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Review Article

Digital-Based Nutrition Interventions Employing the Dietary Approaches to Stop Hypertension (DASH) Diet: A Systematic Scoping Review

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Background: The Dietary Approaches to Stop Hypertension (DASH) diet is an internationally recognized anti-hypertensive dietary model. This systematic scoping review examines the effectiveness of digital-based interventions utilizing the DASH dietary pattern.
Methods: A search was conducted using 14 databases to include relevant studies from 1997 to January 2025 using PRISMA guidelines for scoping reviews.
Results: The review included 24 studies with almost 7000 participants, including randomized controlled trials and cohort studies conducted in several countries. Interventions using the DASH dietary pattern positively affected blood pressure (BP), nutrition behavior, and weight. Some studies also reported secondary outcomes such as reduced healthcare cost savings.
Conclusion: Technology-based DASH diet interventions yielded favorable health outcomes, particularly in reducing BP and dietary salt intake, as well as improved diet quality. This systematic scoping review supports the potential of digital-based interventions utilizing the DASH dietary pattern to improve nutrition and health outcomes, particularly those related to hypertension management. The findings emphasize the importance of using evidence-based approaches, which are grounded in theoretical frameworks and models to develop effective interventions, and thoughtful program design to maximize group effectiveness. Other factors that influenced the effectiveness of the intervention included the type of technology used, as well as participant comfort with using technology. Further research and development are needed to optimize these interventions for widespread impact and long-term sustainability.

Keywords: Dietary Approaches to Stop Hypertension (DASH); interventions; mHealth; nutrition; technology

1. Introduction

Hypertension affects one-third of adult populations and is regarded as the leading preventable cause of premature death worldwide [1–3]. While blood pressure (BP) is considered elevated at a measure of systolic blood pressure (SBP) of 120–129 mmHg and diastolic BP (DBP) of > 80 mm/Hg, stage 1 hypertension is diagnosed with an SBP of 130–139 mmHg and DBP of 80–89 mHG [4, 5]. The number of individuals living with hypertension doubled

between 1990 and 2019, from 650 million to 1.3 billion [6, 7]. Worldwide, nearly half of the population presumed to have hypertension is unaware of their condition because high BP typically has no symptoms [8, 9]. Therefore, regular medical examinations are essential for prevention, diagnosis, and treatment. Hypertension is often referred to as a 'complex disease' with genetic factors, lifestyle choices, and social determinants of health impacting incidence and management [10]. Ethnicity, education level, poor healthcare access, socioeconomic status, and living in high-poverty regions can all contribute to an increased risk of hypertension [10–12], as well as risk factors such as physical inactivity and unhealthful dietary patterns, particularly those that include large quantities of ultra-processed foods [1, 2, 13–17].

The Dietary Approaches to Stop Hypertension (DASH) dietary pattern was developed to prevent and manage hypertension and focuses on the consumption of vegetables, fruits, legumes, nuts/seeds, and whole grains while limiting salt, alcohol, and saturated fats [18–20]. Compared to a typical Western Diet, DASH diets tend to be higher in micronutrients, fiber, and plant-based protein and have a marked reduction in dietary salt intake (1500 mg/day) compared to the US average daily consumption of 3300 mg [21, 22], which can have positive effects on BP and overall health outcomes [20, 23].

Recent research has investigated the utility of digital-based and online platforms for the delivery of nutrition education and behavior change interventions [24–28]. Referred to as mHealth (mobile health) or eHealth (electronic health) delivery modalities, interventions that are offered digitally have demonstrated promise in improving health, nutrition, and lifestyle behaviors [29, 30]. However, several reviews have found that while many eHealth and mHealth interventions were considered accessible and low cost to implement, many were not rooted in evidenced-based nutrition guidelines [31–37]. Other reviews and studies have also found that eHealth and mHealth interventions are cost-effective, appealing to a broad section of the population, and more easily accessible than place-based interventions, particularly for those with lower incomes and across a variety of ethnicities [38–44]. The aim of this systematic scoping review is to evaluate the current literature on DASH digital interventions and the impact on nutrition and health behavior outcomes.

