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REVIEW
Arterial hypertension

Non-pharmacological factors for hypertension management: a systematic review of international guidelines

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Lifestyle modifications are one of the cornerstones of hypertension prevention and treatment. We aimed to systematically review hypertension guidelines on their recommendations on non-pharmacological factors including lifestyle interventions, to highlight strength of evidence, similarities, and differences. This systematic review was registered with the international Prospective Register of Systematic Reviews (CRD42021288815). Publications in MEDLINE and EMBASE databases over 10 years since January 2010 to June 2020 were identified. We also included the search from websites of organizations responsible for guidelines development. Two reviewers screened the titles and abstracts to identify relevant guidelines. Two reviewers independently assessed rigour of guideline development using the AGREE II instrument, and one reviewer extracted recommendations. Of the identified guidelines, 10 showed good rigour of development (AGREE II ≥ 60%) and were included in the systematic review. The guidelines were consistent in most recommendations (reduced salt intake, weight, dietary patterns, increased physical activity and smoking cessation, and limiting alcohol intake). Some areas of disagreement were identified, regarding recommendations on novel psychological and environmental factors such as stress or air pollution, alcohol intake thresholds, meat, coffee and tea consumption and refined sugars. Current guidelines agree on the importance of lifestyle in the treatment and prevention of hypertension. Consensus on smoking cessation, limited salt intake, increased physical activity support their integration in management of hypertensive patients and in public health measurements in general population as preventative measurements. Further research into the role of environmental and psychological factors may help clarify future recommendations.

Keywords Hypertension • Blood pressure • Lifestyle • Non-pharmacological interventions • Guidelines

Introduction

Hypertension is the most prevalent noncommunicable chronic disease and cardiovascular risk factor and affects a large proportion of the general population. In 2010, 31% of the global adult population had a diagnosis of hypertension.[1] As its prevalence is estimated to further increase over the next 10 years, the World Health Organization (WHO) has prioritized a reduction to 25% by 2025 as one of its global targets.[2]

All the major scientific societies' hypertension guidelines include lifestyle modifications as fundamental part of treatment at any stage of hypertension, including those at highest risk with resistant hypertension.[3–5] Integration and adherence to long-term comprehensive lifestyle interventions (such as smoking cessation, salt reduction, dietary and psychological interventions, and increased physical activity) leads to lower blood pressure (BP) and improved cardiovascular biomarkers[6,7] and to reduced medication load.[8]

Therefore, recommendations for non-pharmacological interventions are an essential part of treatment and prevention of hypertension now more than ever, with more emphasis given to the strength of evidence in their support when included in guidelines. However, it is unclear whether guidelines are consistent in their recommendations.

Furthermore, due to the evidence from the SPRINT trial[9] but also other studies and meta-analyses,[10,11] some international guidelines have recommended a lower threshold for the diagnosis of hypertension.[5] Consequently, a much larger population of patients with lower cardiovascular risk profile will be recommended to implement

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lifestyle modifications to reduce their BP, while initiation of pharmacological treatment, in conjunction with lifestyle advice, will be reserved for those with a 10-year cardiovascular risk higher than 10% (such as in presence of diabetes and/or renal disease).[5,12]

Lifestyle changes in hypertension include several non-pharmacological interventions and factors with different levels of evidence and strength of recommendation. Moreover, they can differ among societies and group of patients.

We aimed to systematically review contemporary hypertension guidelines from different scientific societies and the selection of appropriate non-pharmacological interventions based on currently available evidence, highlighting similarities and differences and strength of recommendations. By a critical appraisal, we sought to provide a summary to help healthcare professionals and researchers involved in hypertension treatment and prevention and provide highlight potential gaps for future research or guideline development.

