Review Of
DIABETIC
STUDIES
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# The Effect Of Dietary Interventions On Arterial Stiffness In Men. A Systematic Review Of The Literature

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**Abstract**

**Background and introduction**

Cardiovascular diseases (CVDs) are the leading cause of death globally, encompassing conditions like coronary heart disease and strokes. Risk factors include hypertension, diabetes, and lifestyle choices such as smoking. Arterial stiffness is a crucial risk factor in hypertension, refers to the reduced flexibility of the arterial walls. This condition arises as blood vessels age and is associated with various cardiovascular diseases. Studies have shown that dietary interventions can significantly reduce CVD risks by improving factors like blood pressure and arterial stiffness, particularly in men. This paper is to systematically review the current literature on the effects of different dietary interventions on arterial stiffness in men

**Methodology**

This systematic review adheres to PRISMA guidelines, employing a flow diagram to outline the article selection process, focusing on adult males at risk for cardiovascular diseases. It assesses the impact of dietary interventions on arterial stiffness, measured by carotid-femoral pulse wave velocity (PWV). The review specifically includes randomized controlled trials (RCTs) published from January 2015 to June 2024 that are in English and utilize PWV for measuring arterial stiffness. Excluded are non-RCT studies, those combining diet with exercise, and those involving females, children, or mixed groups. Primary outcomes are changes in PWV, while secondary outcomes include variations in systolic blood pressure, heart rate, and triglycerides.

**Results**

The systematic review process identified five randomized controlled trials (RCTs) met the inclusion criteria out of an initial 1,131 papers after rigorous screening. Only one study using cocoa flavanol intervention achieved significant reduction on the pulse wave velocity, the same study also showed significant decrease in systolic blood pressure, also another study showed significant reduction in systolic blood pressure after consumption of high fat beef patties.

**Conclusion**

This review indicated that cocoa flavanols can significantly improve arterial stiffness and systolic blood pressure, but other dietary interventions lacked similar impactful results. The findings suggest that effective strategies might need to integrate diet with exercise and other lifestyle changes to significantly enhance cardiovascular health.

**Keywords:** arterial stiffness, cardiovascular disease, pulse wave velocity, nutrition, diet, men.

## Introduction

For many years, cardiovascular diseases have been the top cause of death worldwide. In 2021, cardiovascular conditions led to the deaths of 20.5 million individuals (Cesare et al, 2023). CVDs include various disorders of the heart and blood vessels, such as coronary heart disease, cerebrovascular disease, rheumatic heart disease, and other conditions. More than 80% of deaths from CVDs are due to heart attacks and strokes, with one-third of these fatalities occurring prematurely in people under 70 years' old (WHO, n.d). CVDs encompass various types, with four main categories being coronary heart disease, strokes and transient ischemic attacks (TIAs), peripheral arterial disease, and aortic disease. Coronary heart disease happens when oxygen-rich blood flow to the heart muscle is obstructed or reduced. Strokes happen when the brain's blood supply is cut off, potentially causing brain damage or death, while TIAs, or "mini-strokes," involve temporary disruptions in blood flow to the brain. Peripheral arterial disease involves blockages in the arteries supplying the limbs, typically the legs. Aortic diseases affect the aorta, the largest blood vessel in the body, responsible for transporting blood from the heart to the rest of the body (NHS, 2022). The most common form of cardiovascular disease, ischemic heart disease, is a widespread and fatal condition that can result in acute myocardial infarction (AMI). (Virani et al, 2020). When it comes to the risk factors for cardiovascular diseases, the most common ones include hypertension (which acts as both a cardiovascular disease itself and a risk factor for other cardiovascular issues), Diabetes Mellitus, dyslipidemia, obesity, smoking, and age. These factors are also key contributors to the development and progression of atherosclerosis (Garcia et al, 2016) (Keto et al, 2016).

As for hypertension, it can be defined as when systolic blood pressure of at least 140 mm Hg, a diastolic blood pressure of at least 90 mm Hg, or both, as measured in a clinic or office setting (NICE, 2019). A key indicator of risk in hypertension is arterial stiffness, can be assessed at material or structural levels. Structural assessment includes the effects of the wall's geometry and composition, as well as the organization within the wall itself (Boutouyrie et al, 2021). Arterial stiffness refers to the inflexibility of the arterial wall, occurs due to aging of the blood vessels and is linked to a wide range of cardiovascular diseases (Luca et al, 2022). In 2019, heart and circulatory diseases caused the deaths of an estimated 9.8 million men and 9.2 million women worldwide. Additionally, about 110 million men and 80 million women globally have coronary heart disease (British Heart Foundation, 2024). The reason behind men being more at risk for CVDs is because of testosterone which is the primary hormone responsible for male sexual characteristics. As men get older, levels of testosterone generally decline (Kloner et al, 2016). A meta-analysis of 70 studies by Corona et al, (2011) showed that lower testosterone correlates with increased risk of CVD mortality.

