disease states have been shown to be associated with low functional levels of neurotransmitters in the body, which are made from ingesting essential amino acids from food (Newsholme & Blomstrand, 2006).

Research results clearly show the importance of amino acid nutrition. Research studies have also shown the importance of vitamins and minerals for health and well-being. In a relatively large

observational and cross-sectional cognitive study (sample size 3970 from population weighted ethnic/race percentages, and using blood sampling and cognitive assessment testing) from Drexel University, School of Public Health, by Nguyen, Gracely, and Lee, (2013), showed that higher serum folate (B Vitamin) concentrations had a strong positive relationship with better cognitive test scores for reading and block design in children age 6-16 years of age (Nguyen et. al., 2013). Despite the limitations of many small studies, this large study again raises important questions about the importance of nutritional diets, not only with autistic children, but with the population at large (Arnold et al., 2003, Nguyen et. al., 2013). Even though the prevalence of vitamin/mineral deficiencies vary widely around the world and it was assumed that study participants from India and Kenya were more nutritionally deficient than participants from other locations, there is evidence that B vitamins influence cognitive function in all children (Arnold et al., 2003, Nguyen et al., 2013). For example, in the Nguyen et al., (2013) study's hypomethylation hypothesis, folate is believed to have directly affected the central nervous system. This result suggests folate is essential for the synthesis of nucleic acids as well as for methylation of DNA (Nguyen et al., 2013). Folate acts as a donor to homocysteine which is then converted to methionine and then to SAM or S-Adenosylmethionine. Therefore low concentrations of folate, for example, result in low concentrations of SAM which affect the metabolism of neurotransmitters (Nguyen et al., 2013).

Changes in neurotransmitter levels in the brain can account for a number of diseases (Newsholme & Blomstrand, 2006). For example, studies have shown depression is due in part to a low level of catecholamines. Parkinson's disease is due in part to a low level of dopamine, and schizophrenia or dissociative disorder is due, in part, to a high level of dopamine (Newsholme & Blomstrand, 2006). Children with autism are more likely to have lower plasma levels of amino

acids than non-autistic children (Arnold, Hyman, Mooney, & Kirby, 2003). Deficiencies in amino acids are further exacerbated in children with autism who are on casein restricted or gluten-free diets (Arnold, et. al., 2003).

Also found is that the amino acid L-arginine appears to positively affect pathophysiological mechanisms in the progression of atherosclerosis (Boger, 2007). Dietary L-arginine has a stronger relationship to effect change in early stages of the disease when functional changes are still reversible. Thus, as a supplement, L-arginine can be a nutraceutical support agent in functional impairment of vascular disease and in prevention of vascular disease. However, structural atherosclerotic changes of the vascular wall in advanced cases may cause individuals to be less responsive to a therapy (Boger, 2007). Though traditionally deemed non-essential, L-arginine is very important for proper blood flow, and is now considered semi-essential to have in our diets plentifully (Amen, 2008; Wardlaw, 2003).

The peptide Vasopressin (VP) shows promise in being a neuro-protective agent (Chen, 2010). Vasopressin has a protective effect because it is released in the brain during stress conditions (Chen & Aguilera, 2010). Vasopressin receptors are present in neurons at sites that control behavior as well as learning (Chen, 2010). Thus, breakthroughs in scientific research are giving people not only a new understanding of the amino acids' role in health, healing, and wellness, but pointing to ways of fostering a new vitality in life through better health (Sahley, 2007).