Methods

Data sources and guideline selection

We conducted an updated systematic review of guidelines for primary (essential) and/or resistant arterial hypertension. The systematic review was registered with the international Prospective Register of Systematic Reviews (CRD42021288815). The search strategy is reported in Supplementary material online, *Table S1*. Practice Guidelines, guidelines guidance, and scientific societies position papers and statements were included. References that met the Institute of Medicine's definition of a guideline were included (i.e. 'statements that include recommendations, intended to optimize patient care, that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options).[13] Abstracts, conference and opinion papers, case studies and letters, commentaries, editorials, and papers lacking full text were excluded. Guidelines focused on pre-eclampsia and secondary hypertension were also excluded.

Our search was restricted to national and international guidelines written in English.

We searched for published guidelines using MEDLINE and EMBASE between January 2010 and June 2020. We also searched websites of guideline development organizations, including those affiliated with all the guidelines included in our previous publication,[14] to find relevant additional or updated guidelines (see Supplementary material online, *Table S2*).

Study selection

Guidelines were excluded if they were focused on non-adult population or only made recommendation on pharmacological intervention.

Two independent reviewers (A.L., K.B.P.) assessed articles based on the title and the abstract and initial a priori inclusion and exclusion criteria used to conduct the database search were applied. Relevant guidelines were then assessed for full text review and extraction based on inclusion and exclusion criteria.

The Appraisal for Guidelines and Research Evaluation (AGREE) II tool[15] was used to calculate the rigour of development score. A score of over 60% was deemed to represent a rigorously developed guidelines, in the context of addressing lifestyle modifications, and was required for inclusion in the final analysis.

Data extraction and quality assessment

The titles and abstracts of papers were assessed by two independent reviewers (A.L., K.B.P.). Any disagreement was settled by consensus or the impartial judgement of a third reviewer who arbitrated (C.M.). The same reviewers independently performed full data extraction into a prespecified extraction which included methods, patient groups and a summary of the lifestyle advice and intervention recommendations.

Data synthesis and analysis

Three reviewers (C.M., A.L., K.B.P.) extracted all the relevant recommendations from the guidelines that had an AGREE II score $\geq$ 60%. General lifestyle advice was the main emphasis of the data extraction. A recommendation matrix was produced.

Results

Our search retrieved 5890 titles, of which 140 titles were identified as potentially eligible. Based on the abstract review, we excluded 118 articles. After full article review, 12 more were excluded. We included 22 guidelines on hypertension. *Figure 1* shows the PRISMA flow diagram highlighting the full inclusion and exclusion process.[16] Ten guidelines had an AGREE score above the threshold of 60% and were included in the final extraction table. *Table 1* summarizes the selected guidelines, along with rigour scores and conflicts of interest.

The areas of agreement and disagreement are summarized in *Figure 2*.

Supplementary material online, *Table S3* shows the guidelines excluded based on their AGREE score.

Areas of agreement

Smoking

There was a consensus regarding the importance of smoking cessation advice. The only guidelines that did not have recommendations on smoking were the 2017 American College of Cardiology/American

Heart Association (ACC/AHA) ones as smoking was not included in the guideline's clinical questions. All guidelines recommend offering referral to counselling services and pharmacotherapy. Most guidelines also emphasize avoidance of second-hand smoke.

Dietary sodium restriction

There was consensus regarding the anti-hypertensive effect of sodium restriction and the role of limiting salt intake in diet, not only in hypertensive patients but also as a measure of prevention of hypertension in the general population. Salt intake can be estimated from the 24-h urine collection measurement of sodium. Four of the selected guidelines recommended 5 grams of salt (approximately 2 grams of sodium) as thresholds of maximum daily amount. The AHA/ACC recommends less than 1.2 grams of sodium, equivalent to 3.8 grams of salt a day.

Interestingly, the Japanese Society of hypertension guidelines kept into consideration that the average daily intake of salt in their general population is one of the highest worldwide (>10 grams/day) and accept a threshold <6 grams/day for hypertensive patients. Similar advice is from other Asian guidelines (Korean and Chinese) and the Australian ones.

