Preplanned Studies

Associations of Mediterranean-DASH Intervention for Neurodegenerative Delay Diet with Blood Pressure and Hypertension Among Older Adults — China, 2019–2022

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Summary

What is already known about this topic?

Very limited research shows that the Mediterranean-dietary approaches to stop hypertension (DASH) intervention for neurodegenerative delay (MIND) diet is not associated with incident hypertension in adults.

What is added by this report?

Based on three-year follow-up data, higher adherence to the MIND diet was significantly associated with decreased systolic and diastolic blood pressure among older adults with and without hypertension, while confirming previous research showing it does not affect rates of incident hypertension.

What are the implications for public health practice?

The MIND diet can be beneficial for prevention, intervention, and management of hypertension among older adults.

ABSTRACT

Introduction: The Mediterranean-dietary approaches to stop hypertension (DASH) intervention for neurodegenerative delay (MIND) diet has demonstrated benefits for brain health, yet evidence regarding its antihypertensive effects among older adults remains limited and inconsistent. This study investigated associations between the MIND diet and blood pressure outcomes among Chinese older adults.

Methods: Logistic regression analysis was used to examine associations between MIND diet scores and both baseline hypertension prevalence and incident hypertension. Repeated measures analysis of variance assessed adjusted mean differences in blood pressure between MIND diet score groups. Sensitivity analysis was conducted after imputing missing blood pressure values at follow-up using multiple imputation techniques.

Results: Logistic regression analyses revealed that high MIND diet scores were negatively associated with baseline hypertension prevalence (P<0.05); however, no significant relationship was observed between MIND diet adherence and incident hypertension. Among participants who completed follow-up, those with high MIND diet scores had significantly lower blood pressure (P<0.05) compared to those with low scores. The adjusted mean differences for systolic blood pressure (SBP) and diastolic blood pressure (DBP) were −1.46 [95% confidence interval (*CI*): −2.59, −0.31] mmHg and −1.09 (95% *CI*: −1.76, −0.41) mmHg, respectively. Similar results were observed among both participants with hypertension taking medication at baseline and those without hypertension at baseline. Sensitivity analyses following multiple imputation confirmed these findings.

Conclusion: The study revealed the potential of the MIND diet to reduce blood pressure levels, providing new approaches for hypertension prevention among older adults.

Hypertension is a significant public health problem, but research on the antihypertensive effects of the Mediterranean-dietary approaches to stop hypertension (DASH) intervention for neurodegenerative delay (MIND) diet among older adults remains scarce and inconsistent. This study utilized data from the Healthy Aging Evaluation Longitudinal Study in China (HAELS), a community-based cohort survey conducted across 6 provincial-level administrative divisions (PLADs) from 2019–2022, to investigate associations between the MIND diet, blood pressure, and hypertension among Chinese adults aged 65 years and over. The findings revealed that greater adherence to the MIND diet was negatively correlated with

hypertension prevalence at baseline, though no significant relationship between the MIND diet and incident hypertension was observed. Among participants who completed follow-up, those with high MIND diet scores had significantly lower blood pressure (P<0.05) compared to those with low scores: adjusted mean differences in systolic blood pressure (SBP) and diastolic blood pressure (DBP) were −1.46 [95% confidence interval (*CI*): −2.59, −0.31] mmHg and −1.09 (95% *CI*: −1.76, −0.41) mmHg, respectively. Similar results were observed in both participants with hypertension taking medication regularly at baseline and those free of hypertension at baseline. These findings suggest that the MIND diet could be recommended by public health practitioners for hypertension prevention and management.

The 6 PLADs were selected based on economic development level. In each PLAD, 2 counties or city districts were randomly sampled, from which 4 villages or communities were selected using multistage stratified probability-proportional-to-size (PPS) sampling. Residents aged 65 years and over were then randomly sampled from each village or community, considering the overall PLAD-based proportion of 2 age groups (65–79 years and ≥80 years). Individuals with severe hepatitis or kidney diseases, severe mental diseases, or cancer were excluded (*1*). A total of 4,690 older adults aged 65 years and over were recruited, representing a representative sample of older adults in the 6 PLADs (*1*). After excluding 13 participants with missing key information such as hypertension status, 4,677 participants were included at baseline. Of these, 3,782 participants completed follow-up assessments in 2022, while 361 participants died and 534 (11.42%) were lost to follow-up. Data were collected through face-to-face interviews conducted by field investigators in community settings. A food frequency questionnaire (FFQ) was used to assess participants' dietary consumption over the previous 12 months. The intake of 15 food items in the MIND diet was scored according to established criteria, with scores ranging from 0 to 15 (*2*). Hypertension was defined as blood pressure exceeding 140/90 mmHg or by self-reported diagnosis in a hospital. Participants were classified into three groups based on tertiles of MIND diet scores: low, moderate, and high.