2. Methods

2.1. Search Procedures. The search (see Figure 1) was conducted to include relevant studies from 1997, when the clinical data from the first DASH diet trial was published [45], to January 2025 and used PRISMA guidelines [46] and the framework of Arksey and O'Malley [47]. A comprehensive search was conducted using 14 academic databases—ArticleFirst; BioMed Central; BioOne; BIOSIS; CINAHL; ProQuest; Taylor and Francis; PubMed; SAGE Reference Online; ScienceDirect; Scopus; EBSCOHost; SpringerLink; and Wiley Online. Relevant studies were identified using a combination of the following terms: "online; app; digital; computer; technology; internet; web-based; intervention; program; education; DASH diet; DASH dietary pattern; DASH diet; hypertension; BP." The search strategy was adapted according to the indexing systems of each respective database.

(See Supporting Information (available here)—Keyword search strategy applied to Scopus Database).

2.2. Selection Criteria and Study Quality Assessment. Article titles were screened for relevancy, and journal abstracts were reviewed. Studies were evaluated for relevance, merit, and inclusion/exclusion criteria (see Table 1). Reference lists of included studies were screened for additional relevant studies. Articles accepted for inclusion were individually reviewed by each author, and relevant data were extracted and tabulated (see Table 2). In order to investigate the effectiveness of digital-based nutrition and health behavior change interventions including the DASH dietary pattern, studies were eligible if they (1) included a digital-based intervention component such as an app, computer, internet web, smartphone, or any other technology-based approach, modality, or platform; (2) the digital intervention assessed any kind of nutrition behavior or outcome; and (3) the measured outcomes included nutrition or health-related outcomes, including nutrition behavior and physical activity. Feasibility studies with no outcomes were excluded. Methodological quality and bias assessment were conducted based on the 2022 Academy of Nutrition and Dietetics Evidence Analysis Manual Quality Criteria Checklist for primary research, and the rankings are included in Table 2 [48].

3. Results

In total, 24 studies including almost 7000 participants were evaluated for the systematic scoping review. Eighty-three percent ($n = 13$) of the studies included used a randomized study design [49–65], while the remaining designs included quasi-experimental and longitudinal/observational ($n = 4$) [66–69]. There was one small pilot study [70]. The majority of the studies were conducted in the United States ($n = 16$); two studies were conducted in New Zealand [57, 63], and one study was conducted in each of the following countries: Bangladesh [61], China [52], Iran [64], Japan [66], Saudi Arabia [70], and Thailand [71]. All studies included in this review utilized adult participant populations. In terms of participant health status, 50% ($n = 12$) of the studies were carried out with individuals with a diagnosis of pre-hypertension or hypertension [51–53, 56, 61, 64, 65, 68–72]. Three studies included patients with cardiovascular disease (CVD) or CVD risk factors [54, 55, 63], four studies included participants from the general community [58, 60, 66, 67], one study examined intervention effects in pregnant women [49], and one in women with a history of preeclampsia within the last 5 years [59], while another investigated mothers with a BMI > 24.9 [62]. Finally, one study examined adults with a BMI > 25 [50], and one enrolled participants with gout [57]. For the delivery of the interventions, thirteen of the studies utilized an app as the primary educational tool