Potassium intake

There is evidence that potassium intake is inversely related to BP,[17,18] and that potassium-rich foods can help prevent and improve

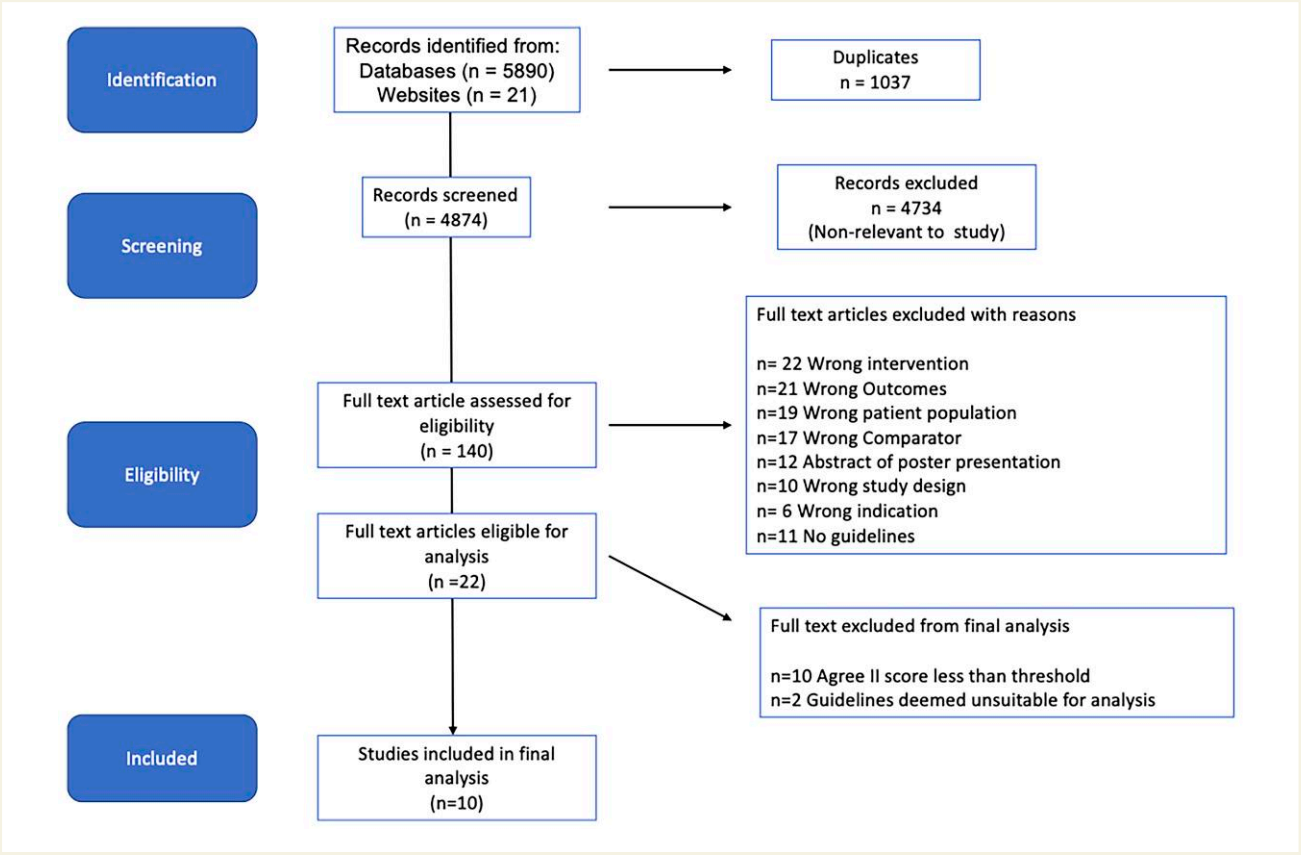

Figure 1 Summary of the guidelines search and review process. The number of guidelines at each step is indicated in brackets. AGREE II = Appraisal of Guidelines for Research and Evaluation II.

hypertension via different mechanisms including increased natriuresis, improved endothelial function and increased nitric oxide (NO) release, and inhibition of sympathetic activity.[19,20] Hence, eight guidelines recommend increased intake of potassium mainly by increasing dietary intake of fruit and vegetables, but not in patients at risk of hyperkalaemia (such as those with kidney failure or on mineralocorticoid receptor antagonists). The daily amount recommended is between 3.5 and 5 grams/day.

