# Extended Essay

"Ketogenic Diet, Fasting and Health"

Research question: How has the development and implementation of dieting and fasting methods affected the American populous?

World Studies: Health and Development (Biology, Psychology)

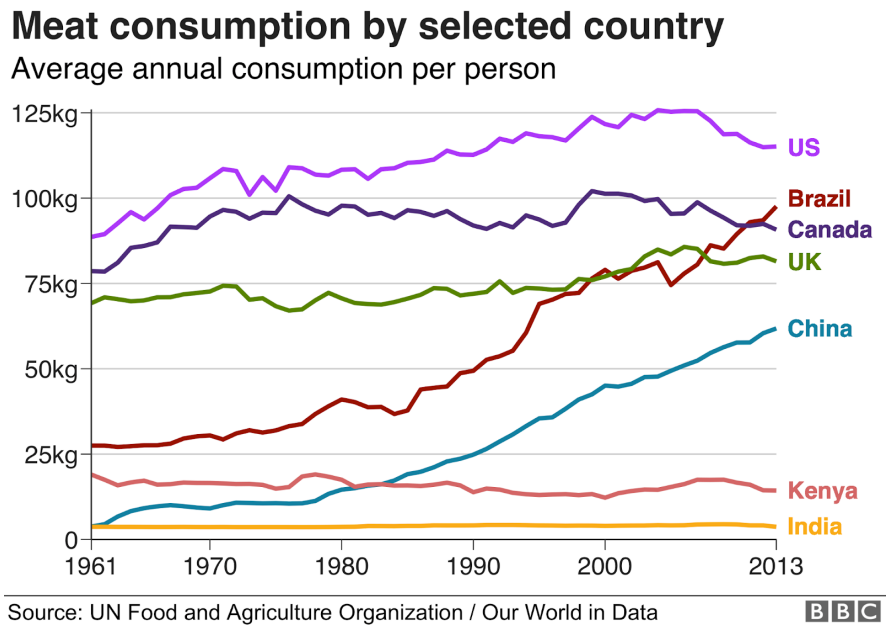
Word Count: 3774

# Contents

## Introduction

The misconceptions surrounding diet culture have grown rampant along with the media and government's push to villainise weight gain. In the United States, diversity of food products has resulted in varied dietary preferences. A number of these dietary habits are founded on a lack of research on the role of fats in a diet, thus creating a global phenomenon around the understanding of dietary and health complications. The economic and industrial state of many developed regions has reached a state of equilibrium. The commoditization of meat has improved the accessibility and availability of food. As demonstrated in *Figure 1*, there exists an upward trend in meat consumption which varies based on political, social, and economic situations of countries (UN, 2013).