Obtaining these nutrients via the diet would be ideal. However dietary supplements may play a helpful role. Supplements have shown promise to restore nutrients that may have been lost due to genetics, pregnancy, injury, or poor nutrition (Sahley, 2007). For example, in the prefrontal cortex of the human brain, problems with diminished conscience, poor judgment, impulsivity,

short attention span, disorganization, trouble learning from experience, confusion, poor time management, and lack of empathy can be diagnosed (this is sometimes referred to as Jiminy Cricket deficiency syndrome). Such symptoms have seen improvement from supplements which increase dopamine in the brain (Amen, 2008). The use of L-Tyr for this syndrome as well as Types I and 2 ADD, some forms of depression (without manic episodes), and cocaine and nicotine withdrawal appears to be a successful addition to conventional treatments. A number of studies have shown encouraging results regarding the use of L-Tyr supplements to ease symptoms of depression especially when used together with the supplement 5-HTP. In addition, supplementing with L-Tyr has been reported to help boost energy levels, mood, focus, metabolism, motivation, and concentration. It also has helped with sleep deprivation, emotional upset, and the body adaptation to, and coping with, stress.

Amino acid and other nutritional supplementation have continued to be a popular option for alternative medicine health modalities. Such supplementation can be combined with complementary practices, such as exercise and good diet (Norton & Layman, 2006). Exercise or movement is a complementary practice to increase brain levels of, for instance, Trp, which is an amino acid building block for the neurotransmitter serotonin (Amen, 2008). Regularly, Trp is found to be low in many depressed patients (Amen, 2008). Because Trp is a relatively small amino acid, it often has trouble competing against the larger amino acids to cross the blood and enter the channels into the brain. Exercise uses the larger amino acids for nourishment of muscle tissue and decreases the availability of the larger amino acids in the blood stream. Then Trp can compete more effectively to enter the brain and raise needed brain serotonin levels to ward off depression and anxiety and make other needed neurotransmitters.

A step closer to the final product, serotonin, is 5-HTP, which is more widely available as a supplement than L-Trp and is more easily taken up in the brain (Amen, 2008). A number of double-blind research studies have shown that 5-HTP is effective as an antidepressant supplement and, by boosting serotonin levels in the brain, helps calm cingulate gyrus hyperactivity, allowing the cingulate to help with shifting of attention. The amino acids most likely to be low in a diet are Trp, threonine, methionine, and lysine (Wardlaw, 2003).

Discussion of Results, Findings, and Analyses

Amino acid therapy is used to help balance brain chemicals in order to affect the physiology in one's body (Wardlaw, 2003). Neurotransmitters, the chemicals manufactured by the human body, allow our nervous system and all processes to function effectively because they facilitate passage of signals from one neuron to another, once they have been released into the synapse. Simply put, when the body requires a specific function to be carried out, the neuron's presynaptic ending releases a specific chemical into the synapse, which serves as a reservoir of neurotransmitters and other brain chemicals. Unused or depleted neurotransmitters are then recycled back into a cell to be reused. Having adequate amounts or neurotransmitter precursor molecules in the brain is important. Diet is important in their manufacture.

Researchers have found that people unknowingly trigger cognitive inflexibility or stuck, upset, or sad feelings by eating diets that are low in the essential amino acid L-Trp or failing to have proper movement for burning off excess large amino acids to let L-Trp to pass to the brain. Unhealthy diets of incomplete amino acids (protein) in carbohydrates such as sugary drinks, candy, pasta, breads, pastries, chips, crackers, popcorn, and pretzels do not help (Amen, 2008). At best, incomplete amino acid grain products provide a quick and temporary increase of L-Trp

levels in the blood resulting in more L-Trp available to enter the brain where it is converted to serotonin (Amen, 2008). However, just as dopamine and serotonin levels end up dropping from alcohol use or prescription drugs, which only stir up serotonin already in the system, grain products create a similar effect. Furthermore, both alcohol and grain products convert to sugar. The cycle that carbohydrates produce in the body is not healthy for brain chemical balance (Amen, 2008). The temptation to use these foods repeatedly, and to develop cravings for them, is their short term effect. They produce a quick reaction of feeling calmer and more flexible from the calming effect of serotonin. This effect wears off, but use of carbohydrates becomes a habitual cycle that is very difficult to break (Amen, 2008). In contrast, if one's serotonin levels, from dietary Trp, are at a higher, more healthy level, serotonin aids sleep and decreases the desire to eat excessive carbohydrates (Wardlaw, 2003). Also, cravings for alcohol, sugar, and grains are due in part to their temporary effect of alleviating anxiety and sadness (Wardlaw, 2003). If carbohydrates can be considered a drug, they are therefore an ineffective drug in the long-term sense.