Baseline characteristics by hypertension status were compared using *t*-tests for continuous variables and chi-square tests for categorical variables. Logistic regression analysis was used to examine associations between the MIND diet and both hypertension prevalence at baseline and incident hypertension. Repeated measures analysis of variance was used to investigate adjusted mean differences in blood pressure across MIND diet score groups among all participants with follow-up data, including both participants with hypertension taking medication regularly at baseline and those free of hypertension at baseline. Sensitivity analysis was performed after imputing missing blood pressure values using multiple imputation. Three models were fitted: Model 1 included no adjustments; Model 2 was adjusted for age, sex, education level, marital status, and income; and Model 3 was further adjusted for smoking, alcohol drinking, tea consumption, physical activity, obesity, stroke, dyslipidemia, and diabetes. All analyses were conducted using SAS (version 9.4; SAS Institute, Cary, NC, USA).

As shown in Table 1, the mean age of participants was 72.49 years, with 45.58% being male. Participants with hypertension were more likely to be older and female, and had a higher prevalence of diabetes, stroke, and obesity (P<0.05). Those with hypertension had significantly lower MIND diet scores (P<0.05). Among the 2,315 participants with hypertension, 2,056 were taking medication regularly. Of the 3,782 participants with follow-up data, 1,669 had hypertension and were taking medication regularly at baseline, while 1,918 were free of hypertension at baseline.

As shown in Table 2, logistic regression analysis revealed that high MIND diet scores were significantly associated with lower baseline hypertension prevalence (P<0.01), with an odds ratio (*OR*) of 0.83 (95% *CI*: 0.72, 0.96) in the fully adjusted model.

However, no significant association was observed between high MIND diet scores and incident hypertension (among participants free of hypertension at baseline) (P>0.05) — the adjusted *OR* was 1.05 (95% *CI*: 0.98, 1.13) in the fully adjusted model (Table 2). Similarly, no significant association was found between MIND diet score groups and incident hypertension (P>0.05).

Among all participants with follow-up data, the SBP of the high MIND diet score group was significantly lower (P<0.05) than the low MIND diet score group, with an adjusted mean difference of −1.46 (95% *CI*: −2.59, −0.31) (Table 3). Similar results were observed among participants with hypertension taking medication regularly at baseline and those free of hypertension at baseline, with adjusted mean differences of −1.88 (95% *CI*: −3.70, −0.06) and −2.03 (95% *CI*: −3.57, −0.48), respectively.

Among all participants with follow-up data, the

TABLE 1. Characteristics of the Participants by hypertension status among Chinese older adults aged 65 years and over in 2019–2022.

