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## Effects of chocolate, cocoa, and flavan-3-ols on cardiovascular health: a systematic review and meta-analysis of randomized trials

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### Abstract

**Background:** There is substantial interest in chocolate and flavan-3-ols for the prevention of cardiovascular disease (CVD).

**Objective:** The objective was to systematically review the effects of chocolate, cocoa, and flavan-3-ols on major CVD risk factors.

**Design:** We searched Medline, EMBASE, and Cochrane databases for randomized controlled trials (RCTs) of chocolate, cocoa, or flavan-3-ols. We contacted authors for additional data and conducted duplicate assessment of study inclusion, data extraction, validity, and random-effects meta-analyses.

**Results:** We included 42 acute or short-term chronic ( $\leq 18$  wk) RCTs that comprised 1297 participants. Insulin resistance (HOMA-IR: -0.67; 95% CI: -0.98, -0.36) was improved by chocolate or cocoa due to significant reductions in serum insulin. Flow-mediated dilatation (FMD) improved after chronic (1.34%; 95% CI: 1.00%, 1.68%) and acute (3.19%; 95% CI: 2.04%, 4.33%) intakes. Effects on HOMA-IR and FMD remained stable to sensitivity analyses. We observed reductions in diastolic blood pressure (BP; -1.60 mm Hg; 95% CI: -2.77, -0.43 mm Hg) and mean arterial pressure (-1.64 mm Hg; 95% CI: -3.27, -0.01 mm Hg) and marginally significant effects on LDL (-0.07 mmol/L; 95% CI: -0.13, 0.00 mmol/L) and HDL (0.03 mmol/L; 95% CI: 0.00, 0.06 mmol/L) cholesterol. Chocolate or cocoa improved FMD regardless of the dose consumed, whereas doses  $> 50$  mg epicatechin/d resulted in greater effects on systolic and diastolic BP. GRADE (Grading of Recommendations, Assessment, Development and Evaluation, a tool to assess quality of evidence and strength of recommendations) suggested low- to moderate-quality evidence of beneficial effects, with no suggestion of negative effects. The strength of evidence was lowered due to unclear reporting for allocation concealment, dropouts, missing data on outcomes, and heterogeneity in biomarker results in some studies.

**Conclusions:** We found consistent acute and chronic benefits of chocolate or cocoa on FMD and previously unreported promising effects on insulin and HOMA-IR. Larger, longer-duration, and independently funded trials are required to confirm the potential cardiovascular benefits of cocoa flavan-3-ols.

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