Understanding the mechanics of neural transmission is key to understanding disease, health and wellness (Ottersen, 2011). Many substances beside neurotransmitters play an important role in neural transmission. Transmission of a signal down the neuron utilizes a change in the sodium and potassium concentrations along the neuron's axon (Wardlaw, 2003). As the "message" or transmission is sent, there is an influx of sodium and a loss of potassium through the cell membrane. Then ion concentrations are restored to normal amounts in the neuron and it would be ready to send another message. Thus, calcium is needed for the release of neurotransmitters from neurons. Vitamin B-12 also plays a role in the formation of a myelin sheath which increases efficiency by providing a form of insulation around parts of most neurons. Regularly

supplying carbohydrates in the form of glucose is important for providing for the energy needs of the brain. The human brain can use other "fuels" to power the brain, but people commonly use carbs to produce the breakdown to glucose (Wardlaw, 2003). Balance in blood proteins is also important in maintaining the body's fluids. Without sufficient protein in the bloodstream, edema develops in the human body. Some blood proteins are very good buffers for the body.

Quantitative EEG brain wave studies and now nuclear medicine brain studies called SPECT (single photon emission computed tomography), which measures cerebral blood flow and metabolic activity patterns, have advanced our understanding of brain physiology (Amen, 2008). These methods of investigation show that synapses are malleable, rather than fixed, as was previously thought (Ottersen, 2011). It is now possible to identify neurotransmitter receptors. There are well over 100 currently known neurotransmitters. These different neurotransmitters perform different and various overlapping functions, regulating the whole body.

Some professionals believe that for any type of amino acid treatment to be proven effective on neurotransmitters, the treatment should include specialized documented urinalysis testing. This provides a reliable means of measuring excretory values of the neurotransmitters. This method has been used in diagnosis of amino acid depletion and supplementation. Measuring excretory values in the urine is hypothesized to translate to an estimate of active values in the brain (Parker & Brotchie, 2011). From these findings, an individualized protocol of amino acid supplementation through pill, diet, or IV is devised to increase the quantity of excretory values in the urine. This is thought to correspond to the quantity of neurotransmitters in the brain (Fernstrom, 2012). The first step in diagnoses, treatment or therapy, and supplementation, is to identify where an individual's neurotransmitter levels are in their current state (Sahley, 2001).

Most of the synapses discussed here use glutamate in neurotransmission (Ottersen, 2011). Glutamate is by far the most prevalent transmitter in the central nervous system (Ottersen, 2011). The recent projects of Nordic Centre of Excellence in Molecular Medicine and FAR-TRAP and GRIPANNT, which are two European Union framework programmed projects, focus on the fact that glutamate receptors are mobile and have plasticity within the synapses as well (Ottersen, 2011). Data from this center, which works with in vivo imaging by multiphoton microscopy, shows Kainite and AMPA receptors are very active and have moving neurons at brain synapses also. Glutamate receptor interacting proteins have been found to be novel neuro-protective targets essential to neural transmission (Ottersen, 2011).

In recent years, knowledge has advanced greatly as to the influence of food and supplementation on brain function (Ottersen, 2011; Amen, 2008). The continual development and application of new medical technologies enables the scientific community to learn much more about the functioning of the brain and body. For instance, multiphoton laser imaging now allows researchers to look into the living brain at the microscopic level and investigate synapses; and the mobility of neurotransmitter receptors can be studied by another new technique called single molecule tracking (Ottersen, 2011).

The latest technological advances enable scientists to see inside the brain, bringing neuroscience farther in understanding neurotransmitters, health, amino acid therapy, and disease states; the brain is reviewed with new visual clarity (Ottersen, 2011). Data has accumulated that chemicals and nutrients do cross the blood brain barrier and affect humans' systems with a chemical reaction and response going out to all organs and systems (Fernstrom, 2012; Parker & Brotchie, 2011).

