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Soft drinks and their effects on health.

Diploma thesis

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Written Declaration

I declare that I completed the submitted work individually and only used the mentioned sources and literature. Concurrently, I give my permission for this diploma/bachelor thesis to be used for study purposes.

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Contents

Summary:

The consumption of soft drinks has increased manifold over the last decades. In parallel to this increase it has been noticed an increase in health problems, especially obesity. Dentists continue to urge their patients not to drink soft drinks, and there has also been suggested a link between soft drink consumption and osteoporosis, hypokalemia and diabetes mellitus 2. Other additives, like caffeine, have been associated with headaches, restlessness and trouble with sleeping. Although more research is needed to confirm these relationships, many scientists suggest that we should start taking action to prevent children from developing the habits of large soft drink consumption we witness today. This could be accomplished by cooperation between parents, health practitioners, school system and government.

Introduction:

Over the last 50 years, soda consumption in the western world has increased manifold. From Coca-Colas start in 1886 with a mere nine drinks sold per day, it is today the worlds most popular soda drink with over a 100 000 000 cans sold each day (1). Coca-Cola has reached world fame for its pleasant taste and high availability. There has been a lot of focus on soft drinks and their influence on health. In parts of the world with scarce or contaminated water supply, soft drink consumption can indeed help minimise the problems associated with infectious diseases and dehydration. Also, it is important to recognize that compared to other highly consumed beverages like beer, soft drinks are to be preferred from a medical point of view. It is clear, however, that in countries with a high consumption of soda, a link has been made to higher incidence of health problems; notably obesity, diabetes, dental decay, osteoporosis. How strong the

link between consumption of soft drinks and health issues actually is, remains a topic of mass controversy, but it's definitely a relevant topic in today's society.

History:

Soft drinks trace their history back to the mineral waters found in natural springs. Ancient societies believed that bathing in natural springs and/or drinking mineral waters could cure many diseases. The earliest soft drinks were sherbets developed by Arabic chemists and originally served in the medieval Near East. These were juiced soft drinks made of crushed fruit, herbs, or flowers (2). From around 1265, a popular drink known as Dandelion & Burdock appeared in England, made from fermented dandelion (Taraxacum officinale) and burdock (Arctium lappa) roots, it was naturally carbonated. The drink (similar to Sarspirilla) is still available today but made with flavourings and carbonated water since the Safrole in the original recipe was found to be carcinogenic (3).

The first marketed soft drinks (non-carbonated) in the Western world appeared in the 17th century. They were made from water and lemon juice sweetened with honey. In 1676, the *Compagnie des Limonadiers* of Paris was granted a monopoly for the sale of lemonade soft drinks. Vendors carried tanks of lemonade on their backs and dispensed cups of the soft drink to thirsty Parisians.

Carbonated drinks:

In late 18th Century, scientists made important progress in replicating naturally carbonated mineral waters. In 1767 Englishman Joseph Priestley first discovered a method of infusing water with carbon dioxide to make Carbonated water when he suspended a bowl of distilled water above a beer vat at a local brewery in Leeds, England. His invention of Carbonated water, (also known as soda water), is the major and defining component of most soft drinks. Priestley found water treated this way had a pleasant taste and he offered it to friends as a refreshing drink. Joseph Priestley published a paper called *Directions for Impregnating Water with Fixed Air (1772)*, which explained how to make soda water by dripping of sulphuric acid onto chalk to produce carbon dioxide, and encouraging the gas to dissolve into a bowl of agitated water (4).

