REVIEW **OPEN ACCESS**

Comparing The Effects of Plant-Based Diets and Western Diets on Cardiovascular Disease Risk Factors: A Review

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Abstract
Introduction: Dietary interventions are modifiable risk factors for cardiovascular diseases (CVDs). In particular, the plant-based diet (PBD), characterized by a higher intake of plant-based foods, has been associated with lower CVD risk. In contrast, the western diet (WD), containing higher intakes of processed and animal products, has been associated with increased CVD risk. This review compares the effects of PBDs and WDs on CVD risk factors including blood pressure (BP), low-density lipoprotein (LDL), and triglycerides.
Methods: A database search was performed in PubMed and Embase (search terms: ("plant-based diet" OR "western diet") AND "cardiovascular disease" AND ("blood pressure" OR "low-density lipoprotein")). Articles were checked for eligibility and excluded if they did not meet the inclusion criteria. A total of seven articles were included in the review.
Results: Of the seven studies, four evaluated BP, five analyzed LDL, and four investigated triglyceride levels. Following a PBD, three studies reported a significant decrease in BP, while one determined no significant changes in BP. Additionally, three studies indicated decreased LDL levels. On the other hand, while following a WD, one study indicated increased BP, another showed increased triglyceride levels and two demonstrated increased LDL levels.
Discussion: Three mechanism of action theories may be used to explain the lowering effect PBD have on BP, LDL levels, and triglycerides. I) The overall lower fat intake in PBDs lowers saturated and trans-fats. II) The modest presence of phytosterols in PBDs provides a cholesterol-lowering effect. III) The higher content of soluble fibres in PBDs lower BP and LDL cholesterol. In contrast, WD are high in saturated fats and trans-fats, resulting in greater LDL levels. WDs are also high in sodium, increasing water retention and thus BP.
Conclusion: The review highlights the potential benefits of PBDs and the harmful effects of WDs on CVD risk factors. Findings of this review suggest a shift towards PBDs may be beneficial in interventions aimed at reducing CVD risk factors. However, studies with larger sample sizes and longer intervention durations are needed to fully understand the relationship between diet and CVD risk factors.

Keywords: plant-based diets; western diets; blood pressure; low-density lipoprotein; triglycerides; cardiovascular disease

Introduction

Cardiovascular disease (CVD) is an umbrella term encompassing various conditions including coronary heart disease, cerebrovascular disease, and peripheral arterial disease [1]. In 2020, CVD was identified as one of the leading causes of mortality, affecting approximately 19.1 million individuals worldwide [2]. There are several risk factors that affect pathogenesis of CVD such as smoking, lack of physical activity, and diet [3]. Additionally, CVD is associated with many physiological changes including increases in heart rate (HR), blood pressure (BP), triglyceride levels, and ratio of low-density lipoprotein (LDL) to high-density lipoprotein (HDL).

Modifiable lifestyle factors, such as smoking and exercise have been investigated to reduce CVD risk factors and improve health outcomes [4]. Notably, several studies have demonstrated that regular exercise and smoking cessation can reduce the risk of CVD [5,6]. Diets also play an integral role in the manifestation of this disease. For example, dietary patterns such as plant-based diets (PBDs) have been associated with lower risk of CVD [7]. For this review, PBDs, such as the Mediterranean diet (MD) and flexitarian diet, are defined as dietary patterns that include a high ratio of plant-based foods, and a low ratio or animal and processed foods. This type of dietary pattern differs from the typical North American or Western diet (WD) that is characterized by proportionally higher intakes of highly processed foods and animal products. Overall, the WD has been associated with increased risk of CVD and atherosclerosis [8].

Following a WD has shown to contribute to growing rate of obesity in North America [9]. Given diet is a modifiable risk factor for CVD, a shift to PBDs is associated with reduced CVD risks and improved health outcomes [10]. Specifically, PBDs have been shown to lower CVD incidence and mortality, as well as improve cardiovascular risk profiles in middle-aged adults [11,12]. PBDs are also associated with an improved metabolic and inflammatory profile, and been consistently recommended for chronic disease prevention [13]. However, insights into similarities and differences between PBDs and WDs with their corresponding mechanism of action in patients with chronic disease are lacking in literature. The purpose of this review was to compare the effects of PBDs and WDs on CVD risk factors including BP, LDL, and triglycerides. These measures were selected among many CVD factors as they have been identified as key components of CVD prediction, are commonly researched, and easily measured in patients [14]. The findings of this review can inform public health policies to encourage the prevention of chronic diseases and promote health.