CHAPTER III: CONCLUSIONS, IMPLICATIONS, AND INTERPRETATIONS

Conclusions

Research in the biochemical sciences continuously improves scientific understanding of neuropsychology (Ottersen, 2011). Experts believe the human brain uses about twenty percent of the body's total energy supply (Sahley, 2001). Therefore, energy must be supplied on a constant basis in the form of nutrition to the constantly demanding brain (Sahley, 2001). Oxygen, glucose, amino acids (proteins), fats, vitamins, and minerals must be fed to the master controller: the brain. The brain controls every muscle, mood, organ, breath, heartbeat, thought, body temperature, body process, and hormone (Fernstrom & Fernstrom, 2007; Sahley, 2001).

Science has established the powerful link between nutrition from diet and health (Wardlaw, 2003). The state of a person's health depends on the state of nutrition of the body (Sahley, 2001). Deficiencies in B vitamins, for instance, especially folate or folic acid and vitamin B-12, influence multiple aspects of neuronal physiology including neurotransmitter synthesis of dopamine, norepinephrine, and serotonin, as well as axon and myelin functionality (Nguyen, Gracely, & Lee, 2013). Humans' intake of vitamins, minerals, and amino acids, as well as of substances that are harmful into the body, influence all aspects. What affects the brain affects the body and what affects the body affects the brain. For instance, a study found that higher serum folate concentrations in children had a positive relationship with cognitive test scores for reading and block design (Nguyen, Gracely, & Lee, 2013). The amino acid L-Trp has been shown effective in treatment of a wide variety of conditions involving low serotonin concentrations in the brain, with surprisingly only a few mild attributed side effects (Fernstrom, 2012; Shibata &

Fukuwatari, 2012). For example, in a research study using nursery pigs under social mixing stress, the study showed reduced stress hormone and decreased secretion of the stress hormone and increased hypothalamic 5-HT (Serotonin) in the following adaptation period after L-Trp supplementation (Yan Bin Shen & et al., 2012).

In addition, the brain needs glucose for energy and to build neurotransmitters for cell to cell communication (Sahley, 2001; Sherman, 2010). The brain cannot store energy so it needs a steady supply of glucose and other nutrients. Some of the factors that affect glucose supply to the brain are the amounts and types of food consumed, when it is consumed, and how effective glucose is in having access to the brain (Sherman, 2010). Other organs play a role. The hormone insulin, for example, is produced in the pancreas. Insulin affects glucose access to brain cells . Thus, insulin regulates learning, memory, and cognitive function . Furthermore, BCAA essential amino acids are important nitrogen donors for synthesis to glutamine and alanine, which are important glucose precursors (Tom & Nair, 2006). The BCAA (branched) amino acids also fuel the gut along with promoting wound healing and having beneficial effects on liver disease. The amino acid glutamine enhances immune function in humans (Wardlaw, 2003). Amino acids such as L-Trp, through food or supplementation, now are clearly shown to easily cross the blood brain barrier because it is possible to microscopically follow their path in the brain from the blood (Ottersen, 2011; Parker & Brotchie, 2011). Drawing on these new imaging technologies, recent studies show the brain is more malleable than previously assumed (Ottersen, 2011). The researched malleability of the brain has changed the prospects for nutritional interventions as well as regarding other environmental factors. Chemicals do shape not only structural processes but the brain's responses to stimuli, environmental stress, and physical health (Ottersen, 2011).

Finally, amino acids such as L-Arginine play a role in neuro-protection and synaptic plasticity (Boger, 2007).