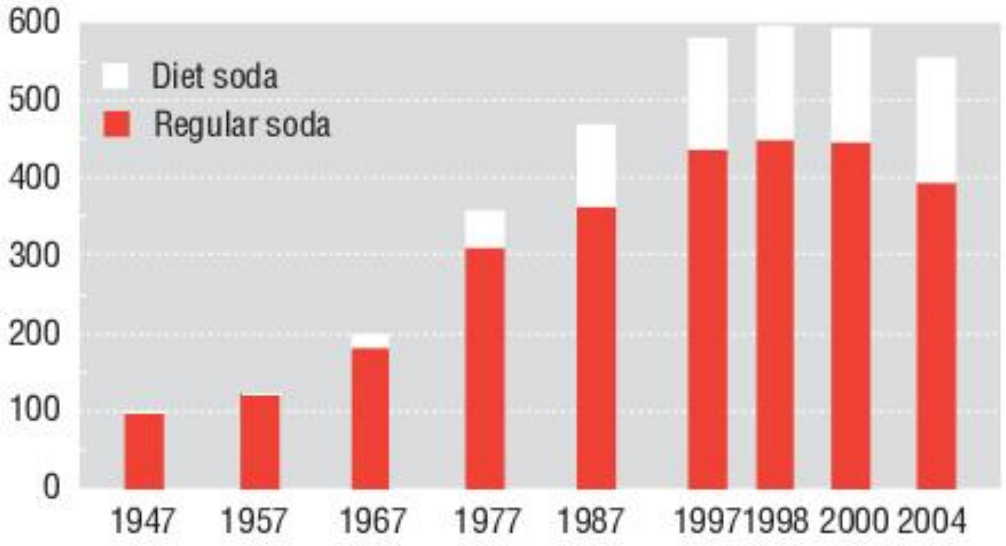
$$H_2O \quad + \quad CO_2 \quad \rightarrow \quad H_2CO_3$$

Soft drinks today

The total number of ‘Coca-Cola’ cans sold per day in 2007 worldwide is 67,873,309. For ‘Diet Coke’ and ‘Coke’ Zero it is 35,387,241 (5). Adding these numbers together shows that the total number of coke cans sold each day are

more than 100 000 000 cans. This vast consumption of soft drinks has become a highly debated and controversial public health issue. In a time of rising obesity amongst children, many target the soft drinks as a possible contributor to this disturbing development. Schools in Britain, France and in the United States have banned or severely limited soft drink sale. A key question is whether such bans and limitations will benefit the public health.

Figure 1
Annual soft drink production in the United States (12-oz. cans/person)



Sources: USDA Economic Research Service (1947–87); Beverage Digest (1997–2004).

Already in 1942 the American Medical Association mentioned soft drinks specifically in a strong recommendation to limit intake of added sugar. At that time, annual US production of carbonated soft drinks was 60 12-oz (355-mL) servings per person; by 2002 this number had risen to over 600 servings (6). Consumption of carbonated soft drinks peaked this year and in a historic turnaround, consumption was 7 percent lower in 2004. And because some

people have switched to diet sodas, the consumption of caloric soft drinks declined by 12 percent.

Sodas are not only a concern for what they contain, but for what they push out of the diet. In 1977–78, American boys consumed more than twice as much milk as soft drinks, and girls consumed 50 percent more milk than soft drinks. By 1994–96, both boys and girls consumed twice as much soda pop as milk. Heavy soft drink consumption is also associated with lower intake of numerous vitamins, minerals, and dietary fiber.

Rank	Countries	Amount
# 1	**United States**:	216,0 litres
# 2	**Ireland**:	126,0 litres
= 3	**Canada**:	119.8 litres
= 3	**Norway**:	119.8 litres
# 5	**Belgium**:	102.9 litres
# 6	**Australia**:	100.1 litres
# 7	**United Kingdom**:	96.5 litres
# 8	**Netherlands**:	96.1 litres
# 9	**New Zealand**:	84.2 litres
# 10	**Sweden**:	82.4 litres
# 11	**Switzerland**:	81.4 litres
# 12	**Denmark**:	80,0 litres
# 13	**Austria**:	78.8 litres
# 14	**Germany**:	72,0 litres
# 15	**Finland**:	52,0 litres
# 16	**Italy**:	50.2 litres
# 17	**France**:	37.2 litres
# 18	**Japan**:	21.6 litres
	Weighted average:	89.8 litres

Liter of carbonated soft drinks per person in 2002

Source: global market information database.