Methods

Literature Search

To conduct this review, a literature search was performed on March 06, 2023, using PubMed and EMBASE databases. The keywords were as follows: ("plant-based diet" OR "western diet") AND "cardiovascular disease" AND ("blood pressure" OR "low-density lipoprotein"). A total of 2264 articles were retrieved from the databases.

Using advanced search settings, articles published prior to January 2015, that were not written in the English language, included animal models, or included participants aged <18 or >64 were excluded. The exclusion of animal models was specifically done as they typically fail to accurately predict human reactions to stimuli. Moreover, only studies involving adult participants were considered as there was limited literature for age groups beyond that range [15].

A total of 303 articles were then screened for study design and duplicates were removed. Specifically, only clinical trials and randomised controlled trials were considered for included. The remaining 59 articles were evaluated for eligibility based on the following criteria (I) included a PBD or WD intervention and (ii) used BP or LDL levels as outcome measure(s). A total of 7 articles were included in the review (Figure 1) [16-22].

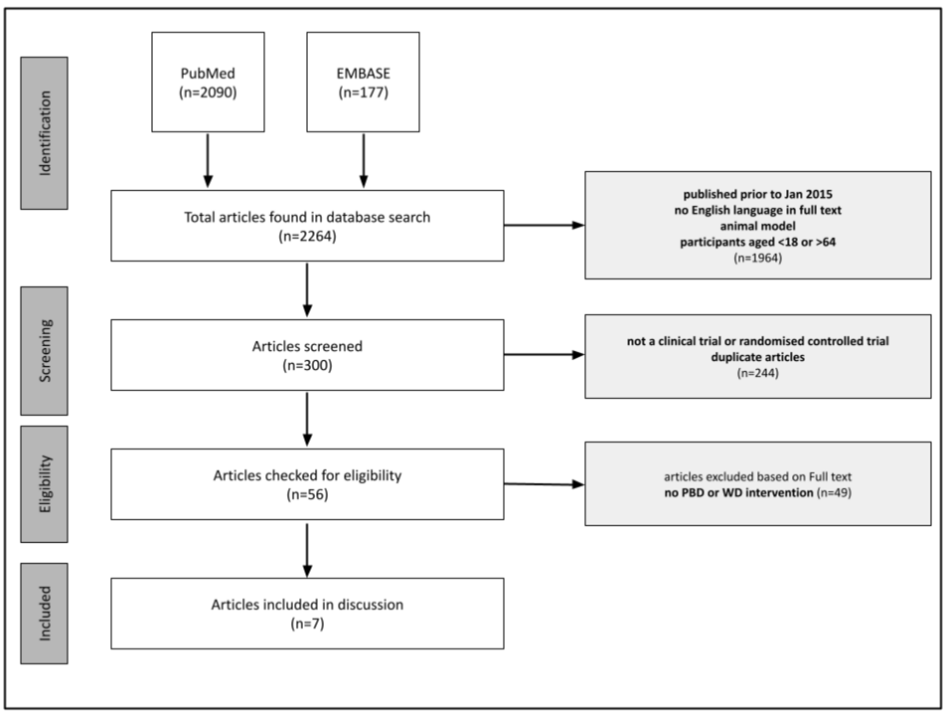

Figure 1. Flow chart of the selected review articles. Abbreviations used PBD: plant-based diets; WD: Western diet. Adobe Illustrator was used in the creation of the flowchart.

Results

Of the seven papers included in this report, five investigated only PBD interventions, and two examined both PBD and WD interventions. Additionally, four articles evaluated BP [16,18,21,22], five examined LDL [17,19-22], and four analyzed triglycerides as outcome measures [18-21]. Finally, five articles examined obese, overweight, or at-risk patients [16,18,19,21,22], while two investigated healthy patients [17,20] (Table 1).