Research studies have shown that poor nutrition at any time in life can permanently alter brain development (Sahley, 2001). The state of nutrition is the state of brain health and functioning for the brain and the rest of the body. Furthermore, high protein diets (rich in amino acids) have been shown to enhance glycemic control (Layman & Walker, 2006). High "sweet" carbohydrate diets that tend to be include comfort foods turn out to be just that as they temporarily raise serotonin by stimulating higher levels of insulin (King, 2007). Insulin, produced by the pancreas, stimulates higher serotonin levels and gets rid of the five amino acids that compete with Trp to enter the brain, thus, making the transition from Trp to serotonin more possible (King, 2007). This means that often what is craved can be translated to what is needed, which research studies have confirmed (King, 2007; Turner, 2011). Insulin is a critical hormone for proper brain function, greatly affecting neurotransmitters like serotonin. Insulin regulation research now shows as one of serotonin's greatest functions (Sherman, 2010). However using sugar, consciously or unconsciously, to raise needed serotonin is defeating at best because of the other consequences to the body such as weight gain, chemicals going to fat stores, damage to the liver and other organs, inflammation, yeast, candida, infections, the destructive affect to the nutritional base, bouncing glucose and insulin levels, empty high calories, and leaving our brains and neurotransmitters depleted instead of replenished with nutrients. Therefore, when nutrients, chemicals, and amino acids compete for absorption, it is of importance that diets are rich in Trp (Kotsopoulos, 2011). To reduce cravings and help balance moods, it is best to consume five to six small meals which should always include protein and fiber throughout the day (King, 2007).

Additionally, it has been shown that omega 3s improve the communication system of neurotransmitters across synapses (Kotsopoulos, 2011). Amino acids are not the only building blocks for proteins for our systems. The omega 3 fatty acid DHA is a primary building block to the brain and its processes (Sahley, 2001). This fatty acid is necessary for the vision, and is most abundant in the brain and the retina (Sahley, 2001).

Several doctors have compared the brain to a computer. However, unlike the computer, the brain needs constant nourishment from nutrients in the blood to continue to process the data that is needed for us to develop from children to adults and to sustain us throughout our lifetime (Sahley, 2001; Amen, 2008). A good comparison between the two is that a computer would go dead, unable to reboot, without electricity or battery charge (Sahley, 2001; Amen, 2008). And the brain also needs fuel (food) or nutrients to produce energy to run on. Both computers and the brain need an energy supply to them.

This paper is a reminder and an additional call to protect and nourish our brain-body system. The software of the brain is the nerve cells. Neurotransmitters, blood flow, and synapse connections, together with the hardware organs and systems of the body, make all the systems function (Amen, 2008). For illness not to occur, the mind-body connection needs to operate at peak efficiency (Amen, 2008). Illness can strike when any of these systems is out of sync or disrupted in the human body, brain, or blood (Amen, 2008). Genetics, physical health, nutrition, exercise, environmental toxins, sleep, and stress play a continual role for the systems of the body (Amen, 2008). When the brain-body connection is healthy all of these factors work together positively for wellness (Amen, 2008). Though the government's advice regarding recommended daily amounts of various dietary components is useful, it must be kept in mind that RDA

recommendations are based on minimum levels to prevent deficiencies and disease states, and not on optimum levels needed for optimal metabolic balance (Layman & Walker, 2006).

Implications

It has been found in some studies of amino acid deficiencies, which relate to poor protein (amino acids) nutrition, that there is an association to unusual food preferences. This phenomenon is particularly apparent in children who are taste and texture based in their food preferences (Arnold et al., 2003). Children with autism , especially those children with taste and texture based food preferences, in particular, have been found to have greater problems with amino acid deficiencies.

It is also well known that street drugs, prescription drugs, alcohol, nicotine, caffeine, medications, and other chemicals disturb amino acid metabolism and amino acid's positive effectiveness on neurotransmitters. It has been less well known to the public that aspartame, a popular artificial sweetener, not only disturbs amino acid (protein) metabolism but disrupts protein structures, neuron function, endocrine balances, enzyme function, and glucose concentrations. Aspartame interferes with the brain's concentrations of catecholamines, as well (Humphries, Pretorius, & Naude, 2007). Additionally, changes in the brain's concentration of catecholamines has a strong positive association with depressed mood. Humphries, et al. (2007) also noted that greater Aspartame use increased: nerves firing excessively, oxidative stress, and destruction of cellular walls.