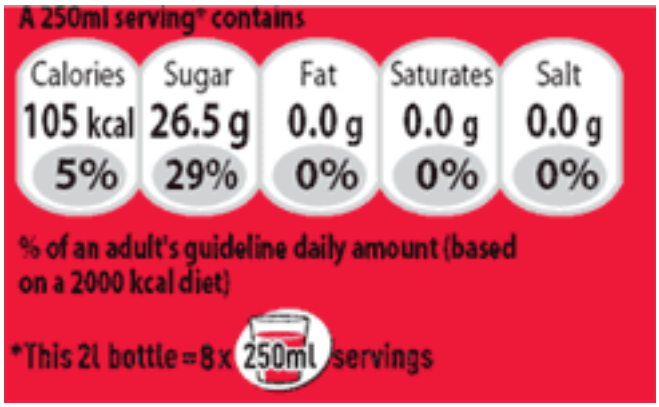
The trend of declining soda consumption noticed in 2004, is also accompanied with a tendency of diet sodas grabbing a larger share of the market.
Diet sodas accounted for 29 percent of total carbonated soft drink sales in 2004, up several percentage points in the last few years and up from just 9 percent in 1970 (7).

Ingredients:

When Coca-Cola was launched two of the key ingredients were cocaine and caffeine. The cocaine was derived from the coca leaf and the caffeine from kola nut, leading to the name Coca-Cola (the "K" in Kola was replaced with a "C" for marketing purposes). It is believed that during the creation of the drink the cocaine made it bitter. This was compensated for by the adding of sugars. To prevent bacterial growth phosphoric acid was then added. In this new acidity, microorganisms such as fungi and bacteria, was not able to grow; thus the acid also acted as a preservative. Acid was also considered a pleasant and refreshing taste. Other acids might have caused the same sensation; however, the widespread use of phosphoric acid is probably due to the fact that when the drink was developed (in the 19th century) phosphoric acid was cheap and easy to obtain

The ingredients in a can of coca cola are listed on the bottle. To prevent competition from copying their product the combination of natural flavorings remains a trade secret in the coca cola recipe.

1.Carbonated water
2.Sugar (sucrose or high-fructose corn syrup depending on country of origin)
3.Caffeine
4.Phosphoric acid v. Caramel (E150d)
5.Natural flavorings (8)



Health effects:

The soft drink companies have always tried to sell their products as a healthy supply to the diet. Their key arguments being that their drinks are composed of 90% water, and that they contain sugars also found in nature. Actually soft drinks may pose health risk based on two different mechanisms. Many soft drinks contain ingredients that are themselves sources of concern: caffeine, high-fructose corn syrup and artificial sweeteners. Soft drinks may also be harmful in that they replace important parts from a normal diet.

Obesity and weight-related diseases:

There are several different possible aetiologies for obesity. Genes, lack of exercise and consumption of fatty food can all contribute, but there is little doubt that soft drinks add non-nutritious unnecessary calories to the diet. From 1977 to 2001, Americans doubled their consumption of sweetened beverages (9) a trend that was paralleled by a doubling of the prevalence of obesity (10). This current increase in obesity in the western world has led to numerous different studies on the correlation between soft drinks and weight gain. Some think that people that live unhealthy lifestyles drink more soda. This could mean that the weight gain is a consequence of the lifestyle rather than a consequence of net soda consumption. Others mean there is a direct correlation between weight gain and soda consumption.

Berkey and coworkers conducted a prospective cohort study that included 11,654 9- to 14-year-old boys and girls participating in the US Growing Up Today Study. After adjustment for potential confounders, the study found that each additional 12-oz serving of sugar-sweetened beverage intake predicted a 4% increase in BMI for boys and a 3% increase in girls over 3 years. Boys gained 0.10 kg/m^2 for 1 sweetened beverage serving and 0.14 kg/m^2 for 2 or more servings, whereas girls gained 0.07 kg/m^2 for each sweetened beverage serving added and 0.10 kg/m^2 for 2 or more servings (11).