Based on the evidence indicating a higher likelihood of cardiovascular disease in males, it is important to explore various dietary interventions in this field more thoroughly. PWV independently predicts the longitudinal increase in systolic blood pressure (SBP) and the onset of hypertension, this indicates that PWV could help identify normotensive individuals who should be targeted for interventions to prevent or delay the progression of subclinical arterial stiffening and the onset of hypertension (Najjar et al, 2008). Any alterations in PWV function can elevate the risk of myocardial infarction, heart failure, stroke, and kidney disease (Palombo and Kozakova, 2016). Healthy habits are essential for preventing CVDs. Nutrition, combined with regular exercise, smoking cessation, and adequate rest, forms the foundation of a healthy lifestyle, strong evidence supports the link between diet and increased risk of CVD, with nutritional factors estimated to account for approximately 40% of all CVD cases (Bendich and Deckelbaum, 2010).

There are many dietary interventions to mitigate the risk of CVD consequences, the Mediterranean diet and DASH (Dietary Approaches to Stop Hypertension) diets are widely studied for their effectiveness in reducing CVDs risk. They both encourage consuming fruits, vegetables, whole grains, and legumes. The DASH diet focuses on limiting sodium, saturated fats, and total fat intake, whereas the Mediterranean diet emphasizes the consumption of unsaturated fatty acids (Lorente et al, 2023). In a 1-Year European Multi-Center Trial by Jennings et al (2019), 1294 participants aged 65-79 were recruited, the study involved an intervention group receiving a Mediterranean-style diet and a control group continuing their usual diet. The results showed a significant reduction in systolic blood pressure (SBP) by 5.5 mm Hg in the intervention group, particularly in males, who also experienced a decrease in pulse pressure. Additionally, there was an increase in 24-hour urinary potassium and a decrease in urinary sodium in males. In terms of arterial stiffness, the intervention group showed a significant improvement in the augmentation index, especially in females, with no change in PWV. Overall, the Mediterranean-style diet led to clinically relevant improvements in older adults in cardiovascular health, with notable reductions in blood pressure and arterial stiffness. In a systematic review by Pase et al (2011) examines the efficacy of dietary and nutrient interventions in reducing arterial stiffness, the review included 38 relevant randomized controlled trials, finding that supplementation with omega-3 polyunsaturated fatty acids (PUFAs), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), and soy isoflavones significantly reduced arterial stiffness. Salt restriction and fermented milk products containing bioactive peptides also showed moderate benefits. However, there was insufficient evidence for the efficacy of vitamins and micronutrients, while caffeine intake acutely increased arterial stiffness, the review also concluded that omega-3 and soy isoflavone supplementation are effective for reducing arterial stiffness. Nevertheless, there are no recent reviews investigating the impact of diet on improving arterial stiffness in men. The aim of this paper is to systematically review the current literature on the effects of different dietary interventions on arterial stiffness in men.

## Methodology

### Search strategy

According to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020), this systematic review utilized a PRISMA flow diagram (see Figure 1 in the results) to depict the process of selecting articles. The search strategy included screening PubMed and Medline databases for English-language papers published from employing the following keywords (arterial stiffness) (vascular function) (cardiovascular disease) (Pulse Wave Velocity) (nutrition) (diet) (dietary intervention) (men) (male).

The PICO model was followed in this review as shown in table1.

**Table1**. PICO model

| | |
|---|---|
| Population | adult male participants who are either at baseline risk for cardiovascular diseases or who may become at risk as a result of their participation in the study |
| Intervention | trials using a specific dietary intervention or a dietary supplement |
| Comparison | different dietary intervention than the intervention group |
| Outcome | improvement in the arterial stiffness measured by carotid-femoral Pulse wave velocity (m/s). |

### Inclusion criteria

This systematic review included only randomized controlled trials (RCTs) published between January 2015 to June 2024 involving adult male participants who are either at baseline risk for cardiovascular diseases or who may become at risk as a result of their participation that focus solely on specific dietary or supplement interventions. These studies must be written in English and utilize carotid-femoral pulse wave velocity as the method for measuring arterial stiffness.

### Exclusion criteria

Excluded from this systematic review studies that are secondary researches such as systematic reviews, also case control, cross-sectional, cohort studies or any other studies that are not RCTs, studies published before January 2015, those involving females, children or mixed groups, trials that combine dietary or supplement interventions with physical exercise, studies not in English, and studies using methods other than carotid-femoral pulse wave velocity to measure arterial stiffness.

**Primary Outcome**

Changes in pulse wave velocity measured by carotid-femoral Pulse wave velocity (m/s).

**Secondary Outcome**

Changes in systolic blood pressure (mmHg).

