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Heart Disease: Causes, Prevention, and Current Research

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Abstract
Heart disease is the leading cause of death in the United States. The causes and prevention of heart disease have been studied for years, and new information is emerging. For the last several decades, saturated fat and cholesterol have been thought to be major contributors to coronary artery disease, and therefore people are typically advised to strictly limit these in their diet. However, recent studies are indicating that it may not be wise to strictly limit the intake of dietary saturated fatty acids or replace them with polyunsaturated fatty acids when taking other health conditions into consideration. Depending on a person's genetics, diet may or may not be an important factor in preventing heart disease. Exercise is also beneficial for everyone in preventing heart disease. When considering human development, including the negative effects of heart disease, humans still have a lot to learn about the human body and the interaction of diet, the environment, and genetics.

Cover Page Footnote
Pete Peterson, PhD, was the JCCC faculty adviser on this paper.

Human development can be defined as changes in the interactions between an individual and their environment across the lifespan. Development begins when a zygote is formed in utero and continues throughout the remainder of an individual's life. There are many factors that can affect healthy development, but perhaps none is so devastating in the United States of America as cardiovascular disease (see Appendix A). The term cardiovascular disease refers to a variety of ailments that affect the heart as well as all of the blood vessels in the body. Atherosclerosis is one of these ailments, and is caused by a buildup of plaque in a person's arteries; this buildup can accumulate to the point that a clot forms and clogs the artery completely, leading to either a stroke or a heart attack ("What is Cardiovascular Disease (Heart Disease)?", 2013). When atherosclerosis occurs in the heart, it is then called Coronary Artery Disease (CAD) and CAD is the leading cause of death amongst people with heart disease - (webmd). Heart disease itself is the leading cause of death in the United States (National Center for Health Statistics, 2013). The causes and prevention of heart disease have been studied for years, and new information is always emerging. For the last several decades, saturated fat and cholesterol have been thought to be major contributors to CAD, and therefore people are typically advised to strictly limit these in their diet (Siri-Tarino, Sun, Hu, & Krauss, 2010). However, recent studies are indicating that it may not be wise to strictly limit the intake of dietary SFAs or replace them with polyunsaturated fatty acids (PUFAs) when taking other health conditions into consideration.

Lipids are ". . .oily or fatty biological substances that are not soluble in water. . . (Lawrence, 2010)". Lipids include fatty acids as well as cholesterol (which is a steroid), and other substances such as fat soluble vitamins. There are two types of fatty acids: saturated and unsaturated. Unsaturated fatty acids are further broken down into two subcategories: *poly*unsaturated and *mono*unsaturated. Saturated fatty acid molecules have a hydrogen atom for

each carbon atom in the molecule, hence they are called saturated. Polyunsaturated fatty acid molecules have one carbon to carbon bond (or double bond), meaning that additional hydrogens can be added; monounsaturated fatty acid molecules have two or more double bonds (Lawrence, 2010). Each one of these categories of fat has a different effect on the human body, and there are many sub-categories of fatty acids that fall into each of these three categories. Polyunsaturated fatty acids include both Omega-6 (found mostly in plant sources) and Omega-3 (found mostly in cold-water fish) fatty acids (Lawrence, 2010). It is important to understand these distinctions in order to better understand how dietary fats affect heart disease.

Back in the 1800s, cholesterol levels were linked to atherosclerosis, but even after almost 200 years of research, there is still a lot to be learned on this topic, and it is an area of great controversy among scientists and nutrition experts (Lawrence, 2010). Cholesterol is only found in animal sources, and it is also supposed to be limited in the diet since the human body makes its own cholesterol (Allen, 2009). Studies have shown that blood cholesterol level increase of even 1% can put someone at a 2% higher risk of heart disease (DeBakey, 2012). Although High Density Lipoproteins and Low Density Lipoproteins are the two types of cholesterol in the bloodstream that are typically measured by doctors, there are actually five types in the blood; the higher the density, the smaller or more compact the particles of cholesterol are (see Appendix B). Limiting dietary cholesterol can be quite difficult, depending on an individual's typical diet. For example, one large egg contains approximately 186 mg of cholesterol (NDL/FNIC Food Composition Database Home Page). This is over half of the recommended daily intake of 300 mg for a healthy person, and almost the entire amount (200 mg) recommended for someone at high risk for heart disease (Dietary Guidelines for Americans, 2010). In addition to low cholesterol consumption, Americans are advised to keep saturated fatty acid consumption as low