Ebbeling and coworkers randomized 103 adolescents – who regularly consumed sugary soft drinks – to receive home delivery of non-caloric beverages or not. At 25 weeks, the control group had no change in beverage consumption habits, and the intervention group had an 82% decrease in sweetened beverage consumption. BMI increased 0.21 units in the control group and 0.07 in the treatment group (overall treatment effect, -0.14 BMI units; -0.75 + 0.34 units in highest tertile baseline BMI) (12).

Newby and colleagues studied dietary data of 1345 2- to 5-year-old children in a prospective, longitudinal study over 8 months and found that weight change was not significantly related to intakes (per ounce) of sweetened beverage consumption (13).

There are different schools of thoughts about the way the soft drinks influence the fat content of the body. One school is that consumption of soda increases dietary intake of fructose. This can either come from high-fructose corn syrup, or sucrose. Metabolism of fructose is extremely rapid and is initiated by fructokinase. Fructokinase activity is not regulated by metabolism or hormones and proceeds rapidly after intake of fructose. While the intermediates of fructose

metabolism are similar to those of glucose, the rates of formation are excessive. This fact promotes fatty acid and triglyceride synthesis in the liver, leading to accumulation of fat throughout the body and possibly non-alcoholic fatty liver disease.

One study showed that when consuming beverages high in fructose together with meals, the circulating insulin and leptin concentration decreases compared with beverages high in glucose. Because insulin and leptin function as key signals to the CNS in the long-term regulation of energy balance, prolonged consumption of diets high in energy from fructose could lead to increased caloric intake and contribute to weight gain and obesity (14).

A different school thinks that intake of liquid sugars compared to solids, increases the chance of weight gain.

In one study, subjects added 450 calories a day to their diets from either soft drinks or jellybeans during two four-week periods. When they ate jellybeans, the subjects subconsciously compensated for the added calories by consuming roughly 450 fewer calories from other foods. However, when they drank soft drinks, the subjects failed to compensate, adding 450 calories to their previous diet. They concluded that liquid carbohydrate promotes positive energy balance, whereas a comparable solid carbohydrate elicits precise dietary compensation. Increased consumption of energy-yielding fluids may promote positive energy balance. This theory is theory is supported by some and challenged by some. But as we wait for definite research results we should keep in mind that it is possible that liquid calories are especially conducive to weight gain (15).

It is clear that more research is needed in this area, but overall most scientists seem to agree that there is, in fact, a link between soft drinks and weight gain.

This was in 2004 reflected in the conclusion from the committee that advises the American government on Dieatry Guidelines (16):

> *"In summary, although the evidence is not large and there are methodological problems with this research, the preponderance of prospective data available suggest that added sugars (particularly in beverages) are associated with an increase in energy intake. As a result, decreasing the intake of added sugars (particularly in beverages) may help prevent weight gain and may aid in weight loss."* .

Diabetes mellitus type 2:

Type 2 diabetes mellitus affects about 17 million US individuals (17). The prevalence of diabetes has increased rapidly during the last decades (18) in parallel to the obesity epidemic.

Sugar-sweetened beverages like soft drinks and fruit punches contain large amounts of readily absorbable sugars .The possibility that high, long-term intake of carbohydrates that are rapidly absorbed as glucose may increase the risk of type 2 diabetes has been a long-standing controversy. Two main mechanisms have been hypothesized, one mediated by increases in insulin resistance and the other by pancreatic exhaustion as a result of the increased demand for insulin.

Willet and colleagues studied the risk of diabetes 2 according to glycemic load. They found epidemiologic evidence suggesting that replacing high-glycemic-index forms of carbohydrate with low-glycemic-index carbohydrates will reduce the risk of type 2 diabetes. Among patients with diabetes, the weight of evidence suggests that replacing high-glycemic-index with low-glycemic-index forms of

carbohydrate will improve glycemic control and reduce hypoglycemic episodes among those treated with insulin (19).

In addition, cola-based soft drinks contain caramel coloring, which is rich in advanced glycation end products that might increase insulin resistance and inflammation (20).