**Figure 1**



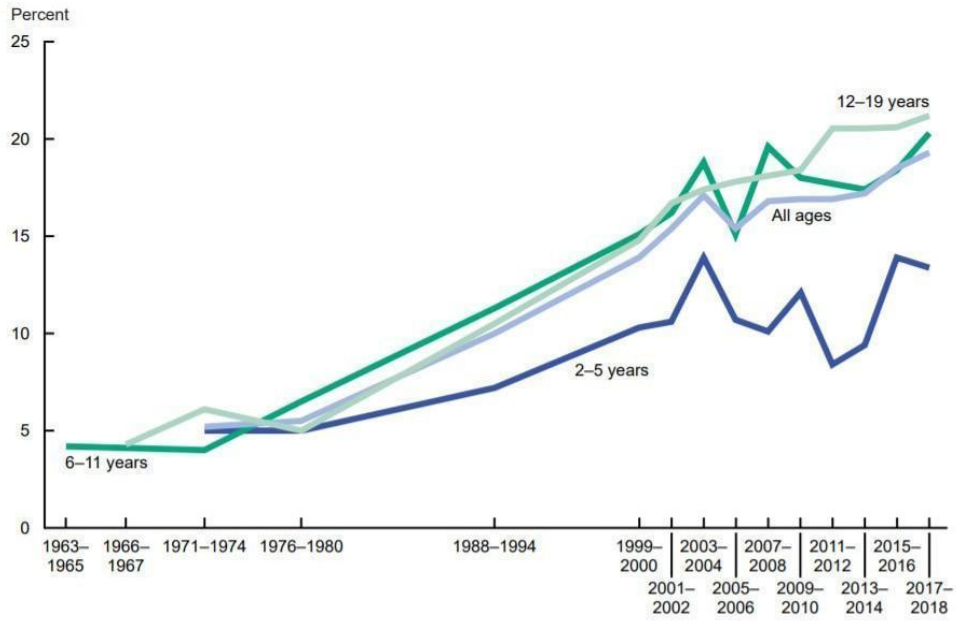

*Note.* Food consumption by country from 1961 to 2013.

While fats are typically considered the source of weight gain, it is usually due to high intakes of sugars or carbohydrates. This misconception stems from the mid-20th century United

States; studies done in the 1940s display a correlation between high-fat diets and increases in cholesterol levels. This suggested that low-fat diets can better control cholesterol levels and thereby improve heart diseases. Throughout the 1960s, low-fat diets were introduced and accepted by the general public as a means to improve general health. In the 1980s, there was pressure from the government, food industry, and media through different forms of propaganda which led to the American populace adapting this low-fat ideology. There exists no proof that the diet reduces heart disease nor promotes weight loss (La Berge, 2008).

There was lacking belief towards the low fat-ideology during early development. As time went on, however, through the illusory truth effect, belief in low-fat diets grew. This effect states that the more a fact is repeated, the more humans tend to believe it. When something novel is first introduced, the mind automatically views it as suspicious and dangerous. However, with increased interaction with the novelty, the mind begins to become fond of it instead (Jackson, 2018). Alongside the social pressure for conformity as well as information from trusted and official government sources, low-fat diets became the preferred rhetoric of the American food and diet industry (Cobalt Communications, 2019) (Jackson, 2018).

**Figure 2**



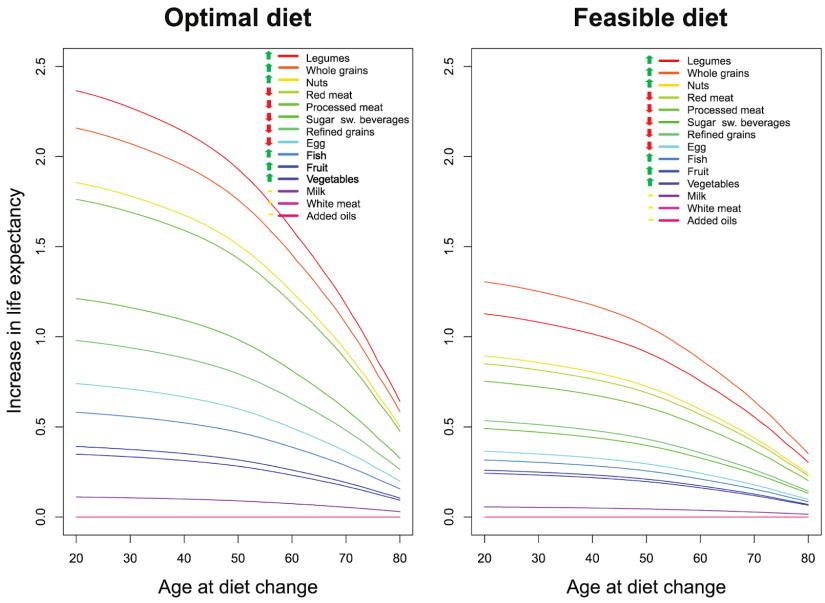

*Note.* Obesity percentages in Americans from 1963 to 2018. CDC, 2018.