Changes in heart rate (bpm).

Changes in triglycerides (mM).

**Data Extraction**

We employed Rayyan software (Ouzzani et al, 2016), to detect duplicate papers and perform initial screening of titles and abstracts, ensuring a blind and efficient data extraction process, Data collection covered various elements such as publication details, study design, characteristics of participants, type of intervention and its duration, as well as baseline and post-intervention outcomes including carotid-femoral pulse wave velocity, systolic blood pressure, heart rate, and triglycerides.

The five selected studies underwent evaluation for methodological quality using the updated Cochrane risk-of-bias assessment tool for randomized trials (RoB 2), developed by Sterne et al. (2019). This assessment specifically addressed five essential domains: randomization procedures, adherence to intended interventions, handling of missing outcome data, accuracy in outcome measurement, and selection of reported results. (see Table 2).

**Data Management and Synthesis**

**Data Synthesis**

The data will be analyzed by examining mean differences (MD) values in conjunction with standard deviation (SD) to assess the impact of various dietary interventions on arterial stiffness. Given the substantial heterogeneity across studies concerning the nature of interventions and control groups, a meta-analysis was deemed inappropriate for this review. Nonetheless, the primary objective of this review is to investigate the effects of different dietary interventions on arterial stiffness in men and to identify which specific dietary interventions exert a significant influence on this physiological parameter.

**Results**

Initially, a search of PubMed and Medline databases using the keywords resulted in 1,131 papers. After removing 531 duplicates, 600 papers remained. Among these, 399 were excluded because they were not randomized controlled trials (RCTs), leaving 201. Further screening excluded 82 studies published before 2015. The full screening of the remaining 119 RCTs led to the exclusion of 39 papers that do not have a dietary intervention. An additional three papers were excluded because they involved study populations that were not the focus of this review; one study focused on children and two were exclusively on female participants. Also, 69 trials that included both male and female participants were removed to maintain a homogeneous study group. This process narrowed the selection to eight RCTs. Of these, three were excluded because they combined dietary interventions with physical activity, which could potentially affect the results related to arterial stiffness from dietary changes alone.

Ultimately, five RCTs that exclusively studied the impact of dietary interventions on male participants were selected for in-depth analysis. The studies included in our final review are from diverse researchers: Heiss et al. (2015) conducted a randomized control double-masked trial involving 42 participants over a 14-day trial period; Lytle et al. (2023) executed a double-blind crossover trial that lasted 5 weeks with an additional 4 weeks' washout period including 23 participants; Agbalalah and Mushtaq (2023) carried out a pilot randomized control trial over eight weeks with 55 participants; Schär et al. (2015) conducted a randomized placebo-controlled crossover trial with 16 participants; and Tripkovic et al. (2015) implemented a randomized controlled crossover study involving ten participants over a 4-week intervention period followed by a 4-week washout period. All these RCTs included a total of 146 male participants. One study was conducted in the United States (Lytle et al., 2023), three in the United Kingdom (Tripkovic et al., 2015), (Agbalalah and Mushtaq 2023) and (Schär et al, 2015) and finally Heiss et al., 2015 study was conducted in Germany.

**Risk of bias in the included studies**

Agbalalah and Mushtaq (2023) and Tripkovic et al, (2015) both showed a low risk of bias across all domains, Heiss et al, (2015) and Lytle et al, (2023) were judged of having some concerns, while Schär et al, (2015) showed high risk in the overall judgement.

