ORIGINAL ARTICLE

Effect of Dietary Pulses on Blood Pressure: A Systematic Review and Meta-analysis of Controlled Feeding Trials

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BACKGROUND
Current guidelines recommend diet and lifestyle modifications for primary prevention and treatment of hypertension, but do not encourage dietary pulses specifically for lowering blood pressure (BP). To quantify the effect of dietary pulse interventions on BP and provide evidence for their inclusion in dietary guidelines, a systematic review and meta-analysis of controlled feeding trials was conducted.

METHODS
MEDLINE, EMBASE, Cochrane Library, and CINAHL were each searched from inception through 5 May 2013. Human trials ≥3 weeks that reported data for systolic, diastolic, and/or mean arterial BPs were included. Two reviewers independently extracted data and assessed methodological quality and risk of bias of included studies. Effect estimates were pooled using random effects models, and reported as mean differences (MD) with 95% confidence intervals (CIs). Heterogeneity was assessed (χ^2 test) and quantified (I^2).

RESULTS
Eight isocaloric trials (n = 554 participants with and without hypertension) were included in the analysis. Dietary pulses, exchanged isocalorically for other foods, significantly lowered systolic (MD = −2.25 mm Hg (95% CI, −4.22 to −0.28), *P* = 0.03) and mean arterial BP (MD = −0.75 mm Hg (95% CI, −1.44 to −0.06), P = 0.03), and diastolic BP non-significantly (MD = −0.71 mm Hg (95% CI, −1.74 to 0.31), *P* = 0.17). Heterogeneity was significant for all outcomes.

CONCLUSIONS
Dietary pulses significantly lowered BP in people with and without hypertension. Higher-quality large-scale trials are needed to support these findings.

CLINICAL TRIAL REGISTRATION
NCT01594567

Keywords: blood pressure; dietary pulses; hypertension; legumes; meta-analysis; guidelines.

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Elevated blood pressure (BP) is a significant risk factor for stroke, cardiovascular disease (CVD), and renal failure.[1] Even before progressing to hypertension (systolic BP (SBP) ≥140 mm Hg or diastolic BP (DBP) ≥90 mm Hg), individuals with prehypertension (120 mm Hg ≤ SBP ≤ 139 mm Hg or 80 mm Hg ≤ DBP ≤ 89 mm Hg)[1–3] are at an elevated risk of

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developing hypertension and its associated complications.[4–6] The prevalence of prehypertension in North America is estimated to be 31%.[7]

The American Heart/Stroke Associations (AHA/ASA);[8] the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7);[1] the Canadian Hypertension Education Program;[3] and the European Society for Hypertension[9] recommend diet and lifestyle approaches as a primary means for prevention and treatment of hypertension. Each recommends increasing the intake of dietary pulses (low-fat, dry seeds of leguminous plants such as beans, peas, chickpeas, and lentils, which are distinct from leguminous high-fat oil seeds such as soy or peanuts)[10] as part of a dietary approaches to stop hypertension (DASH) diet to lower BP. Dietary pulses are generally consumed whole as boiled, canned, or dried foods or are ground into flour and incorporated into baked goods. Dietary pulses have a low glycemic index and saturated fat content and are high in fiber, potassium, and plant protein, each of which independently confers BP-lowering effects.[11–13] Whether there is sufficient evidence to emphasize dietary pulses alone to lower BP, however, is unclear. Therefore, to synthesize and quantify the effect of dietary pulses on BP, a systematic review and meta-analysis of controlled feeding trials were conducted.

METHODS

Design

The Cochrane Handbook for Systematic Reviews of Interventions was followed in conducting this meta-analysis.[14] Results were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines.[15] The protocol was registered at ClinicalTrials.gov (identifier: NCT01594567).