Characteristic	Overall (*n*=4,677)	Hypertension status		*P*
		Hypertension (*n*=2,315)	Non-hypertension (*n*=2,362)	
Age (years) [mean (SD)]	72.49 (5.64)	72.67 (5.72)	72.31 (5.54)	0.025
Gender [*n* (%)]				<0.001
Male	2,132 (45.58)	981 (42.38)	1151 (48.73)	
Female	2,545 (54.42)	1,334 (57.62)	1,211 (51.27)	
Education (years) [*n* (%)]				0.528
0	1,227 (26.23)	614 (26.52)	613 (25.95)	
1–6	2,097 (44.84)	1,019 (44.02)	1,078 (45.64)	
>6	1,353 (28.93)	682 (29.46)	671 (28.41)	
Marital status [*n* (%)]				0.071
Married/cohabiting	3,449 (73.74)	1,680 (72.57)	1,769 (74.89)	
Divorced/widowed/other	1,228 (26.26)	635 (27.43)	593 (25.11)	
Income (USD) [*n* (%)]				0.924
≤4,000	2,460 (52.56)	1,216 (52.53)	1,244 (52.67)	
>4,000	2,217 (47.40)	1,099 (47.47)	1,118 (47.33)	
Smoking status [*n* (%)]				0.006
Current smokers	1,078 (23.05)	489 (21.12)	589 (24.94)	
Past smokers	556 (11.89)	273 (11.79)	283 (11.98)	
Non smokers	3,043 (65.06)	1,553 (67.08)	1,490 (63.08)	
Alcohol drinking (yes) [*n* (%)]	1,123 (24.01)	523 (22.59)	600 (25.40)	0.025
Tea drinking (yes) [*n* (%)]	1,998 (42.72)	1,007 (43.50)	991 (41.96)	0.286
Adequate physical activity (yes) [*n* (%)]	2,475 (52.92)	1,198 (51.75)	1,277 (54.06)	0.113
Diabetes (yes) [*n* (%)]	689 (14.73)	483 (20.86)	206 (8.72)	<0.001
Dyslipidemia (yes) [*n* (%)]	973 (20.80)	593 (15.62)	380 (16.09)	<0.001
Obesity (yes) [*n* (%)]	659 (14.09)	443 (19.14)	216 (9.14)	<0.001
Stroke (yes) [*n* (%)]	514 (10.99)	369 (15.94)	145 (6.14)	<0.001
MIND diet scores [mean (SD)]	6.98 (1.56)	6.92 (1.54)	7.03 (1.57)	0.020
MIND diet scores groups [*n* (%)]				0.021
Low	1,732 (37.03)	870 (37.58)	862 (36.49)	
Moderate	1,157 (24.74)	603 (26.05)	554 (23.45)	
High	1,788 (38.23)	842 (36.37)	946 (40.05)	
Baseline SBP [mean (SD)]	137.07 (16.52)	143.4 (16.52)	130.9 (13.97)	<0.001
Baseline DBP [mean (SD)]	80.05 (10.18)	82.73 (11.18)	77.41 (8.27)	<0.001

Abbreviation: MIND=Mediterranean-dietary approaches to stop hypertension intervention for neurodegenerative delay; SBP=systolic blood pressure; DBP=diastolic blood pressure; SD=standard deviation.

DBP of the high MIND diet score group was also significantly lower compared to the low score group (P<0.05), with an adjusted mean difference of −1.09 (95% *CI*: −1.76, −0.41). This pattern was consistent both for participants with hypertension taking medication regularly at baseline and those without hypertension at baseline, with adjusted mean differences of −1.17 (95% *CI*: −2.26, −0.09) and −1.63 (95% *CI*: −2.56, −0.71), respectively.

Sensitivity analysis conducted after imputing missing blood pressure values yielded results consistent with the main analysis, confirming that the adjusted blood pressure levels of the high MIND diet score group were significantly lower (P<0.05) than the low MIND diet score group (Supplementary Table S1, available at https://weekly.chinacdc.cn/).

TABLE 2. Association of MIND diet with hypertension prevalence at baseline and incident hypertension among Chinese older adults aged 65 years and over in 2019–2022.

Hypertension status	Model 1	Model 2	Model 3
Baseline prevalence (*n*=4,677)			
Low	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Moderate	0.92 (0.79, 1.07)	0.93 (0.79, 1.08)	0.95 (0.81, 1.11)
High	0.83 (0.72, 0.95)**	0.82 (0.71, 0.94)**	0.83 (0.72, 0.96)*
Incident hypertension (*n*=1,918)			
MIND diet scores	1.05 (0.98, 1.12)	1.05 (0.98, 1.12)	1.05 (0.98, 1.13)
MIND diet score groups			
Low	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Moderate	0.93 (0.71, 1.21)	0.93 (0.71, 1.21)	0.93 (0.71, 1.23)
High	1.07 (0.84, 1.37)	1.07 (0.83, 1.38)	1.09 (0.85, 1.41)

Note: Data were shown as (*OR*, 95% *CI*). Model 1: not adjusted for covariates; Model 2: adjusted for age, sex, education level, marital status, and income; Model 3: further adjusted for smoking, alcohol drinking, tea consumption, physical activity, obesity, stroke, dyslipidemia, and diabetes.
Abbreviation: *OR*=odds ratio; *CI*=confidence interval; MIND=mediterranean-dietary approaches to stop hypertension intervention for neurodegenerative delay.
* $P<0.05$.
** $P<0.01$.