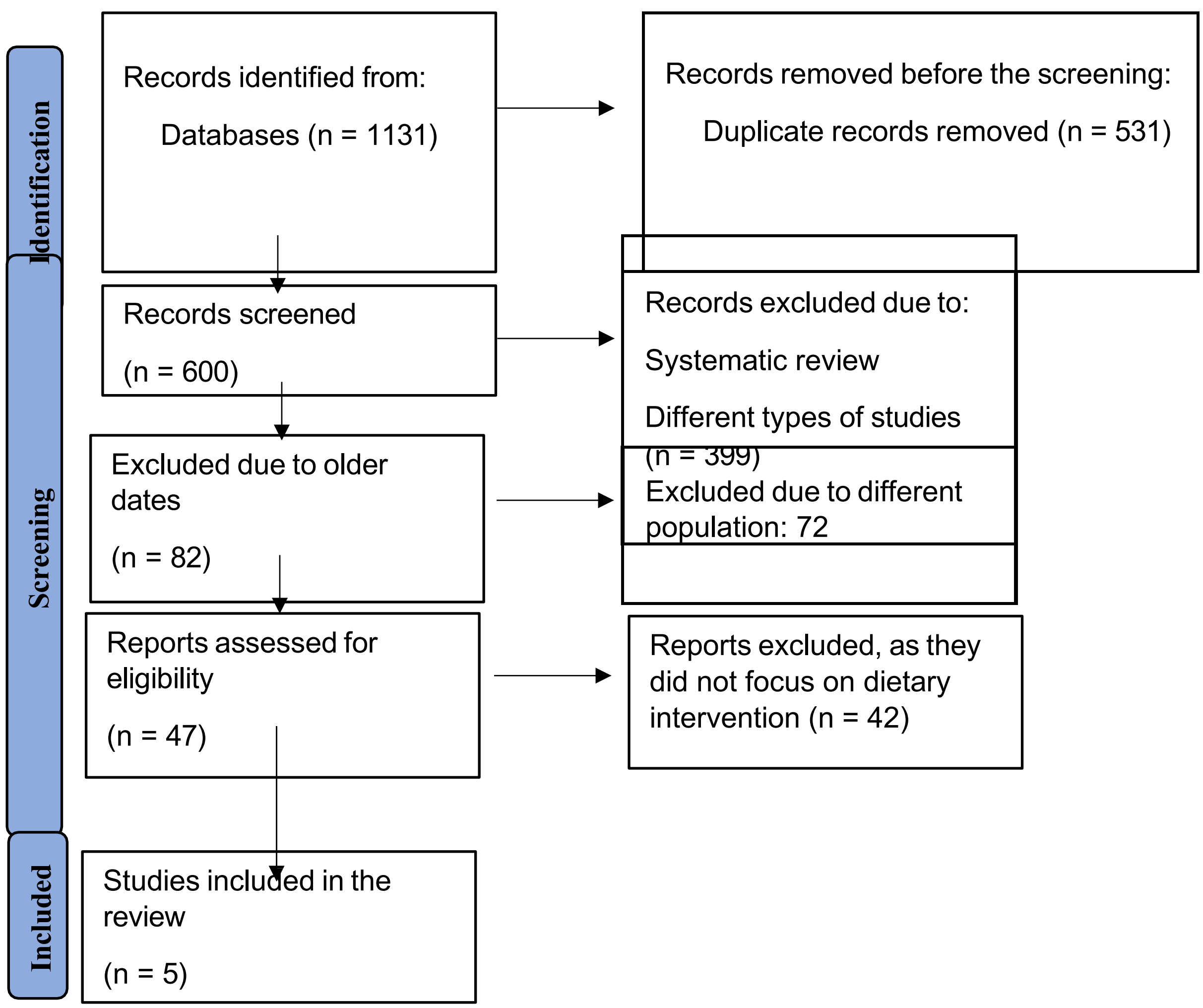

Figure 1: PRISMA flowchart demonstrating the selection of articles included in the review.

**Table2.** Risk of Bias Judgment.

| Author | Randomization process | Intended interventions | Missing outcome | Measurement of the outcome | Outcome selection of the reported result | Overall risk-of-bias judgement |
|---|---|---|---|---|---|---|
| Agbalalah and Mushtaq (2023) | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk |
| Heiss et al, (2015) | Low risk | Low risk | Some concerns | Low risk | Low risk | Some concerns |
| Lytle et al, (2023) | Low risk | Low risk | Low risk | Some concerns | Low risk | Some concerns |
| Schär et al, (2015) | High risk | High risk | Low risk | Low risk | Low risk | High risk |
| Tripkovic et al, (2015) | Low risk | Low risk | Low risk | Low risk | Low risk | Low risk |

**Table3.** Baseline characteristics of the selected studies.

| Author | Duration | N of participants | Design | Age (years) | Intervention | Control Group |
|---|---|---|---|---|---|---|
| Agbalalah and Mushtaq (2023) | 8 weeks | 55 | pilot randomized control | 18-65 years old | 5000 IU vitamin d3/d | placebo |
| Heiss et al, (2015) | 14 days | 42 | randomized control double-masked | Mean age 26 in young group, mean age 60 in elderly | two 500 ml drinks of cocoa flavanols\d containing 900 mg cocoa flavanols | Placebo |
| Lytle et al, (2023) | 9 weeks | 23 | double-blind crossover | Mean age 39.9 | Low fat beef (5%) or high fat beef (25%) 115 g meat patty 5 times a week | Each participants receive the opposite after the washout |
| Schär et al, (2015) | Same day | 16 | randomized placebo-controlled crossover | Mean age 61 | 320 mg hesperidin in orange juice or supplement | placebo |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tripkovic et al, (2015) | 8 weeks | 10 | randomized controlled crossover | 39.8 mean age | 15 g of inulin or wheat fiber\d in bread rolls or Refined bread rolls | Each participants receive the opposite after the washout |