Study selection

Databases searched included MEDLINE, EMBASE, CINAHL, and the Cochrane Central Register of Controlled Clinical Trials, each from inception through 5 May 2013 (Supplementary Table S1). Using the search term "(pulses *OR* fabaceae *OR* lentil *OR* chickpea *OR* bean *OR* pea *OR* peas *OR* legume *OR* leguminous) AND (blood pressure *OR* BP *OR* SBP *OR* DBP *OR* mean arterial pressure *OR* MAP)," human randomized controlled clinical trials were identified. Manual searches of reference lists of included studies supplemented database searches. Eligible studies included randomized trials where dietary pulses constituted the majority (>50%) of the intervention, with a ≥3-week follow-up,[16] and an adequate comparator of equivalent caloric value (isocaloric). Soy and peanut interventions were excluded as they are not classified as dietary pulses.

Data extraction

Three reviewers (V.H.J., V.H., R.J.d.S.) independently reviewed and extracted all trial characteristics and outcomes from each study selected for analysis using a standardized *pro forma*. Extracted data included authorship, publication year, study design (crossover vs. parallel), randomization (yes/no), blinding (single/double/no), level of feeding control (metabolic/partial metabolic/non-metabolic), sample size, participant characteristics (including age, health status, and sex), baseline BP, dietary pulse form (whole/powdered), dose (grams/day), comparator, follow-up duration, dietary macronutrient profiles of treatment group at end of intervention, and funding sources (agency/industry).

Each study was subjectively assessed for risk of 5 major biases using the Cochrane Risk of Bias Assessment tool (sequence generation, allocation concealment, blinding, outcome data, and reporting).[14] The quality of each study was assessed using a modified Heyland methodological quality score (MQS), with an added point for metabolic feeding control (min = 1, max = 13); an MQS of ≥8 was considered high quality.[17] Disagreements were resolved by consensus.

Since no studies directly reported MAP, it was calculated at baseline and end of study from SBP and DBP using $MAP = \frac{2}{3}DBP + \frac{1}{3}SBP$, and mean differences were then subtracted. The standard deviation (SD) was imputed as $\frac{1}{\sqrt{N}}\sqrt{\left(\frac{1}{3}\right)^2\left(S^2_{SBP}\right)+\left(\frac{2}{3}\right)^2\left(S^2_{DBP}\right)}$, where N = sample size and $s = SD_{SBP/DBP}$, using the reported average SBP and DBP.[18] Missing variance measures were calculated from reported P values, t statistics, or confidence intervals (CIs) if provided. If these values were not reported, variance measures were imputed using published formulae (Supplementary Table S2).[14] Since between-treatment changes from baseline are optimal estimates of the true treatment effect,[14] authors not providing these values were contacted to obtain them.

Statistical analyses

The co-primary outcomes were between-treatment mean differences in change from baseline SBP, DBP, and MAP. Pooled-effect estimates were generated using the generic inverse variance method with random effects models and expressed as mean change-from-baseline between-treatment differences (MDs) with 95% CIs (REVMAN v. 5.2). Descriptive statistics are provided as means ± SD. Paired analyses were applied to all crossover trials.[14] To preserve power and mitigate unit-of-analysis error in 1 study with a 4-arm comparison,[19] it was reduced to a single pairwise comparison using a weighted average of the 3 treatment means vs. control. The presence of interstudy heterogeneity was assessed with Cochrane Q (χ^2) statistic at $\alpha < 0.10$ and quantified by the I^2 statistic, where $I^2 \geq 50\%$ represented considerable heterogeneity. Sources of heterogeneity were explored using *a priori* subgroup analyses by mean reported baseline BP (normotensive vs. prehypertensive and as continuous BP), difference in dietary fiber intake between treatment and control arms, design (parallel vs. crossover), dose (<100 g/d (~1 serving) or ≥100 g/d; based on Diet and Lifestyle Recommendations of the AHA),[20] duration

(weeks), MQS (<8 or ≥8), and dietary pulse type (single dietary pulse vs. mixed dietary pulses). Meta-regression was used to assess the impact of these study-level covariates on the effect size. The impact of each individual study on the pooled effect estimate was explored in a sensitivity analysis in which each study was removed and the effect size recalculated. Publication bias was evaluated using 3 methods: visual inspection of funnel plots; assessment of the significance of the Egger weighted regression asymmetry and Begg and Mazumdar adjusted rank correlation tests; and Duval and Tweedie nonparametric "trim-and-fill" analyses, with P <0.10 considered evidence of small study effects. These were conducted using STATA 12 (StataCorp, College Station, TX).