as possible (at or below 10% of total caloric intake) by substituting saturated fatty acids with polyunsaturated and monounsaturated fatty acids (Hoenselaar, 2012). For individuals at high risk of heart disease, saturated fatty acid consumption is supposed to be restricted to 7% or less of total caloric intake (Smith, et al., 2011; DeBakey, 2012). Reducing saturated fatty acids in the diet has been shown to lower Low-Density Lipoprotein (LDL) cholesterol levels in the blood, which is thought to be important in preventing cardiovascular disease (Smith, et al., 2011). Not only is it important to have low LDL cholesterol in the blood, it has also been shown that the higher the concentration of HDL cholesterol in comparison to LDL cholesterol, the lower a person's risk for heart disease (Fogelman, et al., 2011).

Americans are typically told to limit red meat and dairy, as these animal products both contain saturated fats. However, a recent study showed that a higher intake of saturated fat from dairy products actually decreases risk of heart disease, while a higher intake of saturated fat from red meat increases risk of heart disease (Otto, et al., 2012). The reason for this is unclear, but it may have something to do with the different fatty acid combinations in milk and meat. This is contrary to current dietary recommendations that discourage consumption of dairy fats altogether in individuals over the age of 2. In addition, this particular study did not find that replacing saturated fatty acid consumption with carbohydrates had any effect on an individuals' risk of cardiovascular disease. Another study looked at the different effects of replacing saturated fats with monounsaturated fats versus carbohydrates, and found that either replacement resulted in lower LDL cholesterol, but also lowered HDL cholesterol (Berglund, et al., 2007). As previously mentioned, however, the higher the concentrations of HDL cholesterol in comparison to LDL cholesterol have been shown to lower a person's risk for heart disease (Fogelman, et al., 2011). Therefore, simply lowering overall cholesterol may not be the most effective approach to

reducing risk of cardiovascular disease, unless LDL and HDL serum cholesterol levels are at a good ratio already. Other studies have shown saturated fat consumption to increase overall serum cholesterol, not just LDL, but this is not taken into account when dietary recommendations are being prepared (Hoenselaar, 2012).

Although all of these stringent guidelines for dietary cholesterol and saturated fatty acid intake are in place to protect the public from heart disease, not everyone is affected the same way by consuming them (DeBakey, 2012). Some people can eat much higher amounts without a significant increase in blood cholesterol, while others can strictly limit dietary cholesterol and saturated fatty acids but still struggle with high serum cholesterol. Genetics probably account for these differences, and the impact of genes on heart disease is just beginning to be understood. There is one gene that has recently been found to have an impact on the amount of LDL cholesterol that people produce. This gene, PCSK9, has a variation that has been seen to reduce LDL levels (and therefore risk of heart disease) in the people who have it by 40% to 80% (Thanassoulis, 2013). This gene is not alone in its effect on cardiovascular disease, leading us to conclude that an individual's true risk cannot be determined without additional research and extensive genetic profiling. There are at least nine genes that, depending on their alleles, have been shown to influence the incidence of heart disease (Yiannakouris, 2012). The polygenic nature of heart disease combined with environmental effects such as diet, exercise, and other factors makes it a very complicated disease and explains why there is so much confusion over the exact cause and the best way to prevent and treat it.

One thing that all of the current dietary guidelines fail to mention is the fact that Omega-6 polyunsaturated fatty acids are more likely to contribute to other health complications such as cancer while Omega-3s may have a cancer reducing effect (Lawrence, 2010; de Lorgeril &

Salen, 2012). Although the American Heart Association does recommend eating Omega-3 rich fatty fish two times a week, they do not caution people against over consumption of Omega-6 fatty acids which are found in abundance in a typical American diet (The American Heart Association's Diet and Lifestyle Recommendations, 2014; Lawrence, 2010). The Omega-6 polyunsaturated fatty acids are much more susceptible to oxidation (the harmful effect of exposure to oxygen) than Omega-3 polyunsaturated fatty acids and saturated fatty acids (Lawrence, 2010). This oxidation is called lipid peroxidation (Seppanen & Csallany, 2013). Polyunsaturated fatty acids are the most likely to be attacked by cancer causing free radicals (Lawrence, 2010). Omega-3s are also effective against cancer, and may actually decrease tumors while Omega-6s increase them (Tapiero, et al., 2002).