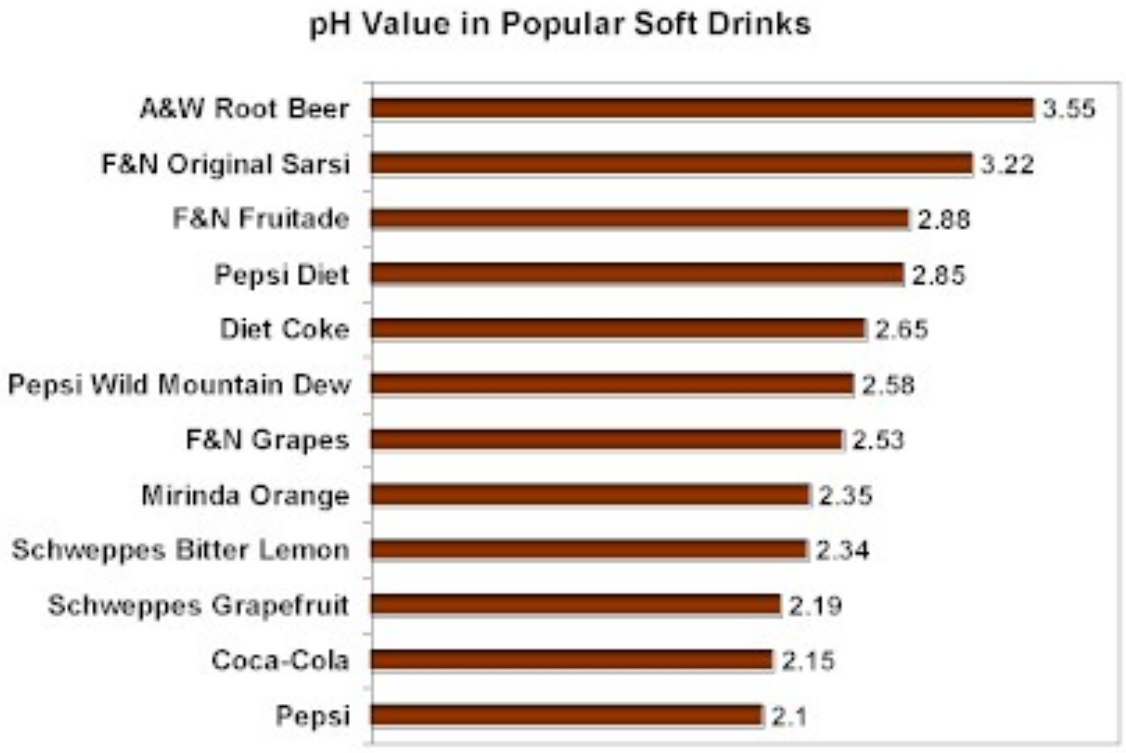
Dental decay:

Dental caries is a common, chronic disease of childhood. The trend towards more soft drink intake rater than milk has been proposed to increase the risk of dental caries in children.

Refined sugars are one of several important factors that promote tooth decay (dental caries). Regular soft drinks promote caries because they bathe the teeth of frequent consumers in sugar-water for long periods of time during the day. An analysis of data from 1971–74 found a strong association between the frequency of between-meal consumption of soda pop and caries (21).

Oral bacteria ferment the carbohydrates and produce acid. Many soft drinks, including Coke, use phosphoric acid as an acidifying agent. This is also part of the reason why a large number of soft drinks are acidic and some may have a pH of 3.0 or even lower. The sweet taste from the Coke's sugar and sweeteners masks the fact that Coke is actually more acidic than for example lemon juice.

These acids may dissolve tooth enamel during the dental decay process; thus, sweetened drinks are likely to increase risk of dental caries. The risk is greater if the frequency of consumption is high. (22)



Source: Consumer Association of Penang

Reduction of consumption of sodas is clearly proposed to help minimize the damage to the teeth, but there are also other measurements that can be taken. For example adoption of specific drinking methods. Many dentists encourage children to drink their soda through a straw. This way the soda will be less in contact with the teeth before it is swallowed.