RESULTS

Search results

Figure 1 summarizes the flow of literature during the search and study selection protocol. Of the 341 eligible reports identified, 8 articles reporting data from 8 isocaloric trials[12,19,21–26] were included in the meta-analysis. The search did not retrieve any non-isocaloric trials.

Trial characteristics

Trial characteristics are provided in Table 1. The 8 trials included 554 participants, of which 215 participants were overweight or obese,[21,23–25] 121 were individuals living with diabetes,[12] 119 had features of metabolic syndrome,[22] and 103 were without apparent disease at baseline.[19,26] The median age of participants was 49 years (range: 28–60 years). All trials were randomized, and all but 2 trials[19,26] used a parallel design. No trials were metabolically controlled. Cooked dietary pulse dose averaged 162 g/d ($1^2/_3$ servings/day; range: 81 g/d–275 g/d), and most interventions involved the incorporation of a mixture of dietary pulses into the diet,[12,19,21–23,26] while 2 implemented a single dietary pulse intervention (i.e., chickpeas or lupin only).[24,25] Most trials[12,21–23,26] incorporated whole dietary pulses, while 3 trials[19,24,25] used dried and powdered dietary pulses. The increase in fiber intake was greater in treatment arms compared with control arms (median between treatment difference: 10 g/d (range: 5 g/d–14 g/d)), and the typical macronutrient profile at the end of follow-up of the dietary pulse interventions was 46% energy from carbohydrate, 21% from protein, and 32% from fat. Dietary pulses were

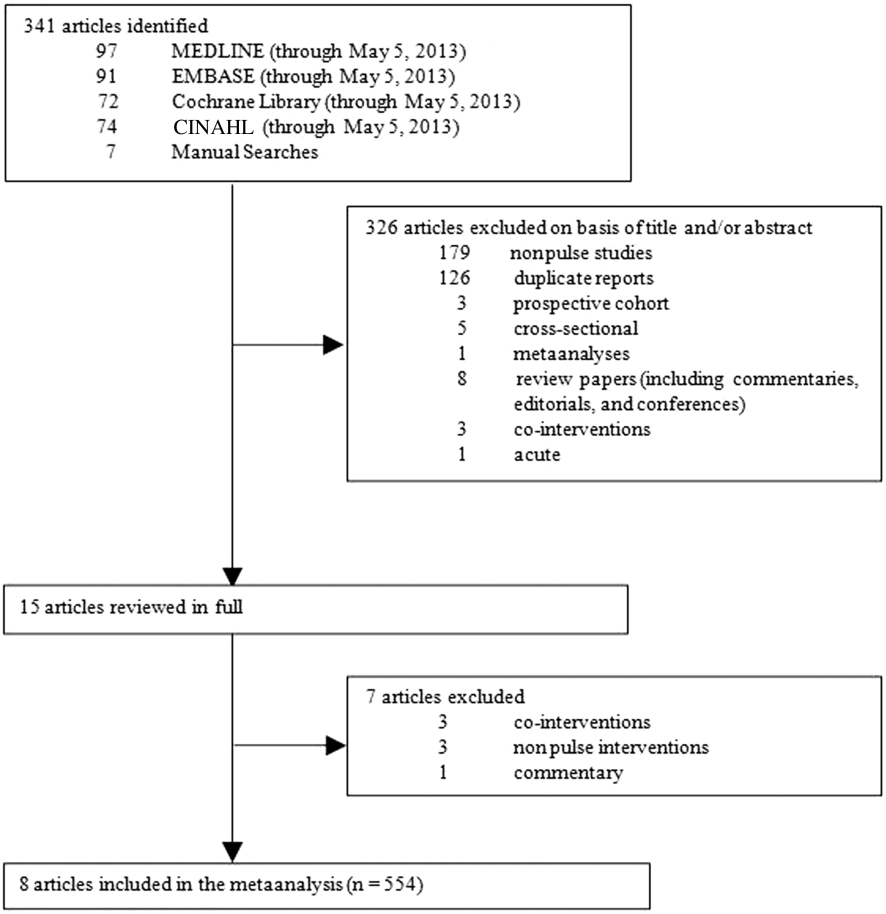

Figure 1. Flow diagram of the literature search. The search identified 341 reports, 326 of which were determined to be irrelevant based on review of titles and abstracts. The remaining 15 reports were reviewed in full. Eight reports providing data for 8 trials of isocaloric comparisons were included in the analysis.