The use of similar propaganda still serves a purpose of convincing consumers to purchase products which are highly addictive and have potential to worsen health. Products which were high in sugar were the most prevalent, and their promotion is strongly linked to the diabetes epidemic (That sugar film, 2015). Within the past decade, there has been a particular influx in health conditions which have links to dietary choices. The percentage of Americans diagnosed with diabetes rose by 15% between the years 2000 and 2015 and obesity by 20% since 1963 (CDC, 2017) (CDC, 2018). Metformin, the main drug prescribed for diabetic patients, still remains the world's best selling drug, where the amount of metformin sold is greater than all other drugs combined (Fung, 2018).

As it stands today, there still exists numerous misinterpretations towards food and its relationship with health and medical conditions. This phenomenon arises from blind trust in non-research based media sources and an unwillingness to accept individual responsibility for

poor dieting habits. A study done by a Norwegian research team at the University of Bergen has shown a direct correlation between diet choices and life expectancy (Fadnes et al., 2022).

**Figure 3**




*Note.* Optimal and feasible diet effects on life expectancy based on age at change. Fadnes et al., 2022.

An optimal diet, as illustrated in *Figure 3*, can be differentiated from a feasible diet given the intensity of the change from an average diet. Whereas an optimal diet greatly limits food choice, a feasible diet allows for a greater variety of food choice. Though an optimal diet has the propensity to ameliorate one's overall physical health, it is also necessary to account for mental wellbeing and long-term compliance to diets (Fadnes et al., 2022).

Different foods are available in different regions which results in region-specific diets. There is a strong link between general health and life expectancies of countries and their diets (UN, 2016). As previously noted, economic and dietary freedom has also given way to development of new diets. Popular diets today include the likes of veganism,vegetarianism, gluten-free and lactose-free diets, as well as low-carbohydrate diets which are more commonly

known as ketogenic diets.

Food groups are often defined according to those found in most food guides which are separated into grains, fruits & vegetables, meat, and dairy. Though used by most governments, this is not an effective nor accurate way of organising foods by their health benefits. A nutrition based approach, on the other hand, is much more effective in categorising foods. With this approach, foods are divided based on their nutritional capacities and their biological properties within the body.

The multigenerational misinformation ingrained in food choices and nutrition have caused many dietary misconceptions to become commonplace. Common misconceptions include caloric values, as well as the consumption of red meats, refined grains, and water. Among the most well-known is the ingestion of sugars and fats and their effects on health (Fung et al., 2020). This paper will aim to dismantle such misconceptions.

A combined focus on the biological and psychological science behind dieting methods as well as the social rise of dietary norms will be the focus of this paper. There will be particular focus in nutrition, metabolism, and the effects of diet shifts and changes, as well as medical application. Views through both biological and psychological lenses are necessary as dieting partakes with both the physical and mental state of the patient. Academic and research papers, books, as well as other publications with a main focus on works of dietician, Jason Fung will be used to support the claims of this paper. Fats are still believed to be the culprits of weight gain. In reality, many studies were done showing that sugars had a causal link to obesity than fats. It is vital to understand the truth about food, most notably, the effects and applications around diets.

## Nutrition

All foods are made up of a combination of nutrients, the chemical components of food. Nutrients are categorised into macronutrient and micronutrient groups and essential and non-essential. Macronutrients are required in large amounts and provide energy for the body, whereas micronutrients are those that are required in smaller amounts, but are necessary to aid macronutrients and chemical reactions within the body. Respectively, non-essential and essential nutrients are nutrients which the body can and cannot produce for itself. Essential nutrients must be taken from an external source. Nutrition can be defined as the ability to take essential nutrients at an adequate rate in order to fulfil basic bodily functions (Taşğin, 2017).