Despite the fact that the USDA recommends increasing fresh produce consumption, the typical American diet is dangerously low in fresh fruits and vegetables, which contain cancer-fighting antioxidants such as Vitamins A, C, and E (Dietary Guidelines for Americans, 2010). Increasing fruit and vegetables in the diet has also been shown to decrease high blood pressure, which in turn lowers risk of heart disease (Dauchet, 2009). Since the second leading cause of death in the United States is cancer (see Appendix A), it may not be wise for individuals who are not at high risk of heart disease to replace saturated fatty acids in the diet with Omega-6 polyunsaturated fatty acids.

Although the information regarding dietary and hereditary causes of heart disease may be confusing and even conflicting at times, there is another, somewhat less controversial, aspect of prevention to consider: exercise. One study showed that women who exercise about 30 minutes a day at moderate intensity were able to significantly lower their risk of heart disease, up to 40% in some cases (Manson, et al., 1999). In America food is highly available and exercise is not a way

of life, but the benefits of exercise have been demonstrated to lower one's risk of heart disease and diabetes, as well as lowering the effects of oxidative stress on the body (Szostak & Laurant, 2011). It was not until 2008 that the United States published official exercise recommendations to supplement the other dietary and nutritional guidelines that they promote. These science-based guidelines include an entire section on how exercise is beneficial, including lowering the risk of coronary heart disease (2008 PAG for Americans). They provide a number of free resources, including how much exercise is needed to achieve optimal benefits (see Appendix C), and yet most Americans still do not follow these guidelines. Perhaps these benefits ought to be stressed more than dietary changes for the general public.

In summary, depending on a person's genetics, diet may or may not be an important factor in preventing heart disease. When it comes to fatty acid consumption, not all types of saturated fatty acids are inherently unhealthy, nor are all types of unsaturated fatty acids inherently healthy. In fact, some of those unsaturated fatty acids and other dietary recommendations given with the intention of reducing heart disease may actually do more harm by increasing the risk of cancer and other diseases in certain individuals. Exercise is beneficial for everyone in more ways than just preventing heart disease, yet very few adults in America exercise at the recommended level. Diet, genetics, and exercise are only three of many aspects that affect heart disease. When it comes to human development, including the negative effect of heart disease, humans still have a lot to learn about the interactions of the human body with the environment as well as the role that genetics play in this process.