Table 1. Trial characteristics

Study	Subjects[a]	Age	Design	Baseline blood pressure (mm Hg)	Metabolic[b]	Randomization	Dose (g/d)[c]	Dietary fiber(g/d)[d]	Pulse form[e]
Abete *et al.*,[21]	18 OB [100%] (18M:0F)	37.2±8.0	P	121/79	No	Yes	113	26±5 (6)	Whole
Abeysekara *et al.*,[26]	87 N [94%] (30M:57F)	59.7±6.3	C	123/78	No	Yes	250	30±15 (8)	Pulse-based meals
Belski *et al.*,[24]	131 OW/OB [71%] (68M:63F)	46.6±9.7	P	122/75	Partial	Yes	123	39±12 (14)	Powder (flour enriched [~32%])
Gravel *et al.*,[22]	132 Pre-MetSyn [87%] (0M:132F)	51.3±8.6	P	120/76	Partial	Yes	81	23±10 (5)	Whole
Hermsdorff *et al.*,[23]	30 OB [100%] (17M:13F)	36.0±8.0	P	115/76	No	Yes	113	26±6 (8)	Whole
Jenkins *et al.*,[12]	121 DM2 [100%] (61M:60F)	59.5±9.0	P	122/72	No	Yes	211	38±11 (12)	Whole
Lee *et al.*,[25]	74 OW/OB [100%] (26M:48F)	57.9±8.0	P	126/76	Partial	Yes	132	36±10 (12)	Powder (flour enriched [~40%])
Veenstra *et al.*,[19]	26 N [81%] (26M:0F)	28.1±5.9	C	127/78	Partial	Yes	275	38 (14)	Powder

Study	Pulse type	Comparator[f]	Blood pressure measurement	Diet (CHO/PRO/FAT, % E)[g]	Methodological quality score	Follow-up	Funding source[h]
Abete *et al.*,[21]	Varied pulses (lentils, chickpeas, peas, beans)	Isocaloric diet lacking legume/fatty fish	Standard mercury sphygmomanometer after the participant was quietly sitting for 5 minutes	51.7/18.7/32.4	7	8 weeks	Agency
Abeysekara *et al.*,[26]	Varied pulses (lentils, chickpeas, peas, beans)	Regular diet	Measured after the participant was in a comfortable seated position for 5 minutes	~49.0/15.9/36.7	6	8 weeks	Agency-Industry
Belski *et al.*,[24]	Lupin kernel	Isocaloric whole-meal flour	24-hour ambulatory measurements from automated sphygmomanometer	~39.0/22.5/31.7	8	1 year	Agency
Gravel *et al.*,[22]	Varied pulses (lentils, chickpeas, peas, beans)	Isocaloric meal lacking pulses	Mean of 3 measurements with a 1-minute interval between each measurement	~49.2/17.2/33.3	6	16 weeks	Industry
Hermsdorff *et al.*,[23]	Varied pulses (lentils, chickpeas, peas, beans)	Isocaloric legume-free diet	Following World Health Organization criteria	50.7/18.9/30.8	8	8 weeks	Agency
Jenkins *et al.*,[12]	Varied pulses (lentils, chickpeas, peas, beans)	Isocaloric high–wheat fiber diet	Seated triplicate measures by automated sphygmomanometer	47.0/22.7/30.3	8	12 weeks	Agency-Industry
Lee *et al.*,[25]	Lupin kernel	Isocaloric white bread	24-hour ambulatory measurements from automated sphygmomanometer	38.9/24.3/30.9	7	16 weeks	Agency
Veenstra *et al.*,[19]	Varied pulses (lentils, chickpeas, peas, beans)	Potatoe flakes	Duplicate measures using a digital sphygmomanometer	54.7/17.3/28.3	6	29 days	Agency-Industry