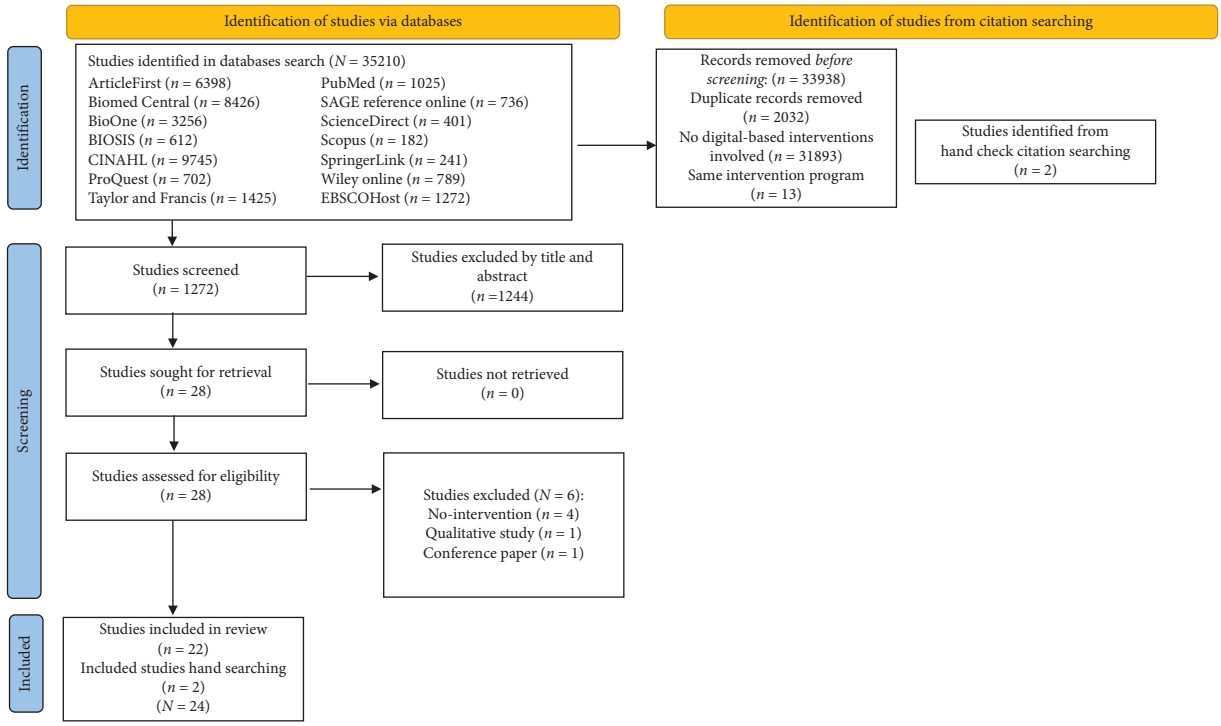

Figure 1: PRISMA 2020 flow diagram.

[53, 54, 57, 58, 60, 63, 64, 66, 68–72], seven were delivered via the internet [51, 52, 55, 56, 59, 62, 67], and four interventions were delivered via cell phone and/or mixed mobile health methods using health coaching prompts by location, SMS messaging prompts, or phone call follow-up [49, 50, 61, 65].

3.1. Digital DASH Interventions and Evidence-Based Approaches. Of the 10 studies that utilized a theoretical framework, model, or construct of behavior change [50, 56, 58, 60, 62, 68, 69, 73, 74], three used the social cognitive theory [50, 56, 73], one study used a combination of social cognitive theory and the social ecological model [74], one study each used motivational interviewing [69], self-determination theory [58], problem-solving skills [60], coaching strategies based on the human behavior-change approach [68], episodic future thinking [62], and the integrated model of health literacy [71]. Ten of the studies included some form of human interaction in the form of coaching [50, 51, 55, 58, 59, 68, 69, 74–76]. Study participants were followed for lengths of time ranging from one to two weeks [62] to 2 years [50]. The studies with the two longest follow-up periods of one and 2 years had strong research designs [50, 77].

Based on the quality assessment of the included articles, thirteen (13) were considered of positive quality [49–56, 59, 61, 65, 71, 72], eight (8) were neutral [57, 58, 60, 63, 64, 66–68], and three (3) had negative quality ratings [62, 69, 70]. The studies included with negative ratings were statistically underpowered pilot studies [62, 69], with one of very short (2-week) duration but with compelling intervention elements aligned with the inclusion criteria for this review.

Outcomes of interest varied across studies, with 15 of the 24 studies specifically noting BP as a study measure [50, 52, 53, 55, 59–61, 63–65, 67–69, 71, 72]. Other outcomes related to DASH dietary pattern adherence such as DASH score, Healthy Eating Index score, and DASH dietary components such as fruit and vegetable intake, potassium, magnesium, vitamin C were assessed across the studies. Physical activity was a frequently assessed outcome, with nine studies [50, 52, 56, 58, 59, 61, 64, 66, 69] reporting on steps per day, level of activity, or minutes spent in physical activity. Four of the studies [57, 63, 66, 69] also evaluated the level of engagement with the app or education modules.

3.2. Digital DASH Interventions and BP. The DASH dietary pattern was initially developed as a dietary approach to controlling hypertension, so it is logical that of the 24 articles reviewed, 15 digitally delivered DASH interventions included BP as an outcome [51–53, 55, 59, 60, 63–65, 67–69, 71, 72]. However, of those 15 interventions, only 10 recorded changes in BP [51–53, 59, 61, 64, 65, 67, 68, 71], and of those, only 5 studies [51, 64, 67, 68] found significant change postintervention, while the remaining four [53, 59, 61, 65] found either nonsignificant decreases in the intervention group or comparable decreases in both the intervention and control groups.

3.3. Digital DASH Interventions and Dietary Outcomes. Of the studies that reported dietary intake changes, three reported significant improvements. Moore et al. [67] observed that interventions led to a significant increase in the intake of fruits, vegetables, and grains ($p < 0.05$). The study

Table 1: PICOS criteria for inclusion and exclusion of studies.