Likewise, in inpatient treatment centers where there is use of IV vitamins, minerals, and amino acids they are finding fewer withdrawal cravings, higher success rates, and with reduced recidivism with patient's drug of choice. Nutritional education for those struggling with

defeating lifestyles has been seen to be of great benefit. Nutritional education is now used everywhere in America seen in in-patient and out-patient treatment centers, jails, drug and alcohol treatment programs, the AA program, school feeding programs, public, private, and home school programs, college courses, probation and parole programs, homeless shelters and feeding programs, the DARE public school-age program, and as well as in community educational programs.

Interpretations and Summary

Examination of the Arnold et al. (2003) pilot study data reveals a trend for even worse protein nutrition in the group of children with autism on the "restricted diets" that parents choose for their children without dietician's advice (primarily because of children's refusal to eat certain tastes and textures) (Arnold et al., 2003). It is plausible that behavioral effects could be due to alteration of neurotransmitters from inadequate neurotransmitter production by inadequate amino acid precursors through manipulation of their children's diet which gave the children inadequate nutrition, namely called in the study "the restricted group" (Arnold et al., 2003). However, the children with autism in this study in both the restricted and unrestricted diet groups had frequent essential amino acid deficiencies which suggest poor protein (amino acid) nutrition. This diet-nutrition and amino acids-neurotransmitter link requires continued exploration for effective diet related future treatments (Arnold et al., 2003).

Layman's research, at the University of Illinois, is one of the reasons it has come to the forefront that increased protein (amino acid) diets and reduced carbohydrates enhances weight loss, loss of body fat, enhanced glycemic control, and reduced loss of lean body mass (Layman & Walker, 2006; Norton & Layman, 2006). Involved in the process are the amino acids leucine and the

glucose and the alanine cycle (Layman & Walker, 2006). However, there are many neurotransmitter health benefits to a 50% ratio of protein in our diet. Increased protein diets, preferably in plant protein, create stimulation and metabolism of our whole system or bodily systems (Layman & Walker, 2006; Turner, 2011).

Finding maximum upper limits of safety for amino acids in humans has been difficult (Moehn, Pencharz, & Ball, 2012). Research has been more successful in distinguishing maximum limits with some amino acids than others and many approaches to the problem have been studied (Moehn, 2012). One approach that has been successful in determining the upper safe intake of Phe in piglets and leucine in rats and humans is to measure the rate of oxidation (Layman & Walker, 2006; Moehn, 2012; Norton & Layman, 2006; Parker & Brotchie, 2011). Okuno et al. among others have suggested analysis of urinary excretion of amino acids to hypothesize the upper limits. It is thought that such analysis will correspond to these amino acids such as Trp metabolites in the brain (Moehn, 2012; Parker & Brotchie, 2011). Amino acids from food or in a concentrated form have very few minor side effects. However, some amino acids do not mix well with pharmaceutical drugs (Fernstrom, 2012). As we now know, from decades of research, Trp is converted to serotonin and Tyr is converted to dopamine. Research has shown both serotonin and Tyr to have a large number of positive effects including relevance in depressive disorders (Fernstrom, 2012; Newsholme & Blomstrand, 2006; Parker & Brotchie, 2011). This report contributed to the large body of information on each of these two amino acids (Trp and Tyr) that relates to their role as precursors of several neurotransmitters, that have been shown to have an antidepressant affect within the brain (Boger, 2007; Brosnan J.T. & Brosnan M.E., 2006; Fernstrom, 2012; Fernstrom & Fernstrom, 2007; Kotsopoulos, 2011; Moehn & et al., 2012;

Newsholme & Blomstrand, 2006; Parker & Brotchie, 2011; Pencharz, Hsu, & Ball, 2007; Sahley, 2001; Yan Bin Shen & et al., 2012; Tom & Nair, 2006).