Abbreviations: C, crossover; P, parallel; M, male; F, female; N, normal; OB, obese; OW, overweight; Pre-MetSyn, premetabolic syndrome; DM2, type 2 diabetes.
[a] Numbers within brackets represent percentage of subjects included in the analysis as trial completers.
[b] Partial, some food was prepared and provided by investigators; no, no foods were prepared or given to patients, only dietary advice was provided.
[c] Obtained values are for treatment diet. Values are approximate or manually derived. All gram values represent cooked pulses. Doses provided in mL were converted to grams using 1 mL = 0.76-g pulse; doses provided as dry weight were converted to cooked weight using a conversion factor of 2.75 [http://archive.saskpulse.com/consumer/recipes/index.php?page=8].
[d] Obtained values are for treatment diet. Values within parentheses indicate between-treatment end differences.
[e] Pulses were provided as follows: 1, whole cooked/canned for direct consumption; 2, powdered, cooked, and dehydrated in order to use in baked goods (flour-enriched (percent pulse of final weight)).
[f] Non-pulse controlled diet.
[g] Obtained values are for treatment diet at end of treatment. (CHO: % energy from carboyhdrate; PRO: % energy from protein; FAT: % energy from fat).
[h] Agency funding is from government, university, or not-for-profit health agency sources.

substituted for isocaloric diets without dietary pulses,[21–23] whole-meal flour,[24] a high-fiber diet,[12] white bread,[25] or potato flakes.[19] The median duration of follow-up was 10 weeks (range: 4–52 weeks). The Heyland MQS was considered low (MQS <8) in 63% of trials. Poor description of protocol, non-consecutive or poorly described patient selection, and absence of double blinding contributed to lower scores (Supplementary Table S3). Individual trials were judged as being at low or unclear risk of bias for the majority of domains measured by the Cochrane Risk of Bias tool (Supplementary Table S4). Three studies measured BP after 5 min of sitting time, 2 measured 24-h ambulatory measures using automated sphygmomanometers, and 3 reported the average of 3 or more measures using automated sphygmomanometers. Funding of all trials was from agency alone (50%), agency–industry sources (37%), or industry alone (13%). All but 1 trialist[19] declared no potential conflict of interests.

Dietary pulses for BP

Figure 2 shows the overall effect of dietary pulse consumption on SBP, DBP, and MAP. Consumption of dietary pulses significantly reduced SBP (MD = −2.25 mm Hg (95% CI, −4.22 to −0.28), $P = 0.03$) and MAP (MD = −0.75 mm Hg (95% CI to −1.44 to −0.06), $P = 0.03$), and reduced DBP nonsignificantly (MD = −0.74 mm Hg (95% CI, −1.74 to 0.31), $P = 0.17$). Significant between-study heterogeneity was observed for SBP ($\chi^2 = 25.73$, $I^2 = 73\%$), DBP ($\chi^2 = 16.86$, $I^2 = 58\%$), MAP ($\chi^2 = 383.78$, $I^2 = 98\%$).

