

Decreasing Blood Pressure: One bite of chocolate at a time

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ABSTRACT

Context: Dark chocolate consumption has been shown to have positive benefits on health. It has been hypothesised to decrease blood pressure, due to the high flavonoid content. The flavonoids in dark chocolate have been speculated to decrease platelet adhesion, and LDL levels, as well as enhance vasodilation. However, studies conducted have been inconclusive.
Objective: To investigate the relationship between consumption of dark chocolate and blood pressure, among those with hypertension.
Methods: A structured literature review, using the uOttawa library database, was conducted using studies published between 2005-2015. Articles written in English were analyzed. The keywords used were 'dark chocolate', 'hypertension', and 'LDL'. Only peer reviewed papers, with experiments conducted on pre-hypertensive and hypertensive humans were considered. After applying this search parameters, 11 articles remained.
Results: Among consumers, most of the articles illustrated a positive correlation between dark chocolate consumption, lowered LDL levels, increased flow-mediated dilation and lowered blood pressure levels overall. However, most of these studies were conducted on small sample sizes, with a small amount of dark chocolate consumed. The aforementioned effects were only observed for a short period of time.
Conclusion: Therefore, it can be concluded that short term dark chocolate consumption has been shown to decrease LDL levels, and induce vasodilation, thus lowering hypertension among the selected population.

INTRODUCTION

Chocolate is one of the most popular foods in the world. Since 460 AD, humans have been consuming and using cacao products, derived from the cacao tree (Katz & Doughty, 2011). In the past, cocoa has been used as a source of indulgence and a pharmaceutical product due to its' healing and medicinal properties (Katz & Doughty, 2011). More recently, the medicinal properties of dark chocolate have been of particular interest due to an ethnographic study of the Kuna Indians of the Sans Blas islands of Panama who consume thirty ounces of a natural cocoa beverages daily (Katz & Doughty, 2011). Studies have found that the Kuna Indians have a low prevalence of hypertension (2.2%) at all ages, as well as lower rates of hypertension than those who have moved inland to urban areas (prevalence of 10.7%) (Katz & Doughty, 2011). The study of this population strengthens the hypothesis of a potential link between chocolate and a positive effect on cardiovascular health, thus a decrease in the development of cardiovascular disease.

The spotlight on dark chocolate research is greatly due to its higher cocoa solids that have antioxidant and vascular endothelial properties (Craig, 2010). Cocoa solids contain 3 types of polyphenols, called flavonoids (catechin, epicatechin, procyanidins) (Katz & Doughty, 2011). The exact mechanism of these flavonoids is unknown, however, they are thought to: neutralize free radicals that oxidize LDL cholesterol, increase HDL levels, upregulate and/or increase the bioavailability of NO that causes vasodilation, display antiplatelet effects by inhibiting blood clot formation, and stimulate immunoregulatory processes in the body (Katz & Doughty, 2011; Craig, 2010; Visioli et al., 2009). The improvement of the aforementioned functions contributes to better vascular health; a prime determinant that can reduce the development of cardiovascular disease.

Cardiovascular disease (CVD) is the top cause of death in the world (World Health Organization, 2014). It involves the circulatory system and encompasses many diseases, such as: ischemic heart disease, cerebrovascular disease, and peripheral vascular disease (Public Health Agency of Canada, 2015). While some risks factors for cardiovascular diseases are inherent, the majority are modifiable risk factors (Public Health Agency of Canada, 2015)

Many other actions can be taken to decrease other risks for hypertension or cardiovascular disease. In general, diet is the most important and most commonly changed lifestyle factor to influence the incidence of CVD (Katz & Doughty, 2011). According to the Framingham Heart Study, the regulation of blood pressure levels among pre-hypertensive patients can decrease the relative risk of all-causes of cardiovascular disease related mortality by 4% (Milliron et al., 2010). Consequently, this research project focussed on decreasing hypertension through the consumption of dark chocolate. The increased flavanol content improves flavanols mechanisms, which contribute to factors that can control hypertension, such as a decrease in: the bioavailability of NO, the amount of fatty plaques and the accumulation of platelets in the circulatory system (Public Health Agency of Canada, 2015).