Table 1. Analysis of the seven studies that investigated the effects of LDL, BP and triglyceride levels in PBDs, WD = Western Diet, or both. All studies were tested for statistical significance ($p<0.05$). Abbreviations used: cRCT = Randomized controlled, crossover trial. Ox-LDL = oxidative low-density lipoprotein. TEM = tocopherol-enriched Mediterranean meal. HFM = high-fat meal. PD = parallel design. HD = healthy diet. SBP = systolic blood pressure. DBP = diastolic blood pressure. LDL = low-density lipoprotein. HDL = high-density lipoprotein. CVD = cardiovascular disease. TAG = triacylglycerol. MD = Mediterranean diet.

Study & Year	Participants (n)	Study Type	Assessment	Comparators	Duration	Significant Results
Barnard et al., 2022 [16]	62 overweight adults	cRCT	Body weight, plasma lipids, BP, body composition	MD and vegan diet	36 weeks (16 weeks MD or vegan diet, 4 weeks washout, 16weeks switch)	There were no significant changes in LDL with a significant decrease in SBP and DBP following a Mediterranean diet.
De Lorenzo et al., 2016 [17]	25 healthy participants	cRCT	Circulating ox-LDL level in plasma	TEM and HFM	Two phases	Ox-LDL levels were significantly lower in the tocopherol-enriched MD compared to the Western high-fat meal.
Fechner et al., 2020 [18]	45 overweight or obese men and women	PD RCT	BP, cholesterol, TAG levels	WD and healthy diet (high in fruits and vegetables, pulses, nuts, fibers fatty fish, etc.)	8 weeks (2 weeks WD, 6 weeks WD or healthy diet)	Changes in LDL cholesterol was significantly different between both groups. Fasting SBP decreased more with HD than with WD. TAG levels significantly decreased in the healthy diet group compared to the WD group.
Sofi et al., 2018 [19]	118 overweight participants	cRCT	LDL, triglycerides	MD and vegetarian diet	2 intervention periods lasting 3 months each	LDL did not significantly change in the MD group. MD significantly decreased triglyceride levels compared to the vegetarian diet.
Koeder et al., 2017 [20]	201 healthy participants	Non-RCT	Total cholesterol, triglycerides, LDL cholesterol	PBD and control	1-year intervention period.	The intervention group demonstrated lower body weight, BMI, total cholesterol, calculated LDL cholesterol, non-HDL cholesterol, remnant cholesterol, glucose and HbA1c. No significant differences were found in triglycerides within the PBD group.
Zhu et al., 2021 [21]	710 overweight or obese participants	RCT	LDL, SBP, DBP, triglyceride level	PBD	3 years	Vegetable intake was inversely associated with an increment in DBP and triglycerides and was positively associated with an increase in HDL cholesterol. The intake of vegetables in PBDs was inversely associated to triglyceride levels.
Wade et al., 2019 [22]	33 participants at risk of developing CVD	PD cRCT	SBP, DBP, LDL	MD supplemented with lean pork and low-fat control diet	24-week (8 weeks MD or low-fat control diet, 8 weeks washout, 8 weeks switch)	No significant difference was observed in the MD intervention in BP or LDL levels before and after the intervention.

Blood Pressure

Throughout the selected studies, measurements of BP were variable. Two studies reported a significant decrease in systolic blood pressure (SBP) and diastolic blood pressure (DBP) following a MD [16,21]. Decreases in BP were also reported in "healthy diets" mainly consisting of fruits, vegetables, nuts, fibers and fatty fish [18]. Specifically, BP measurements were significantly lower in patients adhering to a PBD compared to a WD [18]. Finally, the study by Wade *et al.* noted no significant change in BP measurements after adhering to a PBD supplemented with lean pork for eight weeks [22].

Low-Density-Lipoprotein

Three studies indicated decreased levels of LDL associated with adherence to a PBD [17,18,20]. Contrastingly, LDL levels of participants following a WD were suggested to be higher in comparison to those following a PBD [17,18]. However, several studies found no changes in LDL in PBD groups [16,19,22]. When the MD was compared to a vegetarian or vegan diet, no significant decrease in LDL was observed in the MD [16,19].

Triglyceride Levels

In general, a decrease in triglyceride levels was noted when adhering to a PBD [18,19,21]. However, one study indicated no significant changes in triglyceride levels following a PBD for one year [20]. Furthermore, when compared to a vegetarian diet, the MD showed a stronger effect in reducing triglycerides [19]. One study specifically noted the intake of vegetables in PBDs resulted in the reduction of triglycerides in overweight and obese people [21].