DISCUSSION

This study demonstrated that high MIND diet scores were significantly associated with decreases in both SBP and DBP levels, and were negatively correlated with baseline hypertension prevalence, but not with incident hypertension.

These results were consistent with some limited previous findings. A few cross-sectional studies reported that better adherence to the MIND diet was significantly negatively associated with SBP and DBP levels, as well as with a lower prevalence of hypertension across the entire population, underscoring the important role of the MIND diet in the primary prevention of hypertension (*3*). However, no significant effect of the MIND diet intervention on blood pressure was observed in a very limited randomized controlled study (*4*); this inconsistency may be related to the small sample size and short duration of the trial intervention.

Several mechanisms may explain the associations between the MIND diet and decreased blood pressure levels in older adults. First, the MIND diet emphasizes plant-based foods rich in anti-inflammatory compounds (*2*), including carotenoids, quercetin, and thiamine, which enhance the body's antioxidant and anti-inflammatory properties, thereby reducing blood pressure (*5*–*6*). Second, key components of the MIND diet — whole grains, olive oil, poultry, nuts, and legumes — share similarities with Mediterranean diet and DASH diet; these foods have demonstrated direct antihypertensive properties in previous research (*7*). Third, the MIND diet uniquely specifies consumption of berries and green leafy vegetables, which contain polyphenols, anthocyanins, and other beneficial compounds that have been shown to substantially lower blood pressure levels and promote vascular health (*8*–*9*).

Another notable finding was that associations between the MIND diet and blood pressure levels existed regardless of participants' hypertension status, further supporting the potential significant effect of the MIND diet in reducing blood pressure. Additionally, no significant association was observed between the MIND diet and incident hypertension, which is consistent with a previous prospective cohort study (*10*). This lack of association may be attributed to poor adherence to the MIND diet among patients, preventing them from fully benefiting from this dietary pattern.

This study has several strengths. First, as a 3-year prospective cohort study with a large sample size, it provides a robust framework for examining the relationships between the MIND diet, blood pressure levels, and hypertension. Second, to accurately assess the associations between the MIND diet and blood pressure, the study accounted for the effects of antihypertensive medications by analyzing participants with and without hypertension separately. However, this study also has limitations. First, MIND diet scores

TABLE 3. Adjusted mean differences of blood pressure across MIND diet score groups among Chinese older adults aged 65 years and over in 2019–2022.

Hypertension status	Model 1	Model 2	Model 3
	Mean difference, 95% *CI*	Mean difference, 95% *CI*	Mean difference, 95% *CI*
SBP			
All followed-up participants (*n*=3,782)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−0.35 (−1.58, 0.88)	−0.57 (−1.81, 0.68)	−0.44 (−1.69, 0.82)
High	−1.29 (−2.40, −0.17)*	−1.64 (−2.77, −0.51)**	−1.46 (−2.59, −0.31)*
Hypertension with regular medication at baseline (*n*=1,669)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−0.21 (−2.06, 1.64)	−0.28 (−2.15, 1.59)	−0.17 (−2.06, 1.72)
High	−1.94 (−3.72, −0.16)*	−2.04 (−3.84, −0.24)*	−1.88 (−3.70, −0.06)*
Free of hypertension at baseline (*n*=1,918)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−1.16 (−2.87, 0.54)	−1.43 (−3.15, 0.29)	−1.43 (−3.17, 0.31)
High	−1.80 (−3.31, −0.29)*	−2.28 (−3.81, −0.74)**	−2.03 (−3.57, −0.48)*
DBP			
All followed-up participants (*n*=3,782)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−0.39 (−1.12, 0.33)	−0.45 (−1.19, 0.29)	−0.39 (−1.14, 0.35)
High	−1.02 (−1.68, −0.36)**	−1.13 (−1.81, −0.46)**	−1.09 (−1.76, −0.41)**
Hypertension with regular medication at baseline (*n*=1,669)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−0.12 (−1.23, 0.98)	−0.17 (−1.28, 0.94)	−0.09 (−1.22, 1.03)
High	−1.03 (−2.09, 0.03)	−1.20 (−2.27, −0.13)*	−1.17 (−2.26, −0.09)*
Free of hypertension at baseline (*n*=1,918)			
Low	0 (Ref)	0 (Ref)	0 (Ref)
Moderate	−0.99 (−2.01, 0.02)	−1.10 (−2.13, −0.07)*	−1.12 (−2.17, −0.07)*
High	−1.58 (−2.48, −0.68)**	−1.68 (−2.59, −0.77)**	−1.63 (−2.56, −0.71)**