Dietary patterns

All guidelines recommend a healthy diet, rich in fresh fruit, vegetables, and whole grains, preferring low-fat dairy products, and with reduced content of saturated and total fat and red meats. The most recommended dietary patterns were the Mediterranean or the Dietary Approaches to Stop Hypertension (DASH) diet. Some guidelines mention the Nordic dietarian pattern, rich in oily fish.

Red meat

Most of the guideline recommendations suggest reduction of red meats in diet or recommend dietary patterns such as the DASH or Mediterranean diet, characterized by low weekly amounts of red meat, but do not have a specific recommendation section on red meats. Moreover, there was no specification regarding the maximum amount of weekly or monthly intake.

Fruit and vegetables, wholegrains

All guidelines recommend increased intake in the diet. Some guidelines advice on caution on intake of fruit in patients who are in the overweight/obese categories and those with known hyperkalaemia. International Society of Hypertension (ISH) and Qatar guidelines recommend abundant intake of vegetables rich in nitrates such as beetroot as they are known to lower BP. All guidelines included in this review make a general recommendation without specifying cut-offs or portions/servings.

Fish

All guidelines recement increase in fish intake as part of balanced diet, such as the Mediterranean diet. Only the Qatar Guidelines recommend an intake at least twice a week. Otherwise, the recommendations remain unspecific on the weekly amount.

Fats

There was consensus on the benefits of lowering dietary saturated and trans-saturated fat intake. The Australian guidelines specifically state that total fat intake should account to no more than 20–35% and total saturated and trans fats for no more than 10% of energy intake. Unsaturated fatty acids of vegetable origin, especially olive oil, are explicitly recommended in the diet for hypertensive patients in some guidelines.

Table 1 Characteristics of the 10 guidelines and a summary of their lifestyle recommendations

Organization responsible for guideline development	American College of Cardiology/American Heart Association (ACC/AHA)	National Heart Foundation of Australia	Hypertension Canada	Malaysian Society of Hypertension	Ministry of Public Health Qatar
Country applied	USA	Australia	Canada	Malaysia	Qatar
Year	2017	2016	2018	2018	2016
AGREE II rigour Score %	93.8%	90.2%	89.2%	85.7%	83.9%
Methods used to evaluate evidence	Systematic review	Systematic Review and Externally reviewed	Systematic Review and Externally evaluated against AGREE II	Systematic review	Meta-analysis (systematic review of RCTs, observational studies, and expert opinion/statements)
Methods used to formulate recommendations	Formal consensus	Formal Consensus	Formal Consensus	Formal consensus by DG members using Critical Appraisal Skill Programme checklist This CPG is based largely on the findings of studies conducted in Malaysia.	GDG members developed recommendations of different grades (A, B, C). Level 1, Level2, Level 3
COI	Financial but not intellectual COI disclosed	COI disclosed	COI disclosed	NR	COI disclosed and retained by the MOPH
LIFESTYLE CHANGES					
Smoking	NR	Smoking cessation structured consultations with medical professionals (ask, assess, advise, assist, arrange)	Advice on smoking cessation and use pharmacotherapy if indicated (Grade C).	Stop smoking to reduce overall CVD risk (Grade C).	Stop smoking (L2, RGA).
Dietary patterns	DASH diet (rich in fruits, vegetables, whole grains, and low-fat dairy products, reduced content of saturated and total fat)	NR	NR	Diet rich in fruits, vegetables, and dairy products with reduced saturated and total fat (Grade A)	DASH, Mediterranean diet (L1, RGA)
Diet	DASH pattern	DASH diet	DASH diet, diet high in plant source protein (Grade B)	DASH, Nordic, Mediterranean diets decrease BP by 4.26/2.38 mmHg	DASH or Mediterranean diet (L1, RGA)
Saturated Fat	Reduce dietary intake	Recommended that total fat intake should account for 20–35% energy intake and total saturated and trans fats comprise no more than 10% of energy intake	Low fat dairy products, reduce saturated fat and cholesterol (Grade B)	Reduce dietary intake	Reduce dietary intake (L1, RGA)