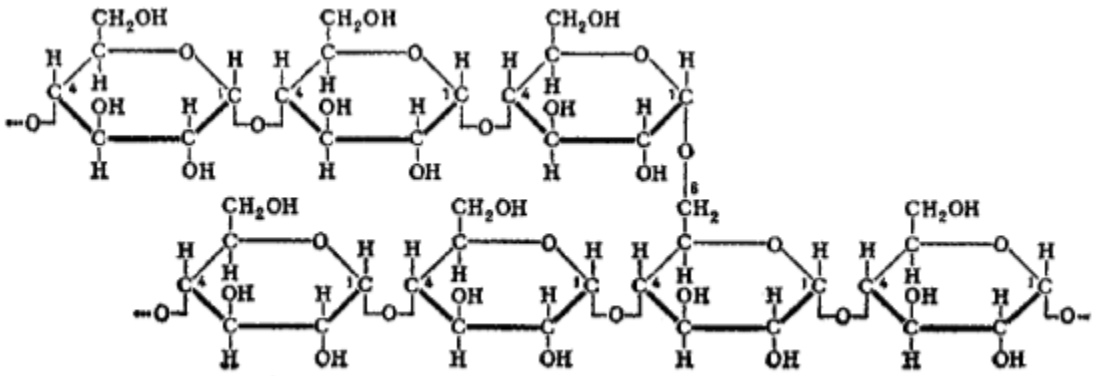
Food and nutrients are processed and utilised within the body through a system of many complex reactions which is generalised as the process of metabolism. Calorie count is often related to metabolism and the amount of food consumed. The kilocalorie (kcal), more often referred to as the calorie is the measurement of how much energy can be derived from food. 1 kcal is equivalent to the amount of energy needed to raise the temperature of water by 1 degree kelvin which is about 4.18 joules. In reference, 1 gram of carbohydrates and 1 gram of protein each equate to 4 calories, whereas 1 gram of fat is approximately 9 calories (Taşğin, 2017).

However, calories prove to be an ineffective way of measuring weight gain and the contents of food consumed. Unfortunately, it is still considered a valued measurement of health benefits in food products. Calorie restriction, the common idea proclaiming weight loss can be achieved by burning more calories than the amount consumed, is incorrect and ineffective, proving dangerous in certain cases (Fung et al., 2020). This common misconception arises in the form of the mere-exposure effect. Many people have an innate preference towards calorie counting as they are something easily accessible and tangible (Falkenbach et al., 2013).

Macronutrients include carbohydrates, fats, proteins, and water. Carbohydrates serve as a short term energy source, and have a general formula of $C_n(H_2O)_n$. They are the most abundant macronutrients, and make up 55-60% of an average American adult's diet. Foods which have a high carbohydrate concentration include grains, legumes, roots, and tubers. They come in many forms, however, they are all built from the 3 basic monosaccharides also known as the simple sugars, glucose, fructose, and galactose. Glucose is the most common and is also known as blood sugar (Taşğin, 2017).

Monosaccharides combine to make disaccharides and polysaccharides through glycosidic links, similar  to how monomers form into polymers. Common polysaccharides include maltose, lactose, and starch (Taşğin, 2017).

**Figure 4**



*Note.* Section of glycogen molecule formed by glucose moieties through glycosidic links. CDC, 2017.

Ingested carbohydrates (or carbs) are categorised as digestible and non-digestible polysaccharides.When carbs are consumed, the corresponding enzyme is needed in order to break it down. The body produces some enzymes which are secreted in the small intestine or via saliva. For instance, a starch's corresponding enzyme is amylase and is easily broken down.

However, corn cannot be digested as it is composed mostly of cellulose for which the corresponding enzyme, cellulase, is not produced within the body. Carbohydrates are broken down into simple sugars, transformed into glucose, then released into the bloodstream, increasing bodily sugar levels. The pancreas responds by releasing insulin which breaks down sugars, allowing cells to utilise the energy and thereafter drops blood sugar levels (Taşğin, 2017).