Note: Model 1: not adjusted for covariates; Model 2: adjusted for age, sex, education level, marital status, and income; Model 3: further adjusted for smoking, alcohol drinking, tea consumption, physical activity, obesity, stroke, dyslipidemia, and diabetes.
Abbreviation: MIND=Mediterranean-dietary approaches to stop hypertension intervention for neurodegenerative delay; SBP=systolic blood pressure; DBP=diastolic blood pressure; *CI*=confidence interval.
* $P<0.05$.
** $P<0.01$.

were assessed using self-reported dietary data, which may introduce bias, although the FFQ is a widely used and validated tool in nutritional epidemiology. Second, the study focused exclusively on older adults in China, which may limit the generalizability of these findings to other demographic groups.

In conclusion, this study suggests potential effects of the MIND diet in reducing blood pressure levels. Public health practitioners should consider recommending the MIND diet for prevention, intervention, and management of hypertension among older adults. Future clinical trials and intervention studies are warranted to provide stronger evidence for these associations.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Adjusted mean differences of blood pressure across MIND diet score groups after multiple imputation among Chinese older adults aged 65 years and over in 2019–2022.

Hypertension status	Model 1	Model 2	Model 3
	Mean difference, 95% *CI*	Mean difference, 95% *CI*	Mean difference, 95% *CI*
SBP			
All participants (*n*=4,677)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	−0.43 (−1.43, 0.57)	−0.61 (−1.61, 0.39)	−0.64 (−1.64, 0.36)
Q3 (High)	−1.14 (−2.06, −0.21)*	−1.34 (−2.28, −0.41)**	−1.32 (−2.25, −0.39)**
Hypertension with regular medication at baseline (*n*=2,056)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	−0.45 (−1.95, 1.06)	−0.59 (−2.11, 0.91)	−0.70 (−2.21, 0.81)
Q3 (High)	−1.49 (−2.89, −0.08)*	−1.63 (−3.05, −0.21)*	−1.65 (−3.07, −0.22)*
Free of hypertension at baseline (*n*=2,362)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	−0.53 (−1.92, 0.84)	−0.74 (−2.13, 0.63)	−0.59 (−1.97, 0.79)
Q3 (High)	−1.54 (−2.80, −0.28)*	−1.81 (−3.09, −0.53)**	−1.57 (−2.85, −0.30)*
DBP			
All participants (*n*=4,677)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	−0.07 (−0.63, 0.47)	−0.11 (−0.67, 0.45)	−0.13 (−0.69, 0.42)
Q3 (High)	−0.89 (−1.39, −0.37)**	−0.96 (−1.48, −0.44)**	−0.95 (−1.47, −0.43)**
Hypertension with regular medication at baseline (*n*=2,056)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	0.30 (−0.58, 1.19)	0.21 (−0.67, 1.09)	0.21 (−0.66, 1.09)
Q3 (High)	−0.71 (−1.53, 0.11)	−0.88 (−1.71, −0.05)*	−0.88 (−1.71, −0.05)*
Free of hypertension at baseline (*n*=2,362)			
Q1 (Low)	0 (Ref)	0 (Ref)	0 (Ref)
Q2 (Moderate)	−0.42 (−1.16, 0.32)	−0.42 (−1.16, 0.32)	−0.44 (−1.17, 0.30)
Q3 (High)	−1.29 (−1.97, −0.63)**	−1.31 (−1.99, −0.63)**	−1.27 (−1.96, −0.59)**

Note: Model 1: not adjusted for covariates; Model 2: adjusted for age, sex, education level, marital status, and income; Model 3: further adjusted for smoking, alcohol drinking, tea consumption, physical activity, obesity, stroke, dyslipidemia, and diabetes.
Abbreviation: MIND=mediterranean-dietary approaches to stop hypertension intervention for neurodegenerative delay; SBP=systolic blood pressure; DBP=diastolic blood pressure; *CI*=confidence interval.
* $P<0.05$.
** $P<0.01$.