Hypokalemia:

There have been several reports that chronic extreme soda drinking may lead to hypokalemia. The mechanism is multifactorial. The large glucose load in the soda can cause both an osmotic diuresis, with increased renal potassium wasting, and hyperinsulinaemia, causing intracellular redistribution of potassium. Second, drinks containing large amounts of high-fructose corn syrup send boluses of largely indigestible fructose into the GI tract, which causes potassium wasting via an osmotic diarrhea. Third, caffeine has been shown to cause beta-adrenergic stimulation, increase Na+／K+-ATPase via cellular phosphodiesterase inhibition, and produce metabolic alkalosis, diuresis and increased renin levels, all of which may contribute to hypokalemia. Soft drinks that combine large amounts of high-fructose corn syrup with caffeine, such as regular colas, might deplete potassium stores effectively because of concurrent osmotic and caffeine-mediated potassium wasting (23).

In a case report about a severely hypokalemic man from 2008, the author suggests that given the very high soft drink consumption in industrialized societies, this (extreme soda consumption) is probably an underreported and under diagnosed cause of potassium depletion. In addition to muscle weakness and cramping, hypokalemia lowers the arrhythmia threshold and may increase the risk of sudden death, particularly in people with heart disease. The author recommends that physicians should ask their patients about soft drink consumption when faced with unexplained hypokalemia (24).

Bone density:

Low calcium intake contributes to osteoporosis, a disease leading to fragile and broken bones. In 2002, the National Osteoporosis Foundation estimated that 10 million Americans had osteoporosis. Another 34 million had low bone mass and were at increased risk for the disease (25). Women are more frequently affected than men. Considering the low calcium intake of today's teenage girls, osteoporosis likely will continue to be a problem.

The risk of osteoporosis depends in part on how much bone mass is built up early in life. Girls build 92 percent of their bone mass by age 18 (26), but if they don't consume enough calcium in their teenage years they cannot catch up later. That's why experts recommend higher calcium intakes for youths aged 9 to 18 than for adults aged 19 to 50. Teenage girls in 1994–96 were consuming only 60 percent of the recommended amount of calcium; those who drank soft drinks consumed almost one-fifth less calcium than those who didn't drink soft drinks (27). This is believed to be due to the displacement of more nutrient-dense beverages. However there are also other reasons to hypothesize that carbonated soft drinks, and colas in particular, may be associated with lower bone mass density (BMD).

Caffeine is an ingredient in most colas and has been identified as a risk factor for osteoporosis. Oral intake of caffeine is associated with increased urinary excretion of calcium for at least 3 hours after intake. This is normally compensated for by intestinal absorption, but especially elderly women have a tendency not to compensate adequately (28).

There has been a hypothesis that the phosphoric acid contained in some soft drinks (colas) displaces calcium from the bones, lowering bone density of the skeleton and leading to conditions such as osteoporosis and very weak bones (29).

However, calcium metabolism studies by leading calcium and bone expert Dr. Robert Heaney determined that the net effect of carbonated soft drinks, (including colas, which use phosphoric acid as the acidulent) on calcium retention was negligible. He concluded that it is likely that cola's prominence in observational studies is due to their prominence in the marketplace, and that the real issue is that people who drink a lot of soft drinks also tend to have an overall diet that is low in calcium (30).

Caffeine:

Caffeine, a mildly addictive stimulant drug, is present in most cola and “pepper” drinks. Caffeine’s addictiveness, in fact, may be one reason why six of the seven most popular soft drinks contain caffeine (31). Some companies have begun marketing soft drinks, such as Red Bull, that contain several times the caffeine level of Coke or Pepsi.

As noted earlier one problem with caffeine is that it increases the excretion of calcium in urine. Drinking 12 ounces of caffeine-containing soft drink causes the loss of about 20 mg of calcium, or 2 percent of the recommended consumption. That loss, compounded by the relatively low calcium intake in girls who are heavy consumers of soda pop, may further increase the risk of osteoporosis.