Parameter	Inclusion criteria	Exclusion criteria
Population	All age groups	N/A
Morbidities	With or without co-morbidities	N/A
Intervention type	All digitally delivered interventions based on dietary approaches to stop hypertension (DASH) or including a DASH component, which examine: - Measuring DASH scores - Adherence to DASH - Impact of DASH on nutrition behaviors - Impact of DASH on nutrition-related health outcomes	Non digitally formatted or delivered interventions
Outcomes	Blood pressure weight Blood lipid profile food intake Diet quality Food purchasing measures sodium intake Overall quality of healthy eating index Commitment in using and accessing the platform or the application	Non-numeric/categorical assessment
Effectiveness of the DASH intervention	Change in scores for DASH adherence changes in blood pressure Changes in weight loss changes in sodium intake Changes in quality of food purchasing and consumption Changes in quality of healthy eating index Changes in frequency of accessing and using the platform or the application	N/A
Language	English	All other languages
Category study types	Peer-reviewed articles intervention-based studies	Nonpeer-reviewed articles commentaries Narratives communications conference papers white papers gray literature Similar article types protocols Feasibility studies without measured Outcomes reported

Note: N/A: not applicable.

Table 2: Summary of literature search ($N = 24$).

Authors, year/country	Quality score —/Ø/+	Target population/sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Alnooh et al., 2024/Saudi Arabia	—	14 adults with HPTN	1 group, 8 week pretest and post-test	N/R	Use noon app daily for 8 weeks to enter all food/beverages consumed	Improvement in self-efficacy and DASH diet adherence not statistically significant; participants found noon app acceptable, suggestions included developing Arabic version, simplifying method of food log in	App was feasible, acceptable; studies needed to examine apps in promoting adherence to DASH diet, BP impact in Saudi Arabia
Darabi et al., 2024/Iran	Ø	88 adults aged 30–69 with HTN	Parallel group RCT × 12 weeks	Social cognitive theory	mHealth intervention IG: usual care + mHealth app with DASH and HTN education intervention; CG: usual care	Significant pre- and postdifferences in IG: SBP ($p = 0.0001$), DBP ($p = 0.0001$) compared to CG; 5 self-efficacy components improved significantly in IG ($p = 0.0001$, $p = 0.0001$, $p = 0.001$, $p = 0.04$, ($p = 0.000$) compared to CG; no differences in DASH diet adherence ($p = 0.771$)	Findings showed a mobile app for educating DASH diet, improving self-efficacy leads to better HPTN control, self-efficacy improvement
Eyles et al., 2017/New Zealand	Ø	66 adults with CVD; IG: 33; CG: 33	Two-arm, parallel, randomized controlled trial × 4 weeks	mHealth approach to behavior change	Use of salt switch smartphone app	Significant decreases in mean household salt purchases in IG compared to CG ($p = 0.03$); no change in any secondary outcomes	SaltSwitch phone app effective in supporting people with CV disease to make lower salt food purchases; larger trial with longer follow-up needed
Glenn et al., 2019/Japan	Ø	559 Japanese adults ≥ 40 years	Single-arm, longitudinal pilot study × 16 weeks	Lifestyle and behavior change	Smartphone multidomain cognitive lifestyle intervention developed in U.S. for Japanese population	Significant relationships between engagement with app and nutrition score ($p = 0.03$) and minutes exercised ($p = 0.01$);	Program feasible as shown by commitment of participants, improvement in nutrition/PA; need larger evaluation with RCT

Table 2: Continued.

Authors, year/country	Quality score —/Ø/+	Target population/sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Hollis-Hansen et al., 2020/USA	—	60 mothers aged 28–53 with BMI > 24.9; $N = 60$, 4 groups, 15/group	2 × 2 factorial randomized pilot study × 1 week	NIH stage model of behavior change	Exploratory trial using the internet × 4 arms: -SET + DASH -EFT + SAFETY SET+	EFT group significantly increased in DASH diet score ($p < 0.05$) compared to SET group; no significant effect of DASH education nor DASH by EFT interactions	Dietary intake, food purchasing results must be replicated in larger samples
Jahan et al., 2020/Bangladesh	+	412 patients with HTN aged ≥ 35; IG: 204; CG: 208	Prospective RCT parallel-group trial × 5 months	Health behavior change	IG: SMS health information text messages + health education; CG: health education only	CG had significantly higher salt intake adherence rates ($p = 0.04$), physical activity adherence rates ($p < 0.03$); salt intake in both groups improved significantly ($p < 0.001$); both groups decreased mean BP ($p < 0.05$), reported improved quality of life ($p < 0.001$)	Can improve intervention with more relevant/timely SMS text messages; community awareness encourages "low-salt culture"
Lesley, 2007/USA	Ø	78 African–American adults	Randomized two groups, multiple post-test design	Social problem-solving model	Two mobile education programs: IG: DASH app plus problem-solving training program; CG: DASH app alone	Intervention effect greatest for participants with BP screenings above normal	Problem-solving training combined with nutrition information may help African and Americans to deal more effectively with dietary problems
Miller et al., 2016/USA	+	123 African–American adults with HTN; IG: 62; CG: 61	Single-center RCT with two parallel arms × 8 weeks	N/R	IG: DASH plus coach-directed dietary advice via cell phone; CG: diet brochure plus debit account to purchase food	IG had significant increase in self-reported fruit/vegetable consumption, estimated intake of potassium, urine potassium excretion compared to CG ($p < 0.05$)	Larger trial needed to obtain a strong evidence about intervention benefit, BP effects