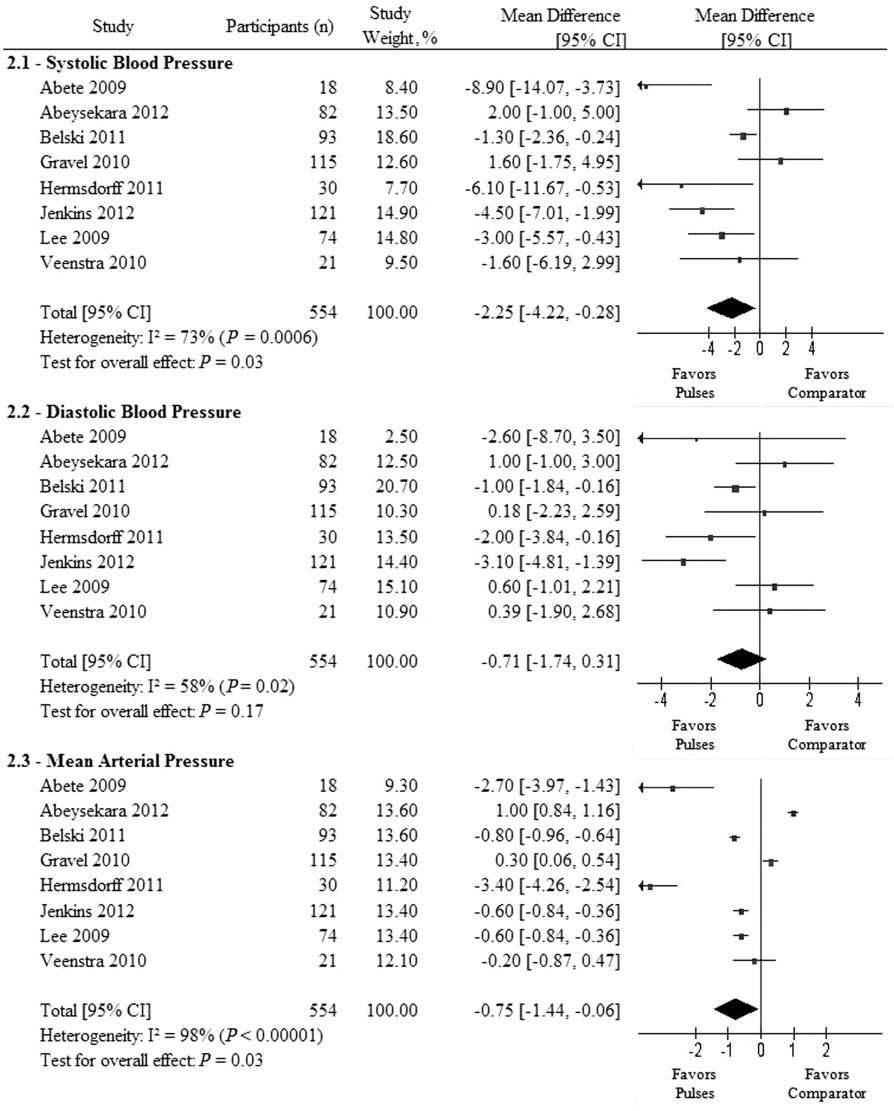

Figure 2. Forest plot of clinical trials investigating the effect of isocaloric exchange of dietary pulses for other adequate comparators on systolic blood pressure (SBP; 2.1), diastolic blood pressure (DBP; 2.2), and mean arterial pressure (MAP; 2.3). The pooled effect estimate is represented as a diamond. Data are represented as mean differences (MDs) with 95% confidence intervals (CIs). *P* values are for generic inverse variance random effects models. Interstudy heterogeneity was assessed via Cochrane Q (χ^2) at a significance level of $P < 0.10$ and quantified by I^2, where $I^2 > 50\%$ was considered to be evidence of substantial heterogeneity.

Sensitivity and *a priori* subgroup analyses

Sensitivity analyses of systematically removing each study from the overall analysis and recalculating the summary effect for SBP revealed that removal of Abeysekara *et al.*,[26] Gravel *et al.*,[22] or Veenstra *et al.*,[19] improved the observed beneficial effects (MD = −2.88 mm Hg, $P = 0.005$; −2.79 mm Hg, $P = 0.007$; −2.35 mm Hg, $P = 0.03$, respectively); removal of all other studies eliminated significance in SBP. Sensitivity analyses did not modify the overall effect or the heterogeneity in DBP. Removal of Abete *et al.*,[21] and Hermsdorff *et al.*,[23] eliminated the significance in MAP.

Subgroup analyses by baseline BP, study design, dose, study duration, change in fiber, or pulse type neither modified the effect nor reduced the heterogeneity for the effect of dietary pulses on any BP outcome under continuous and dichotomous models (Supplementary Table S5; Supplementary Figures S1–S3). The subgroup analysis by MQS (<8 vs. ≥8) for DBP significantly modified the overall effect (between-subgroup MD: −2.19 mm Hg (95% CI, −4.03 to −0.35), residual $I^2 = 5.4\%$, $P = 0.03$), favoring higher-quality trials. The MD in DBP between pulses and control was positively associated with baseline DBP ($\beta = 0.56$ (0.09 to 1.04) per 1 mmHg, residual $I^2 = 14.6\%$, $P = 0.03$).