Discussion

Summary

In the present study, interactions were found between PBDs and WDs in cardiovascular risk factors (i.e. BP, LDL and triglyceride levels). A total of seven studies were included in this review and found that the PBDs (e.g. the MD) lowered BP, circulating LDL levels, and triglyceride levels in adults. Some studies found no effect between the adherence to a PBD and BP or LDL [22]. In contrast, WDs primarily increased LDL levels and/or BP [16-21]. Stronger effects were observed in studies that had longer durations [21]. Interestingly, when compared to vegetarian or vegan diets, PBDs showed an insignificant change in LDL and BP indicating that it might only be significantly lower when compared to WDs.

Mechanism of Action

The observed effects of PBDs on CVD parameters can potentially be attributed to I) the lower overall saturated and trans-fat intake, II) the modest presence of phytosterols (PS) in plant-based foods that provide a general positive cholesterol-lowering effect, and III) The higher content of soluble fibres in plant-based foods that aid in lowering BP and LDL cholesterol [23].

The first mechanism of action is associated with the lower saturated and trans-fat content of PBDs. Particularly, PBDs contain high quantities of unsaturated fats, such as linoleic acid and some omega-3 fatty acids [24]. On the contrary, WDs tend to have a higher content of saturated and trans-fats [25]. This distinction is important because the liver preferentially converts polyunsaturated fats into ketone bodies instead of LDL triglycerides [27]. The increase in HDL after consumption of a PBD helps remove excess LDL from the bloodstream and transports it to the liver for storage. Unsaturated fats found in plant foods function similarly by replacing saturated fats, thereby assisting in reducing triglyceride levels. Further, these fats inhibit the activity of enzymes involved in triglyceride synthesis, thus decreasing the liver's production of triglycerides [27].

The second mechanism of action contributing to health benefits of PBDs involves their cholesterol-lowering effects. A study conducted by Lin *et al.*, found that diets high in phytosterols (PS) resulted in decreased cholesterol absorption and increased excretion [28]. Notably, when PS are ingested, they are transported to the small intestine where they interfere with cholesterol absorption by creating a complex with cholesterol and bile acids. This complex is subsequently excreted from the body instead of being absorbed into the bloodstream. As a result, the amount of cholesterol circulating in the blood is reduced, which may explain the beneficial effects of PBDs found in the seven main studies.

Lastly, the higher intake of soluble fibers with PBDs has been shown to positively impact BP and LDL. Soluble fibers can absorb water and form gel-like substances which slow down cholesterol and carbohydrate absorption [23]. This, in turn, slows down the rate at which glucose enters the bloodstream, resulting in a more gradual increase in blood sugar levels [23]. Additionally, soluble fibres bind with bile acids in the intestine, decreasing the amount of cholesterol reabsorbed into the bloodstream [23]. These combined effects can result in decreased BP and LDL levels.

In contrast, WDs are high in saturated fats, which have shown to increase LDL and triglyceride levels in the body [29]. Saturated fats stimulate the liver to increase the production of LDL cholesterol by enhancing the activity of hydroxymethylglutaryl-CoA (HMG-CoA) reductase, an enzyme crucial in the rate-limiting step of cholesterol synthesis [30]. Moreover, saturated fats reduce the liver's ability to remove LDL by reducing the activity of LDL receptors present on the liver [31]. Trans fats act in a similar fashion, however they also disrupt the body's ability to remove LDL by decreasing the level of HDL cholesterol [32]. Collectively, these factors can predispose individuals following a WD to CVDs if LDL accumulates in their bloodstream [33].

The mechanism by which WDs increase BP is multifactorial. Firstly, WDs are high in sodium and low in potassium, which can lead to fluid retention and increased blood volume, resulting in increased BP [34]. The findings of a study conducted by Van Regenmortel *et al.*, supported this mechanism and found that administered sodium leads to prolonged fluid retention [35].

Moreover, high dietary sodium may trigger inflammation which can damage blood vessels and contribute to high BP. Notably, a study conducted by Gijsbers *et al.*, found that increased sodium levels increase endothelin-1, a potent vasoconstrictor and pro-inflammatory peptide, thus increasing BP [36]. Altogether, these harmful effects might explain the deleterious results found in the seven main studies that observed WDs.