Table 2: Continued.

Authors, year/ country	Quality score —/Ø/+	Target population/ sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Miller et al., 2025/USA	+	301 adults with HPTN	RCT × 12 months	N/R	IG: digital health intervention (DHI) with commercially available app for daily dietary tracking data to compute DASH score, automated, tailored feedback; CG: tracked daily intake in app; access to DASH skills/materials	DASH scores not significantly different between arms at 6 months; IG had significantly greater 12-month changes in DASH score; between-group differences in 6 month changes insignificant for SBP, marginally significant for DBP	DHI had modest BP and DASH improvements; further research needed to understand utility of DHIs to promote DASH, identify interventions to support long-term behavior change
Moore et al., 2008/USA	Ø	2834 employees and spouses of EMC corporation	Longitudinal observational study × 12 months	N/R	DASH for health program with weekly internet articles about healthy nutrition	At 12 months, $n = 735$ (26%) still actively using program; subjects with BMI > 25 ($n = 151$) had significant weight change ($p < 00.001$); those with baseline HTN or pre-HTN had significant change in SBP ($p < 0.001$), but not DBP ($p = 0.16$); visiting website more often led to greater BP/ weight loss	Continuous use of internet delivered nutrition education program led to significant improvement in weight loss, BP diet; effective internet-delivered programs provide benefit to large numbers of subjects at low cost
Rich-Edwards et al., 2019/ USA	+	151 adult women with pre-eclampsia in past 5 years	RCT × 9 months	Social cognitive theory	IG: online educational modules, a community forum, communication with a lifestyle coach CG: Internet links to CVD risk reduction	IG had significantly greater knowledge of CVD risk factors ($p = 0.01$), self-efficacy for healthy eating ($p = 0.03$) compared to CG; no significant differences between groups for DASH adherence, or self-efficacy for/actual reported PA	Program improved CVD risk knowledge, self-efficacy to achieve a healthy diet; reduced physical inactivity among women with recent preeclampsia

Table 2: Continued.

Authors, year/ country	Quality score —/Ø/+	Target population/ sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Schiwal et al., 2020/USA	Ø	146 adults/general community; IG: 104; CG: 42	RCT × 6 months	Self-determination theory	Gray matters app targeted lifestyle risks For Alzheimer's disease, including DASH diet; IG: student health coach, activity tracker + app; CG: health coach + study website	IG motivation increased significantly (2.09 ± 4.82), compared to CG ($p = 0.003$); vigorous PA increased in males with high IM compared to lower IM males ($p = 0.030$). Diet Quality significantly improved in persons With high vs. low IM ($p = 0.038$)	App improved IM, PA/ diet quality for subgroups; future research should examine how IM moderates change across age groups, gender; other motivation associated with behavioral change
Serlachius et al., 2019/ New Zealand	Ø	72 adults with gout; gout IG: 36; DASH IG: 36	RCT × 2 weeks	Behavioral self-management	2 week intervention with self-management or DASH app	Gout IG found app more engaging ($p = 0.003$), informative ($p = 0.04$) than DASH IG at 2 week follow-up; were no significant differences in self-care behaviors	Differences in engagement scores did not translate into Differences in self-care behaviors
Staffileno et al., 2018/USA	+	26 African–American women, age 18-45 with pre-HTN; DASH group: 14; PA group: 12	RCT × 12 weeks	Social cognitive theory, MI, behavioral self-management	Web-based, culturally relevant lifestyle intervention; IG: DASH online education; CG: PA, online education	Significant change in total DASH score ($p = 00.001$) between groups; completion of activities 71%/48% in DASH/PA groups	eHealth platform feasible for improving PA, dietary behaviors in African–American women
Steen et al., 2022/ USA	+	247 adults ≥ 1 CV risk factor; IG#1: 100; IG#2: 101; CG: 46	3 arm RCT with 3 months follow up	Individualized education sessions	Dietician delivered web and supermarket intervention; IG#1: point of purchase DASH nutrition education; IG#2: purchase DASH nutrition education, online shopping technologies/ training; CG: Standard of care	DASH score significantly increased for the combined IG#1 and IG#2 compared to the CG ($p = 0.02$).	Results suggest efficacy of supermarket-based, dietary interventions, modern online shopping tools in improving dietary quality; opportunity for academic investigators to collaborate with retailers to design and test comprehensive healthcare interventions