Publication bias

Egger and Begg tests did not reveal significant evidence of publication bias in any of the analyses, and visual inspection of the funnel plot revealed no obvious asymmetry (Supplementary Figures S4.A–S6.A). The trim-and-fill analysis for SBP and DBP did not identify any potentially missed studies due to publication bias; however, a minor asymmetry in the funnel plot for MAP was identified, and 1 more study was "filled" in to mitigate publication bias. With the inclusion of the "filled" study, the MD for MAP was −1.05 mm Hg (95% CI, −2.05 to −0.05, $P = 0.04$; Supplementary Figures S4.B–S6.B).

DISCUSSION

This systematic review and meta-analysis of 8 isocaloric dietary pulse intervention trials in 554 participants support existing dietary guidelines to increase the intake of dietary pulses (beans, peas, chickpeas, and lentils) as part of a dietary strategy to achieve optimal BP.[1,3] A median of $1^2/_3$ servings/day (~162 g/d) of dietary pulses significantly lowered SBP by 2.25 mm Hg and MAP by 0.75 mm Hg over a median 10-week follow-up in middle-age participants with or without hypertension in the context of a range of metabolic phenotypes (normal weight, overweight, obese, premetabolic syndrome, and type 2 diabetes).

These results are consistent with those reported in large observational studies.[11,27,28] The 1999–2002 National Health and Nutrition Examination Survey (NHANES) found that adults in the United States who consumed approximately ½ cup (1 serving) of cooked dry beans or peas had higher intakes of fiber, protein, folate, zinc, iron, and magnesium and lower intakes of saturated and total fat.[29] A secondary analysis of the NHANES data found that consumers of varied beans had lower odds of elevated BP and a 1.7-mm Hg lower mean SBP than non-consumers.[27] Additionally, the NHANES Epidemiologic Follow-up Study found a 22% and 11% lower risk of coronary heart disease and CVD, respectively, with the consumption of legumes 4 times a week;[28] both of which highly correlate with BP.

Dietary pulses may lower BP through several mechanisms. Dietary pulses are high in dietary fiber, plant protein, and potassium, all of which confer BP-lowering effects.[11,13] In the Optimal Macronutrient Intake Heart study,[30] the replacement of carbohydrates with protein lowered BP. However, since the diets in this meta-analysis were generally matched for protein, the observed effects cannot be ascribed to a protein for carbohydrate substitution. Notably, the possibility of a beneficial effect of replacing animal protein with plant protein from dietary pulses cannot be eliminated.[31] Moreover, replacing high-starch foods with dietary pulses, which have a low glycemic index, can facilitate weight loss,[32] likely contributing to BP reduction. Indeed, in a post-hoc meta-regression, SBP and MAP decreases were found to be linearly associated with weight loss (($\beta_{SBP} = -3.32$ mm Hg; 95% CI: −5.95 to −0.69, $P = 0.02$) and ($\beta_{MAP} = -1.07$ mm Hg; 95% CI: −1.77 to −0.37, $P = 0.01$), for every 1-kg of weight lost), supporting the assertion that the weight loss associated with dietary pulse consumption contributed to the BP reductions.

The BP reductions observed in the present analysis were greater than those observed when comparing the DASH fruits and vegetables–only arm with the control arm in nonhypertensive participants (−2.3 mm Hg vs. −0.8 mm Hg for SBP and −0.7 mm Hg vs. −0.3 mm Hg for DBP, respectively).[33] These results suggest that diets which emphasize dietary pulses alone or as part of a heart-healthy diet based on a DASH dietary pattern may benefit BP. Increasing dietary pulse consumption from the current average American intake (0.1–0.3 servings/day (10–30 g/d)[29] to the amount used in the included trials (mean approximate, $1^2/_3$ servings/day (162 g/d) would be expected to result in a clinically significant decrease in BP. At the population level, an overall mean reduction of 2.25 mm Hg in SBP may potentially ameliorate the risk of mortality from stroke, ischemic heart disease, and other vascular causes in the average middle-aged population.[34] However, an analysis of the Nurses' Health Study and the Health Professionals Follow-Up Study data found that legume protein (from dry beans, peas, soy, and tofu) was associated with an increased risk of ischemic stroke (RR, 1.45; 95% CI, 1.06–2.00).[35] The reasons for this are unclear, and additional research is required to assess the effect of dietary pulses on CVD events, such as stroke.