Limitations of PBDs

Despite the beneficial effect of PBDs on lowering CVD risk factors, there are concerns over following this dietary pattern. One concern involves the presence of antinutrients such as phytic and oxalic acids, which have been associated with reduced bioavailability and decrease in calcium absorption [37]. Certain micronutrients such as zinc, which are essential for physiological processes and immunity, may exhibit lower bioavailability in plant-based foods [37]. The presence of natural substances in plant-based foods (e.g., soybeans, cruciferous vegetables, sweet potatoes, etc.) can interfere with iodine uptake by the thyroid [37]. As a result, metabolic activity may be dysregulated which can impede fetal development during pregnancy and in early childhood. Higher intakes of PBDs also raise concerns for higher risk of vitamin B12 and iron deficiencies. It is important to note that while these vital nutrients may be present in limited quantities in PBDs, supplementation is an option [38].

Strengths and Limitations

There were several strengths of this review including a detailed inclusion and exclusion criterion. Given all studies published prior to 2015 were excluded, all the data presented was relevant and up to date. Furthermore, the definition of PBDs used for the purposes of this review was broad and not limited to vegan or vegetarian diets. As such, the results are more generalizable and applicable to a greater variety of populations.

There were also several limitations such as the small sample sizes of the studies included only two papers included study samples sizes that are greater than 200 participants [20,21]. These small sample sizes make it challenging to generalize results. Larger sample sizes can better determine the effect of WDs and PBDs on BP and LDL levels. Moreover, the studies included in the paper have short intervention duration; five of the seven studies included interventions that ran for less than or equal to a year. The limited intervention duration makes it challenging to determine the long-term effects of the diet plan. Longer intervention durations can better extrapolate effects of WDs and PBDs. Additionally, it is difficult to determine patient compliance to the intervention plans. For example, the study conducted by Barnard *et al.*, indicated high self-reported adherence however actual compliance cannot be determined [16]. Low patient compliance makes it difficult to determine the causal relationships between the intervention (i.e., PBDs or WDs), and the chosen outcome measures (i.e., LDL and BP).

Conclusion

This literature review compares the effects of PBDs and WDs on CVD risk factors and analyses potential mechanisms of actions to explain these effects. The results of this review indicate the potential benefits of PBDs in reducing CVD risk factors such as BP, LDL levels, and triglycerides. In contrast, WDs were associated with a general increase in these CVD risk factors. These findings suggest a shift towards a PBD may be useful in interventions aiming to reduce CVD risk. They also highlight the potential advantages and disadvantages of PBDs as an intervention plan for CVD risk reduction. This review also demonstrated the need for more experimental studies with longer durations that compare the differences between WDs and PBDs on CVD risk factors.

List of Abbreviations Used

URNCST: undergraduate research in natural and clinical science and technology
CVD: cardiovascular disease
HR: heart rate
BP: blood pressure
LDL: low-density lipoprotein
HDL: high-density lipoprotein
PBD: plant-based diet
MD: Mediterranean diet
WD: Western diet
SBP: systolic blood pressure
DBP: diastolic blood pressure
cRCT: randomized controlled crossover trial
Ox-LDL: oxidative low-density lipoprotein
TEM: tocopherol-enriched Mediterranean meal
HFM: high-fat meal
PD: parallel design
HD: healthy diet
TAG: triacylglycerol
PS: phytosterols

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Ethics Approval and/or Participant Consent

This study did not require ethics approval and/or participant consent because it was a review.

Authors' Contributions

AP: Made substantial contributions to the data collection, database search, and data analysis. They also contributed to the design of the study and the writing of the manuscript.
RAR: Contributed significantly to the data collection and data analysis. They also contributed to the writing of the manuscript and final edits.

Acknowledgements
We thank Patricia Acosta who mentored us throughout the development of the paper. She also provided technical help and writing assistance.

Funding
This study was not funded.

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Article Information
Managing Editor: Jeremy Y. Ng
Peer Reviewers: Patricia Acosta, Miriam Basta
Article Dates: Received Apr 10 23; Accepted Jun 15 28; Published Jul 28 23

Citation
Please cite this article as follows:
Philippi A, Al-Rawi R. Comparing the effects of plant-based diets and Western diets on cardiovascular disease risk factors: A review.
URNCST Journal. 2023 Jul 28: 7(7). https://urncst.com/index.php/urncst/article/view/488
DOI Link: https://doi.org/10.26685/urncst.488