Continued

Table 1 *Continued*

Organization responsible for guideline development	American College of Cardiology/American Heart Association (ACC/AHA)	National Heart Foundation of Australia	Hypertension Canada	Malaysian Society of Hypertension	Ministry of Public Health Qatar
Fruit and vegetables	To be increased	Diet rich in fruit and vegetables (2 servings of fruit, 5 servings of vegetables)	Diet rich in fruit and vegetables (Grade B)	Diet rich in fruits and vegetables (Grade A)	Diet rich in fruit and vegetables (caution* observe overweight patient for weight gain) (L1, RGA)
Fish	NR	NR	NR	NR	Preferably oily fish at least 2×/week (L1, RGA)
Grains and nuts	NR	Increased intake of wholegrains	Increase intake of wholegrain food rich in dietary fibre (Grade B)	Increased intake of nuts and legumes	Increased intake of wholegrains (L1, RGA)
Salt	Sodium reduction recommended (Class I Level A). Optimal goal is <1500 mg/d, but aim for at least a 1000-mg/d reduction in most adults	Reduce salt intake to <6 g per day for primary prevention &<4 g/day for secondary prevention, choose food < 120 mg/100 g of salt	Reduce sodium intake towards 2000 mg (5 g of salt or 87 mmol of sodium) per day (Grade A).	Reduce sodium intake to <2000 mg/day or <5000 mg/day of salt (Grade A)	Restrict salt intake to <5000 mg/day (L1, RGA)
Potassium supplementation	Aim for 3500–5000 mg/day consumption via a diet rich in potassium if BP is elevated. Do not recommend if at risk of hyperkalemia and poor renal function (Class I Level A)	Increase dietary potassium fruits and vegetables.	Increase potassium intake with low risk of hyperkalemia (Grade A)	Increasing dietary potassium with low risk of hyperkalemia or impaired renal function, reduces BP by 3.49/1.96 mmHg	Increase potassium intake if low risk of hyperkalemia
Alcohol intake	Reduce intake to no more than 2 drinks/day for men and 1 drink/day for women* (Class I Level A)	Reduce frequency and volume of alcohol (no more than 2 standard units for men and women)	No more than 2 drinks per day (no more than 14 units for men and 9 drinks for women) (Grade B)	Refrain from alcohol intake. Advise patient who insists to continue drinking to consume ≤2 drinks per day (Grade A)	Stop alcohol consumption (R-GDG) or reduce consumption to (L2, RGA2): <14 units per week for men and <8 units per week for women
Oils	NR	NR	NR	Limited evidence	NR
Sugar	NR	NR	NR	NR	NR
sugar-sweetened soft drinks	NR	NR	NR	NR	NR
Meats	NR	NR	NR	NR	NR
Probiotics	NR	NR	NR	NR	NR
Other dietary patterns (high protein etc.)	NR	NR	Calcium and magnesium supplementation not recommended for prevention or treatment of hypertension (Grade B)	Limited evidence	Consume Low-fat dairy products and increased dietary and soluble fibre