Individuals with prehypertension are at greater risk for cardiovascular events than normotensive individuals.[5,36,37] JNC7 recommends diet and lifestyle modifications as the first line of treatment of prehypertensive individuals.[1] In addition, a recent Cochrane Review suggests the inadequacy of antihypertensives in the treatment of mild hypertension.[38] Thus, BP reductions through dietary interventions may lead to modest improvements in cardiovascular outcomes.[12] Consistently, a diet high in dietary pulses ($1^2/_3$ servings/day) may offer a strategy to manage prehypertension[39] and mild hypertension[38] when

supplementing pharmacological agents. Whereas adverse effects from antihypertensive drugs may be problematic,[40] only a few participants on high dietary pulse diets experienced any discomfort.

Six of 8 included trials favored dietary pulses for lowering SBP. The 2 exceptions, Abeysekara *et al.,* and Gravel *et al.*, were conducted under *ad libitum* feeding, free-living conditions, and the participants of Gravel *et al.,* were already achieving the generally recommended dietary fiber intake.[22,26] Although statistically significant SBP- and MAP-lowering effects were found, the possibility that the effect of dietary pulses may be variable cannot be discounted, as a high amount of heterogeneity that could not be explained by study-level characteristics was observed.

Publication bias was rigorously evaluated. Although we found no evidence of publication bias in either the SBP or DBP analyses, it must be noted that with <10 studies, we are likely underpowered for formal tests. Nevertheless, a minor asymmetry in the funnel plot for MAP was identified in the trim-and-fill analysis. Although suggestive of publication bias, it is noteworthy that none of the MAP values were directly provided in any of the studies; and the optimal equation for deriving MAP is a subject of ongoing debate.[41]

Several limitations of this meta-analysis should be acknowledged. First, only 2 of 8 studies assessed BP as a primary endpoint; thus, the included trials might have been underpowered to detect a BP difference. In addition, although no subgroup effects were observed, the small number of studies limited the power to detect these differences. Second, the effect of sodium or other micronutrients were not investigated in any of the trials included in this meta-analysis. Since sodium, potassium, magnesium, and calcium influence BP,[42] variations in these nutrients among diets may have influenced the overall effect size, particularly because dietary pulses may be purchased in a high-sodium canned form. Third, quality was poor (MQS <8), and risk of bias was unclear in the majority of trials. However, the observed effect modifications by study quality suggest a greater DBP reduction in higher-quality studies. Fourth, the relatively small sample size (n = 554) and heterogeneous disease phenotypes, doses, and durations limit the overall generalizability of these results. Last, most participants included in this meta-analysis were aged <60 years, thus these results provide limited information regarding the effects of dietary pulses on BP in older, higher-risk individuals.[1]

This is the first systematic review and meta-analysis to quantitatively synthesize the effect of dietary pulses on BP. Pooled analyses found a significant BP-lowering effect of dietary pulses in predominantly middle-age people with and without hypertension. Dietary pulse intake in Western countries is well below that consumed in the available trials. To achieve BP reductions similar to those observed in this systematic review and meta-analysis, an increase in consumption of at least 2 servings (1 cup) above current average intakes (0.1–0.3 servings/day) would need to be recommended. These findings, however, are limited by several design issues and the poor quality of the available trials. There is a need for larger and higher-quality long-term randomized controlled trials in different demographics to confirm these findings in normotensive, prehypertensive, and hypertensive individuals.

SUPPLEMENTARY MATERIAL

Supplementary materials are available at *American Journal of Hypertension* (http://ajh.oxfordjournals.org).

DISCLOSURE

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