The amounts of caffeine in soft drinks can have distinct pharmacological and behavioral effects. Caffeine is known to increase alertness, however, caffeine also can cause nervousness, irritability, sleeplessness, and rapid heartbeat (32).

It causes children who normally do not consume much caffeine to be restless and fidgety, develop headaches, and have difficulty going to sleep (33)(34).

Also, caffeine's addictiveness may keep people hooked on soft drinks (or other caffeine-containing beverages) (35).
One reflection of the drug's addictiveness is that when children aged 6 to 12 stop consuming caffeine, they suffer withdrawal symptoms that impair their attention span and performance (36).

One study showed that significant caffeine withdrawal symptoms can occur reliably when individuals are maintained on as little as 100 mg caffeine each day (roughly equivalent of 2-3 cans of soft drinks), and the severity of caffeine withdrawal is an increasing function of the caffeine maintenance dose. Administration of caffeine as a single daily dose produces physical dependence similar to that produced by three divided doses over the day, suggesting that the daily dose of caffeine consumed is more relevant to the development of caffeine dependence than the pattern of caffeine intake within the day. Furthermore, caffeine withdrawal (symptoms of tiredness and headache) occurs after as little as 3 consecutive days of caffeine exposure, with a somewhat increased severity of withdrawal observed after a week of caffeine exposure. That study also found that 25 mg of caffeine is sufficient to suppress caffeine-withdrawal headache (37).

Another study showed that after overnight caffeine abstinence, caffeine can significantly affect cognitive performance, mood and thirst at doses (40 mg) within and even lower than the range of amounts of caffeine contained in a single serving of popular caffeine-containing drinks. Regular caffeine consumers appear to show substantial tolerance to the thirst increasing but not to the performance and mood effects of caffeine (38).

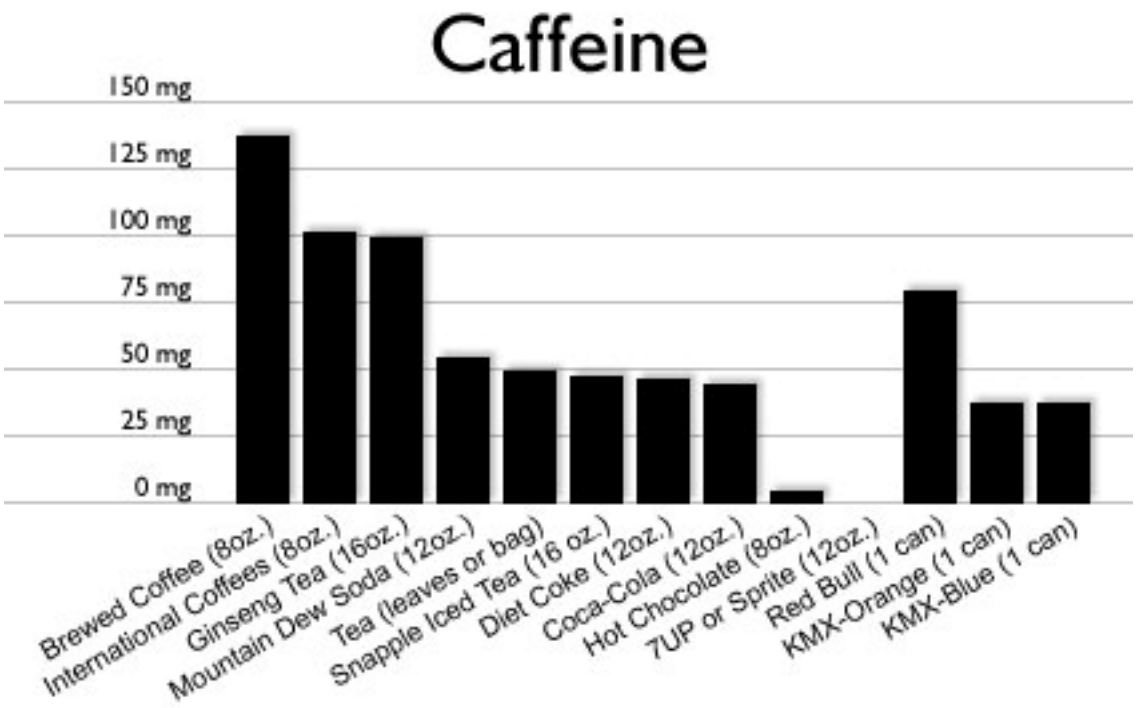
Camarasa and colleagues researched the adverse effects of combining caffeine and MDMA (ecstasy). In their neurotoxicity studies, a hyperthermic effect of MDMA was observed. Although caffeine alone failed to alter body temperature, it potentiated MDMA-induced hyperthermia. This association also significantly increased MDMA lethality (from 22% to 34%) (39).