Continued

Table 1 *Continued*

Organization responsible for guideline development	American College of Cardiology/American Heart Association (ACC/AHA)	National Heart Foundation of Australia	Hypertension Canada	Malaysian Society of Hypertension	Ministry of Public Health Qatar
Food for health?	NR	NR	NR	NR	NR
Coffee	NR	NR	NR	NR	Discourage excessive caffeine intake (e.g. more than 5 cups of coffee a day) (L1, RGB).
Tea	NR	NR	NR	Green and black tea advised in diet (limited evidence)	Green and black tea advised in diet
Dark chocolate	NR	NR	NR	Limited evidence	NR
Behavioral therapies (guided breathing, yoga, transcendental meditation, and biofeedback)	NR	NR	NR	Reduce stress, albeit evidence on relaxation interventions have not been convincing. (Grade C)	Not routinely provided but may be useful adjunct to treatment (Meditation,Cognitive therapies, Muscle relaxation, Biofeedback, Shinrin-yoku (forest bathing) (L1, RGA)
Weight	Weight loss is recommended in adults with elevated BP or hypertension who are overweight/obese (Class I Level A) Best goal = ideal body weight Aim for at least a 1-kg reduction in body weight for most adults who are overweight. Expect about 1 mm Hg for every 1-kg reduction in body weight.	<25 kg/m^2 BMI Waist circumference -Men <94 cm (<90 in Asian men) -Women <80 cm Set achievable intermediate goals and long-term adherence to multiple lifestyle changes in consultations	Promotion of weight loss (Grade B) Maintain weight 18.5–24.9 kg/m^2 BMI, Waist circumference (Grade C) Men <102 cm Women <88 cm Consult individuals that multiple lifestyle interventions are needed to control weight (Grade B)	A 4 kg reduction in body weight would achieve a BP reduction of 4.5/3.2 mmHg. Reduction of 1 kg in weight relates to 1 mmHg reduction in SBP (Grade A)	Encourage reduction of BMI to 20–25 kg/m^2 at a rate of no more than 10% of body weight over 6 months, Waist circumference: <94 cm men of European origin, <90 cm men of other ethnicities, <80 women of all ethnicities (L1, RGA)
Physical activity	NR	18–64 y:150–300 minutes of moderate intensity exercise Or 75–150 min of vigorous exercise per week Over 65 y: At least 30 min of vigorous exercise/day* ensure safety precautions are given	30–60 min of moderate intensity dynamic exercise 4–7 days per week (Grade D)	Advise patients to perform physical activity (e.g. moderate intensity aerobic exercise of at least 150 min per week).	30 min moderate-intensity dynamic aerobic exercise 5–7days/week (walking, jogging, cycling, swimming) (L1, RGA)

Continued

Table 1 *Continued*

Organization responsible for guideline development	American College of Cardiology/American Heart Association (ACC/AHA)	National Heart Foundation of Australia	Hypertension Canada	Malaysian Society of Hypertension	Ministry of Public Health Qatar
Exercise training	Aerobic: (90–150 min/week, 65–75% heart rate rise) Dynamic resistance (90–150 min/week, 50–80% 1 rep maximum,6 exercises, 3 sets/exercise, 10 repetitions/se, Isometric resistance (4 X 2 min (hand grip), 1 min rest between exercises, 30–40% maximum voluntary contraction, 3 sessions/week 8–10 week	Muscle strengthening 2 days a week	Higher intensities of exercise are not more effective (Grade D). The use of resistance or weight training exercise (such as free weightlifting, fixed weightlifting, or handgrip exercise) does not adversely influence BP (Grade D).	NR	Aerobic exercise, dynamic and isometric resistance as well as aquatic training preferably on prescription if available (L1, RGA)
Supervised exercise	NR	(Unstable angina, BP ≥180/100, uncontrolled heart failure or cardiomyopathy, Myocardial infarction within the last 3 months, Severe aortic stenosis, resting tachycardia or arrhythmias, Chest discomfort or shortness of breath at rest or low activity, Diabetes with poor glycemic control)	NR	NR	NR
Stress or psychological factors	NR	Heterogeneity in outcomes-no convincing evidence of BP reduction.	If stress is a contributing factor to high BP stress management should be considered as an intervention (Grade D). Individualized cognitive-behavioral interventions are more likely to be effective when relaxation techniques are used (Grade B).	NR	Stress management (L1, RGA)
Exposure to cold	NR	NR	NR	Exposure to cold should be avoided	NR
Pollution	NR	NR	NR	NR	NR
Sleep	NR	NR	NR	NR	NR