Fats or lipids are an alternative source of biological energy which is often stored for long-term use. Fats are categorised as saturated and unsaturated fats which are found in plants and animals respectively. They are metabolised in the liver and are stored in fat or adipose tissues which can be seen as physical fat (Taşğin, 2017).

The third type of macronutrient is protein. Unlike carbohydrates and fats, proteins are used to grow the body instead of serving as an energy source. They are composed of amino acids and are essential for the construction of cells and tissues. The human body is able to store a large quantity of protein and it can be used as a source of energy during long-term starvation. This happens through a process in the liver which turns excess amino acids into urea which is removed from the body. The remaining carbon portion is converted into either carbs or oils. Some proteins also act as enzymes for the metabolization of carbohydrates (Taşğin, 2017).

Water is also required by the body in large amounts hence why it is considered a macronutrient, however, it does not provide energy. The body uses water for the solvation and transportation of other materials. Many of the chemical reactions within the body also require water (Taşğin, 2017).

Micronutrients include vitamins and minerals, and do not provide energy. Instead, aid bodily functions in alternate ways. Most vitamins act as coenzymes or cofactors which aid enzymes in the metabolic process as catalysts. Minerals are mostly metallic elements which are

found in all parts of the body and also serve as cofactors, as well as regulating the pH of the body.

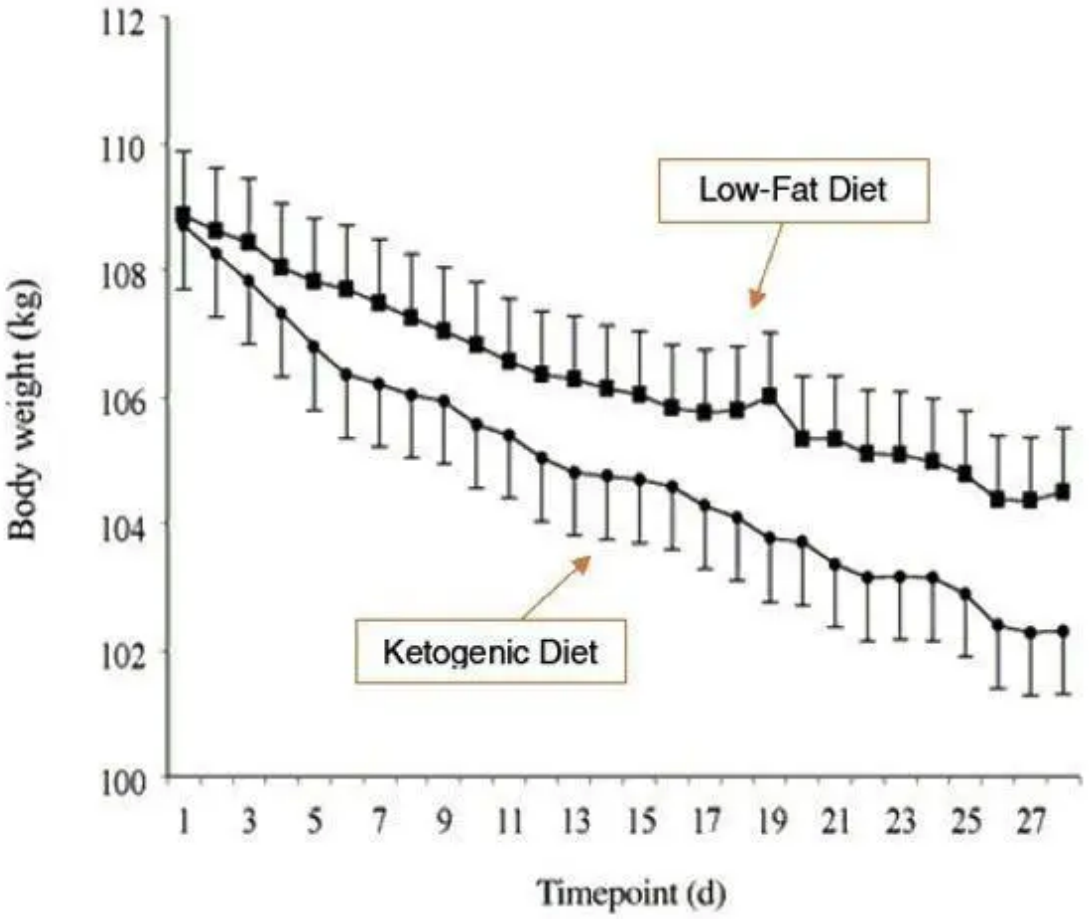
## Ketogenic Diet and Intermittent Fasting