METHODOLOGY

A structured literature review, using the uOttawa library database, was conducted using studies published from 2005 to 2015. This is because studies published prior to 2005 were not rigorous, and did not contain methods of controlling for confounding variables to account for the variations between the test subjects. Articles written in English were analyzed to identify the association between the consumption of dark chocolate and lowered blood pressure levels due to lowered LDL levels, and increased flow-mediated dilation. Only papers that used analytical study designs (randomized control trials, prospective cohort intervention studies, case-control and cross sectional) were examined. The search strategy included articles that were found using the keywords: 'Dark chocolate' AND 'hypertension', 'dark chocolate' AND 'LDL', 'dark chocolate' AND 'circular vasodilation'. Only peer reviewed papers, with experiments conducted on pre-hypertensive and hypertensive humans were considered. After applying these search parameters, 14 articles remained. Of these 14 articles, studies conducted on animals, as well as expert opinion papers and editorials were excluded. The remaining 11 articles were included in the final analysis

Key words 'Dark chocolate' AND 'hypertension', 'dark chocolate' AND 'LDL', 'dark chocolate' AND 'circular vasodilation'

- Databases: uOttawa library
- Limited search to English studies conducted between 2005-2015

- Excluded literature with keywords: Obesity, proanthocyanidins and chocolate candies

- Excluded studies conducted on animals, as well as expert opinion papers and editorials

- Total articles used

11 Articles

14 Articles

106 Articles

Figure 1: Search criteria employed to determine articles for structured literature review