Continued

Table 1 *Continued*

Organization responsible for guideline development	International Society of Hypertension (ISH)	Japanese Society of Hypertension (JSH)	European Society of Cardiology/European Society of Hypertension (ESC/ESH)	Korean Society of Hypertension	Chinese Geriatric Society, National Clinical Research Centre of the Geriatric Diseases
Country applied	Global	Japan	Europe	Korea	China
Year	2020	2019	2018	2018	2019
AGREE II rigour Score %	82.1%	81.3%	76.8%	69.6%	64.3%
Methods used to evaluate evidence	Systematic Review	Systematic review	Systematic review	Systematic Review	Systematic Review and externally reviewed
Methods used to formulate recommendations	Formal consensus	Evidence based consensus	Formal consensus	Formal Consensus	Formal Consensus
COI	COI disclosed	COI disclosed	COI disclosed	No COI	No COI
Smoking	Smoking cessation and referral to smoking cessation programs advised	Treatment/guidance for smoking cessation should be provided Avoid passive smoking.	Smoking cessation, supportive care. Behavioural support is a useful adjunct. Varenicline and nicotine combination superior to bupropion or single use nicotine therapy (Class I, Level B)	Smoking cessation, supportive care, and referral to smoking cessation programs are recommended. (class I level A) Promote nicotine replacement therapies	Smoking cessation
Dietary patterns	DASH diet	Increased intake of vegetables/ fruit; reduced intake of saturated fatty acids and cholesterol; increased intake of polyunsaturated fatty acids and low fat dairy products	Mediterranean diet	Low carbohydrate diet, eat breakfast every morning	NR
Diet	DASH pattern	Diet rich in olive oil and polyunsaturated fatty acids, seafood, grains, vegetables, fruits, beans, moderate meat intake. Mediterranean and Nordic diet recommended	Increased consumption of vegetables, fresh fruits, fish, nuts, and unsaturated fatty acids (olive oil); low consumption of red meat; and consumption of low-fat dairy products are recommended.	Diet rich in vegetable-based diet (class I level A)	Diet rich in fresh vegetables and fruit
Saturated fat	To be reduced	NR	Low consumption	Low fat dairy products (class I level A)	Increase intake of polyunsaturated fat
Fruit and vegetables	Increase intake of vegetables high in nitrates e.g. leafy vegetables and beetroot. Food rich in magnesium, calcium and	Increased intake of vegetables/ fruit (not recommended for patients with renal dysfunction. Ensure fruit intake< 80 kcal/	Increased Consumption	Diet rich in fruit and vegetable consumption (class I level A)	Eat a variety of fresh vegetables and fruit

Continued

Table 1 *Continued*

Organization responsible for guideline development	International Society of Hypertension (ISH)	Japanese Society of Hypertension (JSH)	European Society of Cardiology/European Society of Hypertension (ESC/ESH)	Korean Society of Hypertension	Chinese Geriatric Society, National Clinical Research Centre of the Geriatric Diseases
	potassium such as avocados, nuts, seeds, legumes and tofu.	day in patients who need to restrict their energy intake, such as obese and diabetic patients)			
Fish	NR	NR	Balanced diet-Mediterranean Diet	Regular intake of fish to reduce BP in obese individuals	Increase intake of fish
Grains and nuts	To be increased	NR	Balanced diet-Mediterranean Diet	Increase consumption of nuts (class I level A)	Increase intake of coarse grains and bean products
Salt	Reduce salt in food preparation and table. Avoid/limit consumption of high salt foods e.g. soy sauce, fast food, and processed food e.g. breads and cereals high in salt.	The target of salt reduction is <6 g per day (Grade 1 Evidence Level A)	Salt restriction to <5 g per day is recommended (Class I Level A).	<6 g per day (class I level A)	<6 g per day
Potassium supplementation	NR	At least 90 mmol (ca. 3500 mg)/day from fruit and vegetable intake in DASH diet pattern	NR	Increase potassium, intake if not contraindicated (e.g. renal dysfunction)	Increase potassium intake if not contraindicated
Alcohol intake	2 standard drinks for men and 1.5 for women (10 g alcohol/standard drink). Avoid binge drinking.	Alcohol intake should be restricted to ≤20–30 mL ethanol/day (man) or ≤10–20 mL ethanol/day (woman).	It is recommended to restrict alcohol consumption to: Less than 14 units per week for men. Less than 8 units per week for women (Class I Level A). It is recommended to avoid binge drinking. (Class III Level C). Alcohol-free days during the week and avoidance of binge drinking are also advised.	Moderate alcohol consumption to less than 2 drinks per day (Class I level A) An appropriate moderate daily amount of alcohol is less than 20–30 g for men or 10–20 g for women.	Elderly people should limit alcohol intake, men should drink less than 25 g of alcohol per day and women should drink less than 15 g of alcohol per/day. Liquor, wine (or rice wine) or beer consumption should be less than 50 mL, 100mL and 300 mL, respectively.)
Oils	NR	NR	Unsaturated fatty oils (Olive oil), Mediterranean Diet	High-fat diet including food fried with oil is prohibited	NR
Sugar	Reduce food high in sugar	NR	Reduce intake	See below	NR
Sugar-sweetened soft drinks	NR	NR	The consumption of these drinks should be discouraged	Reduce intake of sugar-containing sweetened beverages avoid a high carbohydrate diet, alcohol, snacks such as bread and	NR