Generally speaking, micronutrients are not considered in most diets as they are readily available and are not very often lacking in any type of diet. Due to the greater capacity of macronutrients in the biology of the human body, they are most often the ones altered in diets. Macronutrients can be adjusted for easily in diets as they are able to supplement each other.

Diets are mostly in the realm of adjustments to macronutrients. They hold a greater capacity in the biology of the human body and can be easily adjusted as they are able to make up for one another (when some are missing). Micronutrients do not need to be considered in most diets as they are readily available and do not often lack in any type of diet.

It is a common misconception that carbohydrates do not have an effect on bodily fats and obesity, yet, the exact opposite is true. As carbs are the preferred source of energy by cells, they will not consume the stored fats until the carbs have been used up (Taşğin, 2017).
In lowering the consumption of carbohydrates, the body will naturally turn to fat as an energy source (Fung, 2019). While an excessive amount of either nutrient is not healthy, high-fat, low-carb diets are often preferred by many as a means to lose weight and improve health (Fung, 2019). These types of diets, more well known as ketogenic (or keto diets) can be defined by a daily intake of  less than 50 grams of carbohydrates (Masood et al., 2021). Though distrusted or misunderstood by most, keto diets have proven a more effective option to weight loss in comparison to other strategies, and should be employed at a greater magnitude (Fung, 2020).

**Figure 5**




*Note.* Weight loss comparison over time between keto and low-fat diets. Johnstone et al., 2008.

Keto diets have been around for thousands of years, with medical applications starting in 1921 by Russel Peters as an alternative treatment for epilepsy. Conversely, after the 1960s, it has become commonplace treatment for obesity (Paoli et al., 2013, 789) (Masood et al., 2021). There are several variations of the keto diet; SKF (standard ketogenic diet) and HPKD (high protein ketogenic diet) are most commonly used, where as CKD (cyclic ketogenic diet) and TKD (targeted ketogenic diet) include periods where large amounts of carbs are consumed, and are employed by athletes. The standard ketogenic diet is composed of 70% fats, 20% proteins, and 10% carbs (Shilpa & Mohan, 2018, 251-253).

During early stages of the ketogenic diet, side effects such as nausea, vomiting, headaches, fatigue can arise due to metabolic adjustments. The diet focuses around the principle of a process called ketogenesis (ketosis). When there are no longer any carbohydrates being ingested, the glycogen stores are depleted and blood sugar drops. This causes the body to undertake metabolic changes to use fat for energy instead. Fat cannot be used directly as a source of cellular energy, and so the liver, through ketosis, converts the fatty acids into the usable energy source of ketone bodies (Masood et al., 2021). Though fats cannot be used directly as energy like sugars, it is a better source of energy in comparison, and can also promote weight loss as a result.

Ketone bodies are composed of acetone and beta-hydroxybutyrate, which are more efficient sources of energy in comparison to glucose. The adenosine triphosphate (the source of energy at cellular level) equivalents for 100g of acetone, beta-hydroxybutyrate, and glucose are 9400g, 10500g, and 8700g of ATP respectively. Ketone bodies are a source of energy that can be easily used by most organs in the body. Yet, red blood cells and the liver are unable to use them due to a lack of mitochondria and enzymes (Masood et al., 2021).