Table 2: Continued.

Authors, year/country	Quality score —/Ø/+	Target population/sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Steinberg et al., 2019/USA	+	306 adult patients with elevated cardiovascular risk	RCT × 12 months	Social cognitive theory	Digital weight loss intervention; IG: mobile app use, tailored diet feedback, weekly monitoring, PA CG: usual care	Improvements in IG DASH nutrient score ($p < 0.001$), weight loss ($p = 0.003$) IG compared to CG; no difference in DASH food score between groups; no association found between DASH adherence/BP changes	Focusing on both calorie restriction and diet quality is recommended in interventions promoting weight loss
Steinberg et al., 2020/USA	+	59 adult women, BMI ≥ 18.5 and HTN CG: 29; IG: 30	RCT × 3 months	Health and behavior change model	DASH cloud intervention; IG: app diet tracking plus feedback on DASH adherence; CG: app diet tracking	No significant changes between IG and CG for mean days tracked ($p = 0.54$), DASH score changes ($p = 0.75$)	Digital health intervention feasible, produced high engagement
Sun et al., 2024/China	+	54 adults > 60 with primary HTN or currently taking HTN medication; IG: 23; CG: 31	2-arm RCT × 12 weeks	Behavior change wheel, integrating 19 behavior change frameworks	IG: received health behavioral digital intervention for hypertensive patients (HBDIHP) + regular care; CG: routine care	Significant changes in SBP ($p = 0.05$), exercise time ($p = 0.03$), medication adherence ($p = 0.02$), BP monitoring frequency ($p = 0.046$), learning performance ($p < 0.001$) between IG and CG	Program may have enhanced health outcomes, adherence to health behaviors; longer-term, larger-scale trial necessary to validate effectiveness
Svetkey et al., 2009/USA	+	32 physicians and 574 patients with HTN MD-I: 16; MC-C: 16 Pt-I: 185; Pt-C: 89	2 × 2 nested RCT × 18 months	N/R	MD-I: HTN training, lifestyle guidance, care; MD-C: usual care; Pt-I: behavior change education, lifestyle counseling; Pt-C: usual care + visit with provider for advice, written materials on lifestyle modifications	Largest effect was found in the combined MD-I/Pt-I group; significant decrease in SBP ($p = 0.0072$) compared to all other groups	Combined physician/patient intervention lowers blood pressure; future research should focus on enhancing effectiveness/sustainability

Table 2: Continued.

Authors, year/ country	Quality score —/Ø/+	Target population/ sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Svetkey et al., 2015/USA	+	365 adults ages 18–35 with BMI ≥ 25; IG#1: (cell phone): IG#2: (cell phone plus coaching): CG: 123	RCT × 24 months	Social cognitive theory, transtheoretical model	mHealth intervention comparing DASH diet education delivered via cell phone to cell phone plus personal coaching	IG 2 participants lost significantly more weight than IG 1 and CG at 6 months ($p = 0.003$), however, that result did not persist at months 12 or 24	Despite strong design, high engagement and retention, interventions did not lead to sustained weight loss; results sound cautionary note re mobile app delivery
Toro-Ramos et al., 2016/USA	Ø	50 adults with pre-HTN or HTN	Pre- and post-test pilot study × 24 weeks	MI, CBT	Mobile app intervention with human coaching	Significant reductions in weight ($p < 0.001$), DBP ($p = 0.004$), HPN ($p < 0.001$); those completing ≥ 80% of program had significant decreases in SBP ($p < 0.001$), weight ($p < 0.001$)	Mobile delivery of intervention showed short-term potential to reduce HPN risk; need for longer-term studies
Van horn et al., 2018/USA	+	281 overweight or obese pregnant women; CG: 141; IG: 140	RCT × 24–36 weeks	MI	IG: DASH/PA phone app coaching sessions, reminders, newsletters, pedometer, text messages; CG: usual care	IG: DASH scores, HEI scores significantly improved ($p = 0.01$, $p = 0.005$, and $p = 0.002$), lower gestational weight gain ($p = 0.01$) compared to CG; no differences in birth weight, percentage body fat, or adverse pregnancy outcomes	Intervention led to better nutrient quality; improving DASH diet/PA adherence needed
Weerahandi et al., 2020/USA	—	17 adults 18–65, on HTN meds or stage 1 HTN	Single-arm pilot study × 4 months	MI	DASH mobile app intervention with health coach	No significant findings on primary parameters from pre- to postintervention.	High overall participant interaction with app suggests good tool for behavioral change