**Table4.** results of carotid-formal pulse wave velocity.

| Author | Intervention Baseline | Intervention Outcome | Control baseline | Control outcome | p value |
|---|---|---|---|---|---|
| Agbalalah and Mushtaq (2023) | 6.5 ± 1.1 | 6.4 ± 0.8 | 6.5 ± 1.1 | 6.3 ± 0.9 | P= 0.4 |
| Heiss et al, (2015) | 9.3 ± 0.5 in elderly 6.0 ± 0.1 in young | 8.5 ± 0.4 in elderly 5.6 ± 0.1 in young | 9.4 ± 0.4 in elderly, 5.9 ± 0.2 in young | 9.3 ± 0.5 in elderly, 6.0 ± 0.1 in young | P= 0.05 in both |
| Lytle et al, (2023) | 7.20 | HFB group increases to 7.32 | 7.20 | LFB decreased to 6.95 | P= >0.05 |
| Schär et al, (2015) | 9.9 ± 6 0.3 in OJ group, in supplement group 9.6 ± 0.5 | 9.8 ± 0.3 in OJ group, 9.9 ± 0.4 in supplement | 9.7 ± 0.4 | 9.8 ± 0.3 | P= 0.77 |
| Tripkovic et al, (2015) | 7.79 ±1.78 | Wheat fiber group decreased to 7.66±1.42 and inulin group increased to 6.91±0.68 | 7.79 ±1.78 | 7.36 ± 1.21 | P= >0.05 |

**Table5.** results of systolic blood pressure.

| Author | Intervention Baseline | Intervention Outcome | Control baseline | Control outcome | p value |
|---|---|---|---|---|---|
| Agbalalah and Mushtaq (2023) | 128.7 ± 11.1 | 127.8 ± 11.0 | 131.2 ± 12.8 | 135.5 ± 13.0 | P= 0.09 |
| Heiss et al, (2015) | 127 ± 6 in elderly, 104 ± 3 in young | 120 ± 5 in elderly, to 103 ± 4 in young | 122 ± 2 in elderly, 105 ± 2 in young | 119 ± 4 in elderly, 103 ± 2 in young | P = 0.05 in elderly. P= >0.05 in young |
| Lytle et al, (2023) | 122.5 | 116.1 in HBF | 122.5 | 120.6 in LBF | P= 0.04 |
| Schär et al, (2015) | 126.3 ± 1.8 in OJ , 127.1 ± 2.0 in supplement group | 123.6 ± 2.9 in OJ, 123.9 ± 2.5 in supplement group | 128.2 ± 2.2 | 123.6 ± 1.8 | P= 0.87 |

| | | | | | |
|---|---|---|---|---|---|
| Tripkovic et al, (2015) | 124.8±9.5 | 126.8±8.0 in wheat fiber, 125.2±11.6 in inulin | 124.8±9.5 | 121.5 ± 11.2 | P= >0.05 |

Abbreviations: HFB= high fat beef, LFB= low fat beef, OJ= orange juice, N/A= not available, p-value not significant if p= >0.05.

**Table6.** results of heart rate.

| Author | Intervention Baseline | Intervention Outcome | Control baseline | Control outcome | p value |
|---|---|---|---|---|---|
| Agbalalah and Mushtaq (2023) | 62.3 ± 12.3 | 61.7 ± 11.7 | 60.9 ± 10.8 | 60.9 ± 11.0 | P = 0.9 |
| Heiss et al, (2015) | 57 ± 2 in elderly, 59 ± 1 in young | 59 ±2 in elderly, 60 ± 3 in young | 56 ± 3 in elderly, 57 ± 3 in young | 60 ± 3 in elderly, 58 ± 2 in young | N/A |
| Schär et al, (2015 | 53.9±1.9 in OJ, 54.5±2.1 in supplement group | 58.4±2.2 in OJ, 58.3±2.0 in supplement group | 54.9 ± 2.0 | 58.6 ± 2.2 | 0.74 |

Abbreviations: HFB= high fat beef, LFB= low fat beef, OJ= orange juice, N/A= not available, p-value not significant if p= >0.05.

**Primary Outcome**

All of the five studies have measured arterial stiffness using carotid-femoral pulse wave velocity(m/s), In the study by Agbalalah and Mushtaq (2023), there were a total of 55 male participants involved. The intervention group received 5000 IU vitamin d3 per day for 8 weeks and the control group received placebo, the PWV remained relatively stable, measuring 6.5 ± 1.1 m/s at baseline and changing minimally to 6.4 ± 0.8 m/s at the end of the 8-week period, similarly in the control group, there was no significant change, with PWV starting at 6.5 ± 1.1 m/s at baseline and slightly decreasing to 6.3 ± 0.9 m/s at the end of the study, p-value indicating no significant results (0.4). in Heiss et al, (2015) study which included 42 participants including young males with mean age of 26 and elderly males with mean age of 60, the intervention group consumed a drink containing 450 mg of cocoa flavanols twice daily. The drink was a low-calorie fruit-flavored beverage mix, which included high flavanol cocoa extract as the source of flavanols, while the control group received a nutrient-matched, cocoa flavanol-free control drink, the PWV showed a significant change in the intervention group in both young and elderly males after 14 days p- value (0.5), in the elderlies PWV decreased from 9.3 ± 0.5 m/s to 8.5 ± 0.4 m/s, while in the young group PWV decreased from 6.0 ± 0.1 m/s to 5.6 ± 0.1 m/s, while the control group did not show any significant results, in the elderly it decreased only slightly from 9.4 ± 0.4 m/s to 9.3 ± 0.5 m/s, on the contrary the young group showed a slight increase in PWV from 5.9 ± 0.2 m/s to 6.0 ± 0.1 m/s.