The intermittent fasting method relies on similar principles to the keto diet. This specific fasting method utilises periodic fasting as a means to burn all carbs and tap into fat storages through ketosis. Fasting takes place throughout most of the day, separated by short breaks of eating. It is vital that a consistent eating schedule is maintained. It is usually done with a 16/8 or 24-hour schedule which involves 16 hours of fasting and 8 hours where eating is permitted, and 1 meal at the same time everyday respectively (Fung 2019). Consistency is important as the body's circadian rhythm can be affected negatively if food is ingested at erratic intervals (Zarbl, 2018). Water, and other 0 calorie liquids are permitted during fasting, as they do not affect the metabolic change (Fung, 2019). Ketogenic diets are often prescribed in conjunction with

intermittent fasting as fasting can quickly deplete glucose reserves, allowing ketosis to take place sooner (Fung, 2021).

Diets also have a variety of psychological effects, as they are extremely behaviour and habit based, and are oftentimes difficult to follow due to an inability to obtain dopamine as well as increased levels of stress. Diets are often restricting on food choice, and it may prove helpful for some people who are indecisive or enjoy a recurrent lifestyle. However, for others who prefer a choice, eating the same thing everyday can wear out their desires for options and variations resulting in negative moods and high stress. Especially when placed in situations of great discomfort or stress, the human mind tends to crave more for things that can cure said discomfort. 98% of people who diet gain their weight back as they are not able to succumb to this mental discomfort (Institute for the Psychology of Eating, 2018). This is a main reason why highly restrictive diets are not usually prescribed to adults, and more in children. Desires and searches for novel sensations develop during adolescent years (15-20) and therefore the discomfort for regularity does not exist within young children (Hall, 1904). Even so, diets are still looked upon as a preferred option due to side-effects from medication.

## Diets and Medical Application

Both keto and intermittent-fasting improve general health and combat a variety of medical conditions. The ketogenic diet was originally developed to combat epilepsy, particularly in children, and still remains one of the main treatments for this condition. This is common practice for drug-resistant patients, and though it is still a phenomenon, it is assumed that ketone bodies are a more effective source of energy for the brain in lieu of glucose. Ketones are able to give similar amounts of energy while causing less intensive activity in the brain, reducing

seizures (Swink et al., 997). A study with 20 children who received less than 10 grams of carbohydrates per day showed 65% of children had greater than 50% seizure reduction, 35% of children had a greater than 90% improvement, and 4 children were seizure free within 6 months (Kossoff et al., 2006). Studies have also shown success in bettering autism, Alzheimer's and other neurological conditions for similar reasons (Lorenzo et al., 2016) (Mychasiuk et al., 2017) (Noebels, 2011).

Obesity is a world-wide health hazard with about 2.8 million annual adult deaths. Both diets have also shown significant effects in weight loss. Obesity shows no correlation to fat consumption, and there is a 44% increased prevalence in obesity with a greater intake of sugar-laden food (Masood et al., 2021). The body enters ketogenesis and uses fat stores as energy during fasting periods. The long-term effects of keto are understudied due to difficulty in extended compliance. However, short term success in weight loss in both regiments is very high at around 10lbs in 2 weeks mostly due to water and some fat (Masood et al., 2021). Intermittent fasting alters bodily metabolism and has shown to carry out consistently in the long term (Fung et al., 2020).

Both types 1 and 2 diabetes have shown improvement from these two diets (CDC, 2020). Diabetes is the world’s third most widespread health problem, under obesity and cancer (CDC, 2020). In 2018, in just the US alone, there were 34.2 million people diagnosed with diabetes which is about 10.5% of the total American population (CDC, 2020). Type 1 diabetes is a genetic condition in which the pancreas naturally produces a smaller amount or less effective insulin. Type 2 diabetes is a condition that arises from lifestyle and dietary issues from consuming too much sugar. In either case, the amount of glucose in the blood supersedes the existing insulin, which is typically referred to as insulin resistance. It requires insulin or metformin supplements

to aid with the process of converting blood sugar into cellular energy. As both diets significantly decrease carbohydrate intake, the glucose to insulin ratio can shift to a manageable level, and external supplements will no longer be required (Fung et al., 2018). As the diabetes epidemic remains one of the world's most crucial issues, a simple switch to dieting alternatives could improve the health of and ease financial situations for millions around the globe.