Table 2: Continued.

Authors, year/ country	Quality score —/Ø/+	Target population/ sample size	Type of study	Theory/framework	Intervention	Main results	Conclusion
Youngiam and Therawiwat 2024/ Thailand	+	80 adults 30–59 with pre-HPTN and high-sodium diet	2-Group RCT × 8 weeks	Integrated model of health literacy	IG: interactive app with 8 weekly activities	IG: NA consumption/ DASH diet health literacy increased significantly ($p < 0.001$) and mean score of sodium consumption behavior, sodium intake, SBP, DBP systolic ($p < 0.05$); no change in CG	App is practical effective in reducing NA intake, BP; further testing in other populations/ settings needed

Note: HTN: hypertension; N/R: not reported; SAFETY = food safety education.

Abbreviations: BMI, body mass index; BP, blood pressure; CBT, cognitive behavioral therapy; CG, control group; CVD, cardiovascular disease; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; EFT = episodic future thinking; HEI, Healthy Eating Index; IG, intervention group; IM, intrinsic motivation; MI, motivational interviewing; PA, physical activity; RCT, randomized controlled trial; SBP, systolic blood pressure; SET, standardized episodic thinking.

by Schiwal et al. [58] found that diet quality improved significantly in individuals aged 58–64 years old ($p < 0.03$) after the intervention. Youngiam and M. Therawiwat [71] found a significant decrease in salt intake in the intervention group, while Jahan et al. [61] reported that both the intervention and the control group experienced a significant decrease in salt intake ($p < 0.001$).

4. Digital DASH Interventions and Physical Activity

The effect of the intervention on weight and BMI was reported in several studies. Moore et al. [67] found that after 12 months, the intervention resulted in a significant reduction in body weight by 4.2 lbs. ($p < 0.001$). Jerome et al. [76] reported a noteworthy decrease in body weight by approximately 10.6 lbs. ($p < 0.05$) following the intervention. Svetkey et al. [50] observed that the test group had significantly higher weight loss compared to the control group at 6 months ($p = 0.003$), but this difference was not sustained at 12 and 24 months. Conversely, Van Horn et al. [49] noted a significant difference in weight gain in the intervention group, with an increase of 3.7 lbs. ($p = 0.01$). Furthermore, Toro-Ramos et al. [68] demonstrated that among participants who completed the program with 80% commitment, there was a significant reduction in weight by 6.7 lbs. ($p = 0.001$).

Some of the studies reported results showing changes in some related aspect of health. For example, the randomized controlled 9-month clinical trial of Rich-Edwards et al. [59] with women with a history of preeclampsia improved CVD risk knowledge and self-efficacy to achieve a healthy diet and reduced physical inactivity among this sample of women. Sacks et al. [77] conducted a study that showed a reduction in healthcare costs by $827 during the year-long intervention ($p = 0.05$).

5. Discussion

Nutrition and health behaviors and dietary patterns are difficult to change [78–81]. Many theories, frameworks, and models of behavior change have been developed to encourage positive change in health behaviors, while discouraging behaviors that may negatively impact health, such as smoking, consuming too much sodium, or consuming a low nutrient density diet [80–85]. In concordance with other literature on health promotion interventions, interventions developed using evidence-based approaches to health behavior change show stronger outcomes. Such approaches ensure that the appropriate behaviors are targeted using educational and behavior change techniques that support the participant and allow the efficacy of the intervention to be assessed [85–90].