Continuing on, in Lytle et al, (2023) trial, 23 males Participants underwent two dietary interventions, each lasting 5 weeks one with low-fat ground beef (~5% fat) and the other with high-fat ground beef (~25% fat), separated by a 4-week washout period to clear the effects of the first intervention before starting the second, both groups had mean PWV of 7.20 m/s, the high fat ground beef group experienced a slight but not significant increase from 7.20 m/s to 7.32 m/s, while the low fat ground beef showed a small also not significant decrease from 7.20 m/s to 6.95 m/s. In addition, Schär et al, (2015) study involved 16 healthy men aged 51-69 years, it was a crossover trial where each participant received three different treatments (orange juice, hesperidin supplement, and control) each on separate occasions, the intervention group received 320 mg of hesperidin either in a supplement or orange juice, while the control received matching beverage for sugars and vitamin C content but without hesperidin, baseline in the control group was 9.7 ± 0.4 and 9.8 ± 0.3 after 5 hours, the orange juice group showed a slight decrease from a baseline of 9.9 ± 0.3 m/s to 9.8 ± 0.3 m/s at 5 hours post-intervention. Conversely, for the hesperidin supplement group, PWV increased from a baseline of 9.6 ± 0.5 m/s to 9.9 ± 0.4 m/s after 5 hours. Lastly, Tripkovic et al, (2015) investigated the effect of consuming bread rolls containing either 15 mg of wheat fiber or 15 mg of inulin or refined wheat grain (control), on top of their regular diet. Each intervention lasted for 28 days with a 4-week washout period between each phase, the study involved ten male participants, aged between 30 and 55 years. At the beginning of the study PWV was measured at 7.79 ±1.78 m/s and decreased to 7.66±1.42 m/s in the wheat group, also the inulin group decreased to 7.66±1.42 m/s, and for the control group PWV measurement also decreased to 7.36 ± 1.21, there were no significant changes in all 3 groups.

**Secondary Outcomes**

**Systolic blood pressure**

All of the five studies measure systolic blood pressure in all groups, In the study by Agbalalah and Mushtaq (2023), SBP results from baseline to week 8 showed minor fluctuations. In the vitamin D group, SBP slightly decreased from a baseline of 128.7 ± 11.1 mmHg to 127.8 ± 11.0 mmHg at week 8. Conversely, the placebo group experienced an increase in SBP from 131.2 ± 12.8 mmHg at baseline to 135.5 ± 13.0 mmHg by the end of the study. These changes were not statistically significant, p- value = 0.099.

In Heiss et al, (2015) study, the SBP baseline for the intervention group in young participants was 104 ± 3 mmHg and decreased to 103 ± 4 mmHg after 14 days, while the control group also decreased but not significantly from 105 ± 2 mmHg to 103 ± 2 mmHg, in the elderly group the intervention SBP was 127 ± 6 mmHg and decreased significantly to 120 ± 5 mmHg after the end of the trial, $p<0.05$, while the control group also experienced a decrease from 122 ± 2 mmHg to 119 ± 4 mmHg but not statistically significant.

In addition, Lytle et al, (2023) SBP baseline was Baseline was 122.5 in both groups, HBF decreased to 116.1 mmHg and LFB decreased to 120.6 mmHg, indicating that SBP was reduced in HFB intervention compared to LFB, p-value= 0.04. However, during the washout period, SBP was lower than it was at the LFB and initial visit time (p = 0.02 and 0.01, respectively). There were no significant differences in SBP between the washout period and the HFB intervention (p = 0.80).

Schär et al, (2015) study, SBP baseline for the orange juice group was 126.3 ± 1.8 mmHg and changed to 123.6 ± 2.9 mmHg, in the hesperidin supplement group they started at 127.1 ± 2.0 mmHg and ended at 123.9 ± 2.5 mmHg, while the control group started at 128.2 ± 2.2 mmHg and decreased to 123.6 ± 1.8 mmHg after 5 hours, none of the results are statistically significant compared to each other.