RESULTS

Title and Type of study	Summary of findings	Qualitative Results
Blood Pressure is Reduced and Insulin Sensitivity Increased in Glucose-Intolerant, Hypertensive Subjects after 16 Days of Consuming High-Polyphenol Dark Chocolate Double blind Randomized controlled trial: Prospective Cohort Study	less insulin resistance due to improved endothelial function caused by higher Nitric Oxide levels and less reactive oxygen and nitrogen species. Improved microcirculation in arteries due to higher levels of (-)-epicatechin resulting in lower BP	Over a 12 week period, the changes were observed in the participants that consumed flavanol rich dark chocolate when compared with white chocolate consumers. -Decrease LDL levels by 7.5% (P<0.001) -Systolic blood pressure (SBP) decreased by 3.82 ± 2.4 mmHg -Diastolic blood pressure (DBP) decreased by 3.92 ± 1.98 mmHg The mean SBP in the dark chocolate group was -4.52 ± 3.94 and DBP was -4.17 ± 3.29
Effects of cocoa products/dark chocolate on serum lipids: a meta-analysis Case-Control	- Stronger reduction of LDL and TC among those with high risk of CVD in a short term intervention - Dark Chocolate decreased insulin resistance and LDL cholesterol levels when compared to white chocolate - Dark chocolate also increased flow mediated dilation due to high levels of epicatechin-7-O-glucuronide and suppression of NO synthase inhibitor.	2-12 week period of consumption depending on the study SBP decreased by 3.82 ± 2.40 mmHg with a mean decrease of 3.92 ± 1.98 mmHg in a 24-h period (P < 0.0001) DBP 4.17 ± 3.29 mmHg with a mean decrease of 4.52 ± 3.94 mmHg in a 24-h period (P < 0.0001) increased Flow Mediated Dilation (P < 0.0001) and decreased total cholesterol by 6.5% (P < 0.0001) LDL cholesterol levels decreased by 7.5%; P < 0.0001
Low vs. Higher-Dose Dark Chocolate and Blood Pressure in Cardiovascular High-Risk Patients Meta-analysis	A larger amount of dark chocolate was observed to result in larger decrease in blood pressure in	The mean systolic blood pressure change across all trials was -4.5mmHg (95% confidence interval) The mean diastolic blood pressure decreased by 2.5mmHg ± 1.2mmg, with a 95% Confidence Interval and P < 0.001
Consumption of healthy foods at different content of antioxidant vitamins and phytochemicals and metabolic risk factors for cardiovascular disease in men and women of the Moli-sani Study Cross-sectional Retrospective Study	Consuming foods with High antioxidant vitamins and phytochemicals resulted in decrease in systolic blood pressure, diastolic blood pressure and C-reactive protein	24 325 patients all residents of Italy over a 6 week period Consumption of high antioxidant foods (including chocolate) was negatively associated with Systolic and diastolic blood pressures in multi-adjusted analysis, with P=0.01 and P=0.001 respectively Low antioxidant food intake was not associated with changes in systolic or diastolic pressures, P=40.05
Consumption of high-polyphenol dark chocolate improves endothelial functions in individuals with Stage 1 hypertension Randomized controlled trial: Prospective Cohort Study	No change in the % body fat, glucose metabolism, lipid profile, biomarkers of inflammation, adhesion molecules, oxidized LDL. Decreases in blood pressure levels was not statistically significant	Over a 8 weeks Endothelial function increased from 1.94 ± 0.18 to 2.22 ± 0.08 with P=0.01.
Plasma LDL and HDL cholesterol and oxidized LDL concentrations are altered in Normo- and Hypercholesterolemic Humans after Intake of Different Levels of Cocoa Powder Prospective Cohort Study	Plasma LDL concentrations decreased in lower, middle and high cocoa groups compared to baseline No discussion on any observed changes in blood pressure levels.	Over a 4 week period the following changes were observed in the 13g dark cocoa powder when compared to placebo participants. LDL cholesterol decreased between 4.4 to 5.0% occurred following the intake Plasma LDL concentrations decreased by ≥3.23 mmol/L
High-cocoa polyphenol-rich chocolate improves blood pressure in patients with diabetes and hypertension Double-Blind Randomized Controlled Trial: Prospective Cohort Study	-Decreases in: systolic blood pressure (SBP), diastolic blood pressure (DBP), apolipoprotein B (Apo B), and a significant increase in Apolipoprotein A (Apo A). In comparison to the control group, the treatment group only had significantly decreased systolic and diastolic blood pressure. - No significant differences between the groups total cholesterol, LDL cholesterol, HDL cholesterol, and Apolipoproteins A or B.	Over an eight week period: Treatment Group (before vs after) SBP: 137.03 ± 10.61 mmHg to 130.62 ± 11.19 mmHg, P=0.001 DBP: 85.15 ± 8.56 mmHg to 79.21 ± 8.89 mmHg, P=0.001 Apo B: 86.53 ± 20.11 mg/dl to 82.06 ± 17.94 mg/dl, P=0.012 Apo A: 149.81 ± 17.89 mg/dl to 154.37 ± 16.02, P=0.045 Control vs Treatment Group Outcome Comparison SBP: -6.40 ± 6.25 mmHg vs 0.17 ± 7.99 mmHg, P=0.004 DBP: -5.93 ± 6.25 mmHg vs -1.07 ± 7.97 mmHg, P=0.002