Dietary approaches to HPN control are important contributors to addressing the disease process, as are evidence-based approaches to behavior change. However, HPT is a long-term, complex disease with a variety of contributing mechanism, including diet in general and salt intake specifically, physical exercise, genetics, baseline weight and body composition, and overall health, including concurrent disease such as diabetes, COPD, renal failure, and/or psychiatric disorders. Interventions that focus on only one or two selected inputs to the HPT disease process for short intervals are less likely to see success in the critical distal outcomes of BP measurement and weight, even with the best of theoretical approaches.

The most important outcomes in studies focused on the contribution of DASH diets and HPT are actual changes in BP, which were recorded as an outcome in only 15 of the 24 identified studies [51–53, 55, 59, 60, 63–65, 67–69, 71, 72]. These changes are going to be difficult to achieve in studies with follow-up that is limited to a few weeks to months [51, 52, 54–56, 61–63, 65, 68]. Proximal outcomes such as knowledge and DASH scores are important for the feasibility of implementing complex and expensive research designs. However, the distal outcome of BP control and cardiac health must somehow be integrated into measuring the complex interactions of diet, disease, and longevity.

In addition to the body of health promotion literature that supports evidence-based approaches to intervention development, implementation, and evaluation, there is also considerable literature considering the effect of intervention delivery mode. Interventions that can be partially or wholly delivered through an app and/or are accessible on a phone or computer may be more accessible to participants, lower cost to researchers, and increase participation by fitting more easily into the busy lives of participants. However, intervention outcomes delivered through these modalities have been mixed [27, 91–94]. The interventions included in this review reflect the range of effect that digitally delivered DASH intervention can have on BP, DASH score, HEI score, and DASH dietary components. Of the 12 positively scored interventions, 11 found significant intervention effects in reduction of salt intake, intake of DASH diet components, increased knowledge on CVD risk factors and self-efficacy for healthy eating, DASH score, overall BP, SBP, weight reduction and gestational weight gain. One of the 11 studies found that the significant weight loss between the intervention and control group did not persist at 12 month follow-up [50]. Although not all included interventions had statistically significant findings, the overall trend toward positive health improvements across the studies indicates the potential for health and nutrition behavior change interventions that are evidence-based and technology-delivered. This is in line with other findings on digitally delivered dietary interventions, but the low-to-moderate quality of the overall evidence across the literature suggests a need for more research in this area [28, 95–100].

Interventions that utilized a personalized approach and/or that included virtual interaction with a member of the research team were in general more effective at achieving at least some of the stated outcomes, suggesting that participants may either find a mixed approach to intervention delivery more engaging or that they were more likely to feel accountable for participation. This is in alignment with the current literature on digital health promotion interventions [28, 95, 98, 101–104].

Based on the existing literature, well-planned and evidence-based approaches to digital health promotion interventions may be able to target and positively impact nutrition and health behavior. Such interventions appear to be most effective when they employ a behavior change framework or model, are culturally appropriate, and include some personalized and/or human interaction. The current review finds that there is a low to moderate impact of digitally delivered DASH interventions on a variety of health outcomes. Due to the heterogeneity of the studies and outcomes of interest, more research is warranted to determine the best approaches to engaging participants with digitally delivered DASH-focused interventions and for effecting change in intended outcomes.

6. Conclusion

This systematic scoping review supports the potential of digital-based interventions using the DASH dietary pattern to improve nutrition and health outcomes, particularly in increasing adherence to the DASH dietary pattern as measured by DASH score. More research is needed to determine how to best effect change in BP, which is the primary intent of the DASH diet. Because the effects on BP were mixed in the articles included in this review, determining the best intervention duration for such interventions is important. Further investigation of the best practices related to the development and delivery of digital-based interventions to improve adherence to the DASH dietary pattern is warranted. Based on the findings of this review, digital-based and online delivery of DASH interventions may be successfully implemented across diverse settings, age groups, countries, and populations, but evidence-based approaches and digital engagement strategies must be considered in intervention design.

Data Availability Statement

The authors confirm that the data supporting the findings of this review are available within the article, figure, and tables.

Ethics Statement

The authors have nothing to report.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. *(Supporting Information)*

Scopus Database

"online" [All Fields]; "app" [All Fields]; "digital" [All Fields]; computer" [All Fields]; "technology" [All Fields]; "internet" [All Fields]; "web-based" [All Fields]

AND

"Intervention" [All Fields]; "Program" [All Fields]; "education" [All Fields]

AND

"DASH diet" [All Fields]; "Dietary Approaches to Stop Hypertension dietary pattern" [All Fields]; "D.A.S.H diet" [All Fields]; AND

"hypertension" [All Fields]; "blood pressure" [All Fields]

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