Cholesterol and blood pressure can also be reduced with dietary changes. Cholesterol is a mixture of protein and fat derived from meats. It is necessary for good health, consequently, excessive amounts can cause high blood pressure and blood clots leading to cardiovascular disease. Cholesterol levels are controlled by lipoproteins, a combination of proteins and fats. Lipoproteins are categorised as LDL (low-density lipoproteins) and HDL (high-density lipoprotein) which each take cholesterol to and from blood. While both are necessary for good health, LDL is commonly known as unhealthy and HDL as healthy as LDL is responsible for high cholesterol levels (Raman 2021). This is a misconception. When consuming large amounts of fat, like in the ketogenic diet, LDL and triglycerides can rise in the short term. This will not cause much harm as high LDL levels must persist for a longer duration (months to a year) in order for it to be dangerous. However, in the long term, LDL and triglycerides drop, and HDL increases which is able to aid with the clearing of cholesterol from arteries and decrease blood pressure. This stems from the body recognizing the high cholesterol diet and in turn produces less LDL and more HDL to aid with healthy metabolism (Raman 2021).

Some other conditions that benefit from an alteration to ketone bodies as a fuel source instead of glucose include GLUT1 deficiency syndrome and NAFLD (non-alcoholic fatty liver disease). GLUT1 deficiency syndrome is a rare genetic disorder which involves deficiency of a certain protein which helps move blood sugar into the brain. Ketone bodies do not require this

protein to be transported to the brain, and can therefore serve as a reliable way for combatting this syndrome (Gumus et al., 2015). NAFLD disease is resultant of the prolonged storage of fat in the liver which results in liver damage. Ketosis converts stored liver fat into ketone bodies which will be removed from the liver (Fung, 2020). A study from Spain with male subjects diagnosed with NAFLD, 93% had a reduction in liver fat in 12 weeks, and 21% were cured of NAFLD (Pérez-Guisado, 2011).

The ketogenic diet is a fat based diet, whereas vegan and vegetarian diets contain a majority of carbohydrates. Each acts in different ways, and is healthy for different reasons. Veganism has shown the lowest percentage of people having diabetes, at 2.4% This is linked to the increased intake of micronutrients to help metabolise at a higher rate, and improve immunity. However, it does not work as an effective responsive diet to diabetes as it would increase glucose concentrations even more (Olfert, 2018). The two diets function and promote health in very different ways. A study done in Chennai, India, where vegetarian diets are more common, found that consumption of carbs in India is higher by 10% compared to America. Findings revealed a direct link between type 2 diabetes and carb consumption (Mohan, 2009).

Intermittent fasting and the ketogenic diet can improve general health and can be utilised by anyone without contradicting health conditions to the diet itself. Due to ketone bodies being a more efficient source of energy in comparison to glucose (supplying 20-30% more ATP per unit). It can promote stamina, reaction times, alertness, as well as other senses (Fung et al., 2020).

## Conclusion

Each year, a diabetic patient spends about $11,000 USD on insulin or other diabetic medication. It is unaffordable for most. With simple solutions that involve a changing of diets,

about 360 billion dollars can be saved annually in the US alone. Dieting can attain the same benefits where drugs would otherwise be needed, but at a much lower price, and oftentimes show more formidable results. Dieting can also be purposed for drug-resistant patients. With more research, affordable medication can be developed based on dietary changes, to mimic the results of dieting without a restrictive diet.

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