Finally, in Tripkovic et al, (2015) trial, Baseline was 124.8 ± 9.5 mmHg for all groups, in the wheat fiber SBP increased to 126.8 ± 8.0 mmHg, and in the inulin group also it increased to 125.2 ± 11.6 mmHg, while the control group decreased to 121.5 ± 11.2 mmHg, there were no significant differences between the groups in these changes.

**Heart rate**

Only three of the studies included in this systematic review given measurements of heart rate, in Agbalalah and Mushtaq (2023) study, the intervention group HR baseline was 62.3 ± 12.3 bpm and decreased to 61.7 ± 11.7 bpm after 8 weeks, while the placebo group started at 60.9 ± 10.8 bpm and stayed around that number at the end of trial 60.9 ± 11.0 bpm, the changes are not statistically different in both groups.

In Heiss et al, (2015) study, the young group in control started at 57 ± 3 bpm and finished the trial at 58 ± 2 bpm, the intervention also changed from 59 ± 1 bpm to 60 ± 3 bpm with no statistical difference between both groups, while the elderly group started at 56 ± 3 bpm in control and changed to 58 ± 2 bpm at the end, while the intervention group started at 57 ± 2 bpm and increased to 59 ±2 bpm, also in this group the results are not significant.

In Schär et al, (2015) study, Baseline was 53.9 ± 1.9 bpm and increased to 58.4±2.2 bpm in the orange juice group, in the supplement group baseline was 54.5 ± 2.1 bpm and increased to 58.3 ± 2.0 bpm, in the control group baseline was 54.9 ± 2.0 bpm and increased to 58.6 ± 2.2 bpm at the end, no significant differences between all groups.

**Triglycerides**

Only Tripkovic et al, (2015) trial gave results for triglycerides level, all groups started with a baseline triglyceride level of 1.65 ± 0.42 mM. By the end of the intervention, the triglyceride levels changed as follows: The Control Group increased to 1.79 ± 0.61 mM, the Inulin Group rose to 2.08 ± 0.86 mM, marking a significant increase, and the Wheat Fibre Group escalated to 2.23 ± 0.94 mM also a significant increase.

**Discussion**

The exploration of the selected studies reveals some variations in the effectiveness of dietary interventions on arterial stiffness among male participants, as measured by PWV. This variation can primarily be attributed to the differences in study design, intervention types, and methodological rigor, each of which plays a crucial role in interpreting the significance and implications of the results. Among the reviewed studies, only one reported a significant reduction in PWV, both in young and elderly male participants, the same study also showed significant reduction in SPB along with another study after consuming the high fat beef patties. Only one study showed significant results in triglycerides after consuming wheat fiber or inulin in bread.

This significant outcome suggests that cocoa flavanols may have a potent effect on vascular function, potentially due to their antioxidant and anti-inflammatory properties that enhance endothelial function (Martin, M.Á. and Ramos, 2021). This is a notable finding as it indicates a rapid improvement in arterial stiffness, which is a crucial predictor of cardiovascular risk. The substantial effect observed in both age groups further underscores the potential universal benefit of flavanol-rich interventions, regardless of age.

In contrast, other studies did not demonstrate significant changes in PWV. These outcomes may be due to several factors such as duration of the study, type of study and the sample size, shorter intervention periods, as seen in Schär et al. (2015), might not be sufficient to witness significant changes in arterial stiffness, and short-term interventions might not alter the structural and functional properties of arterial walls significantly, also the ineffectiveness observed in studies using vitamin D3, different fat contents, hesperidin, and dietary fibers might suggest that these substances either do not directly affect PWV or that the dosages were insufficient. In addition, smaller sample sizes in some studies, like that by Tripkovic et al. (2015), which involved only ten participants, may not provide enough statistical power to detect significant differences, thereby potentially underestimating the effects of the interventions.

The variations in the results across these studies also highlight the complexity of nutritional impacts on cardiovascular health. The lack of significant findings in other parameters such as systolic blood pressure, triglycerides and heart rate across most studies further complicates the understanding of how dietary components might interact with vascular function. It suggests that while certain nutrients like cocoa flavanols show promise, others might require more nuanced or combined approaches to effectively influence cardiovascular risk markers such as arterial stiffness.

As for the effect of cocoa flavanols on cardiovascular functions, this is consistent with a systematic review and meta-analysis by (Buitrago-Lopez et al, 2015), their findings suggest a beneficial effect of higher chocolate consumption resulting in a 37% reduction in cardiovascular disease risk and a 29% reduction in stroke risk among the 114,009 participants included. Also Gong et al, (2017) conducted a meta-analysis of prospective studies to assess the impact of chocolate consumption on preventing heart failure including