Newer to the scene in research is that both amino acid and BCAA leucine have a role in reducing fatigue (Layman & Walker, 2006; Newsholme & Blomstrand, 2006; Norton & Layman, 2006). In addition, BCAA leucine, in its regulation of muscle protein synthesis with both resistance and endurance exercise, is dependent on the replenishment of leucine (Norton & Layman, 2006). It has been found that, for example, "carbohydrates" in themselves and nonessential and other essential "amino acids" do not have as stimulatory and increased effect on protein synthesis after exercise and throughout the exercise process as comparable with the amino acid leucine (Norton & Layman, 2006). So leucine in this situation is the key amino acid needed.

As an outgrowth of research has come a growing educational awareness of the importance of nutritional support and examination of environmental and genetic exposures as risk factors (Shapiro, Fraser, Seguin, 2012). Furthermore, knowledge from scientific advances is improving health for women and pregnant and nursing women. Knowledge further aids in the prediction, prevention, and treatment of significant public health problems and concerns (Shapiro, et al., 2012). In a pristine world with healthy soils, unpolluted water supplies, and a strong desire to educate ourselves and maintain healthy practices including what we put into and around our bodies, our food would supply all necessary nutrients to support optimal brain and body health (Turner, 2011). Food could contain all needed nutrients in one package: all of the vitamins, minerals, enzymes, coenzymes, antioxidants, omegas, amino acids, and all the rest, as pet food and animal fed readily and commonly supplies. The goal for nutrition from food may be then to find fresh, unprocessed, unrefined, whole, organic, fibrous food, rich in omegas, and amino acids. But most of the time, it has been seen to be nearly impossible especially with American

food choices and the society on the go. In reality, the on the go world we live in promotes empty calorie choices, necessitating supplementation for necessary vitamins, minerals, omegas, amino acids, trace elements, and other nutrients. Fortunately, targeted, therapeutic, individualized nutrients can be chosen that are bio-available (Turner, 2011). Realistically, brain health and the body's health rely on receiving nutritionally rich foods, not empty calories, to nourish the brain for optimal mood, energy, cognition, and behaviors (Turner, 2011). Attention to the nutrients taken in one's diet makes it easier to establish healthy eating habits. A healthy diet also provides the greatest protection against age related cognitive decline, illnesses, and diseases. While many individual nutrients have been found to exert positive effects on humans, the best recourse is to begin early maintaining health and continuing with a balanced diet, supplementation, and healthy wellness practices throughout life (Torres-Vega, Pliego-Rivero, Otero-Ojeda, Gomez-Olivan, & Vieyra-Reyes, 2011; Turner, 2011).

Very ambitious large long-term studies that objectively measure behavioral responses to dietary interventions are surely on the horizon (Arnold et al., 2003). Intervention studies with longitudinal follow up are always welcome and are needed to examine long term implications (Nguyen et al., 2013).

Various disorders stemming from dopamine and serotonin metabolism are affected by the metabolism of Phe, Tyr, and Trp and need differential diagnosis, because nutritional treatment is different for each separate disorder (Hyland, 2007). Crucial to human health is a balanced diet that can supply the body with both essential and nonessential amino acids that are building blocks for proteins needed to maintain and create good health (Wardlaw, 2003).

In conclusion, the human body, its organs, and systems scream with demands for balance in all its operations and functions from the heart, to tissues, to muscles, to the blood, to the brain. Each disease state of a body screams out the abuse the systems of that body have undergone from lack of good dietary balance and healthy movement.

It is easily overlooked that humans are made out of energy and sustained by energy. However, many professionals now believe we can begin to appreciate ourselves as positive vibrational fields of energy with the ability to affect the quality of our own experiences and those of others around us in a growing movement towards wellness. This would include researchers, medical professionals, clinicians, educators, scientists, nutritionists, and environmentalists. Changing our health habits, including what we put in us, on us, and around us in the present and future, will produce positive results. Forming new eating patterns and balancing foods and meal choices to yield the proteins needed to obtain enough of all nine essential amino acids (Wardlaw, 2003) takes conscious effort, time, and thought, but the results in health will be astounding. Ideally, these new patterns would spread through society for generations to come.

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