The Australia New Zealand Food Authority has concluded the following (40):

> "The amounts of caffeine in one or two cans of caffeinated soft drink can affect performance and mood, increase anxiety in children, and reduce the ability to sleep, though "the threshold dose for possible behavioral effects in children remains unclear."

> "Typical doses of caffeine "may lead to withdrawal effects and some physical dependence in adults... Further research will be required...in children."

> "There is little evidence for adverse cardiovascular effects."



Source: http://mormonstalk.wordpress.com/2007/08/04/caffeine-anyone/

Artificial sweeteners:

It has been raised concerns with many of the different artificial sweeteners used in diet sodas.

Aspartame (NutraSweet) has the last two decades been the most widely used artificial sweetener. A study done by Van Den Eeden SK and colleagues provided evidence that, among individuals with self-reported headaches after ingestion of aspartame, a subset of this group reported more headaches when tested under controlled conditions. It showed that some people are particularly susceptible to headaches caused by aspartame and should try to limit their consumption (41).

In 2000 the government repealed the law requiring a warning label on products containing saccharin. The Center for Science in the Public Interest (CSPI), however, recommends that the additive still should be avoided (42).
This is due to research linking the additive to urinary bladder cancer in human (43). In animals studies it has also been linked to cancer of both bladder and other organs (44).

In 1998 the artificial sweetened acesulfame (Sunett) was approved for use in soft drinks. At present, acesulfame is very widely used, most frequently in blends with the most popular artificial sweetener in the US, sucralose (Splenda). Acesulfame was nominated twice (in 1996 and again in 2006) for testing in the National Toxicology Program (NTP) bioassay program. Both nominations were rejected by NTP. Rather than carry out bioassays, NTP subjected acesulfame to tests in genetically modified mice (GMM). Those GMM tests yielded results that provided no insight into potential carcinogenicity of acesulfame. A study done by Karstad concludes that acesulfame should be tested in the bioassay program as soon as possible (45).

Conclusion:

The consumption of sugar-sweetened soft drinks has increased enormously over the last decades. Still, due to a lack of clinical trial data, the relationship between soft drinks and adverse health effects is not completely understood. Although there are several observational studies supporting there is a link between soft drink consumption and weight gain, absolute confirmation is yet to be proved. It is however, a strong agreement amongst scientists that measures should be taken to limit the intake of added sugars, especially those from soft drinks.

Many different ways to achieve this goal have been suggested. Many agree that it is important to reach out to young people before large consumption habits have been developed. This could be achieved on different levels.

Parents have a great responsibility to limit their children's soda intake at an early age. A complete ban of soda products in the home is not warranted, but decreasing of non-diet products and promotion of diet-products is something that should be recommended.

Doctors, school nurses and other health practitioners should be more active in educating people about the possible health effects of large soda consumption. Asking about soda consumption should be a part of the anamnesis, and the advising of patients, when necessary, to consume less.

The school system should stop sales of soft drinks and other unhealthy food in their canteens. Limitations or bans on soft drink automats should be considered. Promotion of healthier drinks such as water and low fat milk should be achieved through advertising, and education.

The government should sponsor more research to further explore the effects of soft drinks consumption on obesity, diabetes mellitus 2, dental decay, and hypokalemia and bone density.

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