Characterisation of Hypertensive Patients with Improved Endothelial Function after Dark Chocolate Consumption Prospective Cohort Study	-Flow Mediated Dilation (FMD) increased among all patients after a one week dark chocolate intervention. - Found there was a greater increase in FMD in younger subjects (younger group: responders and older group: non-responders) - Statistically significant decrease in systolic and diastolic pressure in younger group.	Over a seven week period: Responders FMD (before vs after): 8.4 ± 5.9% to 16.6 ± 8.2%, P<0.001 Non-Responders FMD (before vs after): 13.8 ± 2.8% to 11.3 ± 4.2%, P=0.03 Responders SBP (before vs after): 140 ± 3 mmHg to 131 ± 10 mmHg, P=0.015 Responders DBP (before vs after): 85 ± 7 mmHg to 82 ± 8 mmHg, P=0.050
Q/Does chocolate have cardiovascular benefits? Meta-Analysis	Overall, findings were that short term consumption of dark chocolate decreases 24-hour ambulatory, and clinical blood pressure. Only one study found no difference in blood pressure, but this study was classified as an outlier; eliminating this study did not alter mean blood pressure changes.	Between 14-15 days: Meta-analysis: Treatment Group Difference Between Before and After SBP: -4.7 ± 2.9 mmHg, P<0.001 95% Confidence Interval, P=0.002 DBP: -2.8 ± 2.0 mmHg, 95% Confidence Interval, P=0.006 Over an eighteen week period: RCT 1: Treatment Group Difference Between Before and After SBP: -2.9 ± 1.6 mmHg, P<.001 DBE: -1.9 ± 1.0 mmHg, P<0.001 After a two hour period: RCT 3: Treatment Group Difference Between Before and After SBP: -3.2 ± 5.8 mmHg, P<0.001 DBP: -1.4 ± 3.9 mmHg, P<0.001 Over a fifteen day period: RCT1 2: Treatment Group Difference Between Before and After 24-hour SBP: -4.52 ± 3.94 mmHg, P<0.0001, Clinical SBP: -3.82 ± 2.40 mmHg, P<0.0001 24-hour DBP: -4.17 ± 3.29 mmHg, P<0.0001 Clinical DBP: -3.92 ± 1.98 mmHg, P<0.0001
Effects of dark chocolate on blood pressure in patients with hypertension Meta-Analysis	Overall, 5/8 of the Randomized Controlled Trials suggested dark chocolate was associated with a moderate reduction in 24-hour ambulatory and clinical blood pressure. One study found no significant decreases in blood pressure in the treatment group versus baseline values or between the treatment and control group. Furthermore, 2 studies used cocoa drinks, one study found no significant decrease in blood pressure. The second study used 4 cocoa drinks with different doses of polyphenols; the only dosage to show significant decreases in blood pressure was 1052 mg. Several of the studies also found positive effects on LDL cholesterol levels and Flow Mediated Dilation.	RCT 1: Fourteen Day Period SBP: -5.1 ± 2.4 mmHg, P<0.0001 DBP: -1.8 ± 2.0 mmHg, P=0.002 RCT 2: Fifteen Day Period 24-Hour SBP: -11.9 ± 7.7 mmHg, P<0.0001 24-Hour DBP: -8.5 ± 5.0 mmHg, P<0.0001 RCT 3: Eighteen Week Period SBP: -2.9 ± 1.6 mmHg, P<0.001 DBP: -1.9 ± 1.0 mmHg, P<0.001 RCT 5: Two Week Period Treatment vs Control Group SBP Difference after Treatment: -1 mmHg, 95% confidence interval, P= 0.74 Treatment vs Control Group DBP Difference after Treatment: -1 mmHg, 95% confidence interval, P=0.48 RCT 7: Six Week Period Before vs After 1052 mg dose 24-hour SBP: -5.3 ± 5.1 mmHg, P=0.001 24-hour DBP: -3.0 ± 3.2 mmHg, P=0.002 24-hour Mean Blood Pressure Difference between before and after 125 mg dose: - 1.9 ± 1.7 mmHg, 95% Confidence Interval, P= 0.03 After 2 x Twelve Week Phases Before vs After Treatment SBP Phase 1: 135 ± 3.8 mmHg to 133.1 ± 3.5 mmHg SBP Phase 2: 128.2 ± 3.0 mmHg to 126.8 ± 2.8 mmHg DBP Phase 1: 83.6 ± 3.2 mmHg to 84.5 ± 3.5 mmHg DBP Phase 2: 79.1 ± 1.9 mmHg to 77.9 ± 2.2 mmHg RCT 8: Twelve Week Period 24-hour Mean Blood Pressure Difference between before and after 30 mg dose: -2.3 ± 1.9 mmHg, 95% Confidence Interval, P=0.01
Dark chocolate or tomato extract for prehypertension: a randomised controlled trial Single-Blind Randomized Controlled Trial: Prospective Cohort Study	No significant differences in blood pressure were found in groups that consumed dark chocolate or within treatment and control groups.	After 2 x Twelve Week Phases Before vs After Treatment SBP Phase 1: 83.6 ± 3.2 mmHg to 84.5 ± 3.5 mmHg DBP Phase 2: 79.1 ± 1.9 mmHg to 77.9 ± 2.2 mmHg