Appendix A

10 Leading Causes of Death by Age Group, United States – 2010

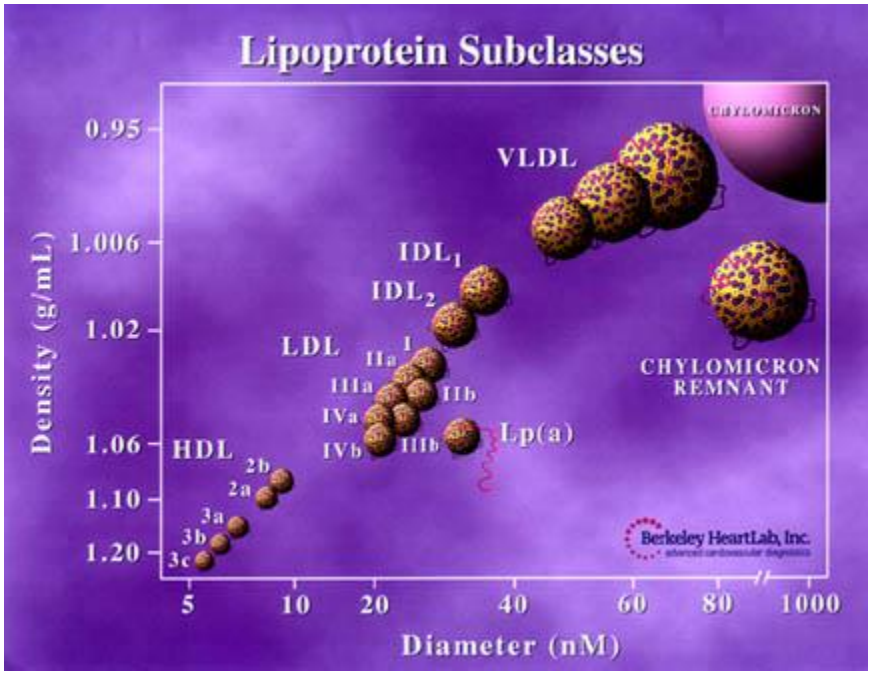
	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Congenital Anomalies 5,107	Unintentional Injury 1,394	Unintentional Injury 758	Unintentional Injury 885	Unintentional Injury 12,341	Unintentional Injury 14,573	Unintentional Injury 14,792	Malignant Neoplasms 50,211	Malignant Neoplasms 109,501	Heart Disease 477,338	Heart Disease 597,689
2	Short Gestation 4,148	Congenital Anomalies 507	Malignant Neoplasms 439	Malignant Neoplasms 477	Homicide 4,678	Suicide 5,735	Malignant Neoplasms 11,809	Heart Disease 36,729	Heart Disease 68,077	Malignant Neoplasms 396,670	Malignant Neoplasms 574,743
3	SIDS 2,063	Homicide 385	Congenital Anomalies 163	Suicide 267	Suicide 4,600	Homicide 4,258	Heart Disease 10,594	Unintentional Injury 19,667	Chronic Low. Respiratory Disease 14,242	Chronic Low Respiratory Disease 118,031	Chronic Low. Respiratory Disease 138,080
4	Maternal Pregnancy Comp. 1,561	Malignant Neoplasms 346	Homicide 111	Homicide 150	Malignant Neoplasms 1,604	Malignant Neoplasms 3,619	Suicide 6,571	Suicide 8,799	Unintentional Injury 14,023	Cerebro-vascular 109,990	Cerebro-vascular 129,476
5	Unintentional Injury 1,110	Heart Disease 159	Heart Disease 68	Congenital Anomalies 135	Heart Disease 1,028	Heart Disease 3,222	Homicide 2,473	Liver Disease 8,651	Diabetes Mellitus 11,677	Alzheimer's Disease 82,616	Unintentional Injury 120,859
6	Placenta Cord. Membranes 1,030	Influenza & Pneumonia 91	Chronic Low Respiratory Disease 60	Heart Disease 117	Congenital Anomalies 412	HIV 741	Liver Disease 2,423	Cerebro-vascular 5,910	Cerebro-vascular 10,693	Diabetes Mellitus 49,191	Alzheimer's Disease 83,494
7	Bacterial Sepsis 583	Septicemia 62	Cerebro-vascular 47	Chronic Low Respiratory Disease 73	Cerebro-vascular 190	Diabetes Mellitus 606	Cerebro-vascular 1,904	Diabetes Mellitus 5,610	Liver Disease 9,764	Influenza & Pneumonia 42,846	Diabetes Mellitus 69,071
8	Respiratory Distress 514	Benign Neoplasms 59	Benign Neoplasms 37	Benign Neoplasms 45	Influenza & Pneumonia 181	Cerebro-vascular 517	HIV 1,898	Chronic Low. Respiratory Disease 4,452	Suicide 6,384	Nephritis 41,994	Nephritis 50,476
9	Circulatory System Disease 507	Perinatal Period 52	Influenza & Pneumonia 37	Cerebro-vascular 43	Diabetes Mellitus 165	Liver Disease 487	Diabetes Mellitus 1,789	HIV 3,123	Nephritis 5,082	Unintentional Injury 41,300	Influenza & Pneumonia 50,097
10	Necrotizing Enterocolitis 472	Chronic Low Respiratory Disease 51	Septicemia 32	Septicemia 35	Complicated Pregnancy 163	Congenital Anomalies 397	Influenza & Pneumonia 773	Viral Hepatitis 2,376	Septicemia 4,604	Septicemia 26,310	Suicide 38,364

Data Source: National Vital Statistics System, National Center for Health Statistics, CDC.
Produced by: Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC using WISQARS™.

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

Retrieved April 10, 2014 from http://www.cdc.gov/injury/wisqars/LeadingCauses_images.html

Appendix B



Retrieved April 24, 2014, from http://www.heartpoint.com/cholesadvanced.html

Appendix C

Classification of Total Weekly Amounts of Aerobic Physical Activity Into Four Categories

Levels of Physical Activity	Range of Moderate-Intensity Minutes a Week	Summary of Overall Health Benefits	Comment
Inactive	No activity beyond baseline	None	Being inactive is unhealthy.
Low	Activity beyond baseline but fewer than 150 minutes a week	Some	Low levels of activity are clearly preferable to an inactive lifestyle.
Medium	150 minutes to 300 minutes a week	Substantial	Activity at the high end of this range has additional and more extensive health benefits than activity at the low end.
High	More than 300 minutes a week	Additional	Current science does not allow researchers to identify an upper limit of activity above which there are no additional health benefits.

Retrieved May 8, 2014 from http://www.health.gov/paguidelines/pdf/paguide.pdf

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