106,109 participants, they found that low to moderate chocolate consumption is associated with a reduced risk of heart failure compared to no chocolate consumption. In addition, the latest meta-analysis, which reviewed 23 prospective studies involving 405,304 participants, also examined the dose-response relationships between chocolate intake and the incidence of CVD, the findings suggested that consuming 45 grams of chocolate per week is the ideal amount for lowering the risk of cardiovascular disease (CVD), whereas consuming higher amounts could lead to negative effects due to excessive sugar intake. (Ren et al, 2019). However, all of those studies involved both male and female participants unlike this systematic review. For instance, despite they are widely researched and used, vitamin D supplements did not make any significant changes especially in PWV and SBP after 5000 IU every day for 8 weeks, Rodríguez et al. (2016) in their systematic review and meta-analysis of randomized controlled trials, including 18 RCTs which were aimed at investigating the effect of vitamin D supplements on cardiovascular functions especially PWV, they concluded that the current evidence does not definitively support vitamin D supplementation for reducing arterial stiffness, as the observed benefits in clinical trials are not significant.

Another thing to consider is that the different intervention applied in the RCTs reviewed in this systematic review were all conducted without including any dietary consultations or physical activity which both could make a significant impact on the cardiovascular biomarkers especially physical activity, in a study that examined 46 healthy, active men who had been consistently participating in resistance training for at least two years to study how different training loads affect arterial stiffness in young adults. The study was conducted over 12 weeks and involved two groups: one performed resistance training with heavier weights and fewer repetitions, while the other used lighter weights with more repetitions. Both groups experienced a decrease in central arterial stiffness, as indicated by the carotid-femoral pulse wave velocity, but there were no significant changes in local arterial stiffness or left ventricular mass (Au et al, 2017). In addition, a recent cross-sectional study included 1,200 males aged 20-49 and explored the immediate impact of aerobic exercise on arterial stiffness. It suggests that just one session of aerobic exercise can positively affect arterial stiffness, with more significant effects seen in individuals without hypertension. These findings highlight the potential of exercise as a preventive measure against cardiovascular diseases associated with increased arterial stiffness (Zang et al, 2022). Interestingly, in a randomized controlled trial comparing the intensive lifestyle treatment with standard care including 76 adults with stage 1 hypertension, the intervention group received intensive lifestyle treatment, which included detailed monthly nutritional counseling and exercise recommendations based on the European Society of Hypertension guidelines while the control received standard care, which consisted of basic lifestyle modification advice according to the same guidelines but was less detailed and frequent, the results for the intensive lifestyle treatment group were mostly significant after combining dietary consultation and exercise including cardiovascular biomarkers such as arterial stiffness, systolic blood pressure and also the lipid profile including total cholesterol and triglycerides compared to the control group (Vamvakis et al, 2020). These results underscore the potential benefits of a structured, intensive program of diet and exercise in managing stage 1 hypertension, improving arterial health, and reducing cardiovascular risk factors.

The strengths of this review include a well-defined search strategy following PRISMA guidelines, the use of randomized controlled trials (RCTs) to ensure high-quality evidence, and a focus on a specific population which are males, these elements help in accurately assessing the impact of different dietary changes on arterial stiffness, offering credible insights into potential preventive strategies. However, the review faces limitations such as the short duration in most studies with the longest one lasting only for 8 weeks, the concerns of bias in the majority of the studies, also the relatively small number of participants with largest one including only 55 participants and finally the significant variability exists among studies in terms of the types of interventions and control groups used which made a meta-analysis an inappropriate for this review.

**Recommendations and Implications for Future Research and Clinical Practice**

Future investigations should focus on longer duration studies to fully capture the progressive effects of dietary interventions on arterial stiffness and other cardiovascular markers. Additionally, involving larger sample sizes would enhance the reliability of findings and allow for generalization to a broader population. Including a more diverse range of ethnic and age groups could provide deeper insights into how different populations respond to dietary interventions, which is crucial for personalized dietary recommendations. Moreover, combining dietary interventions with physical activity in future studies could provide a more holistic understanding of how lifestyle changes impact arterial stiffness and overall CVD risk. Encouraging an integrated approach that combines diet, exercise, and lifestyle modifications offers the best strategy for reducing CVD risk and should be promoted in clinical settings to effectively manage and prevent hypertension and related conditions.

## Conclusion

This systematic review aimed to evaluate the impact of various dietary interventions on arterial stiffness in male participants. The analysis revealed that while some interventions, such as cocoa flavanols, showed significant improvements in arterial stiffness and systolic blood pressure, most other interventions did not yield statistically significant results. This suggests that not all dietary interventions have the same impact on cardiovascular health, specifically arterial stiffness.

Overall, the study suggests that while certain dietary interventions, particularly those involving cocoa flavanols, may positively affect arterial stiffness, a more integrated approach combining diet, exercise, and lifestyle modifications might be necessary to achieve significant cardiovascular health improvements. Future research should focus on longer, larger-scale studies that consider a broader range of demographic factors and combine dietary interventions with physical activity to provide a more comprehensive understanding of their effects on cardiovascular risk.

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