DISCUSSION

In general, the majority of the literature supported the relationship between dark chocolate consumption, and lowered blood pressure due to lowered LDL levels, and increased flow mediated dilation. However, it was observed that the validity of this relationship differed between the case-control and prospective cohort studies. The case-control studies showed a positive association due to the ability to strictly monitor diet and the use of control and experimental groups as to compare the obtained results. Seven prospective cohort studies found statistically significant results, showing larger doses of flavanols result in greater decreases in blood pressure. The association between dark chocolate and reversed endothelium dysfunction, was shown by lowered blood pressure values among participants of all ages. Furthermore, one cohort study showed that when chocolate consumption stopped, blood pressure when back to pre-testing levels; thus the benefits of chocolate are mainly short term.

Four prospective cohort studies showed no association with blood pressure levels because of uncontrolled confounding variables (such as modifying lifestyle factors and level of physical activity) which could have contributed to the lowered blood pressure levels.

The use of dark chocolate for cardiovascular health is controversial due to some biases found in the obtained studies. First, the consumption of dark chocolate was given in various sources, such as powders, chocolate squares, and chocolate drinks. Therefore, the studies that compared groups that consumed different amounts of dark chocolate squares, reported an increase in body weight due to consumption of fats, gelatins and other stabilizers. Because weight gain is associated with a rise in BP, this might counteract potential antihypertensive effects of dark chocolate observed between the groups. Furthermore, dense dark chocolate is high in caffeine, which would also have contributed to the potential for adverse health reactions from the high caffeine content and vasodilating factors that could improve blood pressure. Secondly, some of the obtained results could contain a regression to the mean bias. Because all of the participants had blood pressure levels above the population mean on the first measurement, there could have been a tendency to display lower readings in a second measurement, and subsequent measures thereafter.

Limitations:

There were three limitations that were found. First, the levels of flavanol in dark chocolate can differ by brand, and can be affected by presence of other nutrients/ingredients in chocolate. While the cocoa percentage was given, this value does not convey the level of flavanols as the quantity can vary based on the dark chocolate plant origin and the manufacturing processes.

Secondly, some of clinical trials, using dark chocolate, lacked an adequate control substance that could be used to compare the obtained results. To date, there is no commercially available flavanol-free chocolate that mimics the distinct bitter taste and dark color associated to cocoa-rich chocolate. As a result, most of the examined studies were single-blind or open-label studies. There is a higher drop out rate because the participants knew the type of treatment they were receiving. Consequently, the statistical power, obtained from these studies, is lower and the probability of making a Type II error increases. Moreover, studies that use white chocolate as a placebo, would not be valid because white chocolate offers no nutritive benefits, and therefore can induce negative health effects, unlike a standard placebo.

Finally, there were no regulation methods to eliminate the impact of confounding variables in the observed association between dark chocolate and lowered blood pressure. Because none of the studies required the participants to keep a food log, the participants could have consumed other flavanol-containing foods such as wine, tea and fruits, which could have artificially inflated the relationship between flavanol and dark chocolate. Moreover, the absence of serum polyphenol tests makes it difficult to associate the changes to chocolate consumption and not to lifestyle changes.

CONCLUSION & FUTURE IDEAS

It can be concluded that the majority of the literature supported the relationship between dark chocolate consumption, and lowered blood pressure due to lowered LDL levels, and increased flow mediated dilation.

Due to the fact consumption of dark chocolate is steadily increasing, studies that uncover the association between dark chocolate consumption and blood pressure levels prove to be a significant area of research. Future studies need to determine the precise mechanisms responsible for the presumed blood pressure lowering effect of cocoa-containing foods. Another suggestion would be to conduct more research as to find the metabolism rate of flavanols, as well as the optimal flavanol level that produces the most beneficial effects. Secondly, more trials are needed to study the effects for dark chocolate with various levels of flavanol content. For example, comparison studies that use both drug therapies alongside dark chocolate could potentially offer more treatment options for blood pressure management. Finally, larger and longer-term trials are still required to confirm and expand upon the potential role of flavonoid-rich chocolate in reducing cardiovascular disease risk, and blood pressure levels.

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