Continued

Table 1 *Continued*

Organization responsible for guideline development	International Society of Hypertension (ISH)	Japanese Society of Hypertension (JSH)	European Society of Cardiology/European Society of Hypertension (ESC/ESH)	Korean Society of Hypertension	Chinese Geriatric Society, National Clinical Research Centre of the Geriatric Diseases
				cookies, and sweetened beverages.	
Meats	NR	NR	Low consumption of red meats	Low consumption of red meat (class I level A)	NR
Probiotics	NR	NR		NR	NR
Other dietary patterns (high protein etc.)	NR	NR		Unclear evidence for the effects of micronutrients, (calcium, magnesium, and supplementary fibre on BP)	Increase intake of calcium, fibre and polyunsaturated fatty acids
Food for health?		NR			
Coffee	Moderate consumption	NR	Moderate consumption	Caffeine from various foods rapidly increases BP, but the effect does not progress to HTN because tolerance to caffeine develops	NR
Tea	Moderate consumption	NR	Moderate consumption	NR	NR
Dark chocolate	NR	NR	NR	NR	NR
Behavioral therapies (guided breathing, yoga, transcendental meditation, and biofeedback)	NR	Avoid emotional stress	NR	Management methods, such as relaxation and biofeedback, effect on BP remains uncertain.	NR
Weight	Body weight control is indicated to avoid obesity (especially abdominal fat). Ethnic-specific cut-offs for BMI and waist circumference should be used. Alternatively, a waist-to-height ratio <0.5 is recommended for all populations.	Maintaining proper body weight: BMI <25	Body-weight control is indicated to avoid obesity (BMI >30 kg/m2 or waist circumference >102 cm in men and >88 cm in women), as is aiming at healthy BMI (about 20–25 kg/m2) and waist circumference values (<94 cm in men and <80 cm in women) to reduce BP and CV risk. (Class I Level A).	Reduce BMI <25/kg/m^2 (class I level A)	Maintain BMI 20–23.9 kg/m^2 Waist circumference -Men <90 cm -Women <85 cm
Physical activity	Moderate intensity aerobic exercise (walking, jogging,	Mild aerobic exercise (dynamic/ static muscle Load exercise) for	Regular aerobic exercise (e.g. at least 30 min of moderate dynamic	Regular aerobic exercise (e.g. at least 30 min of moderate	Physical activity regularly, no less than five days a week and no

Continued

Table 1 *Continued*

Organization responsible for guideline development	International Society of Hypertension (ISH)	Japanese Society of Hypertension (JSH)	European Society of Cardiology/European Society of Hypertension (ESC/ESH)	Korean Society of Hypertension	Chinese Geriatric Society, National Clinical Research Centre of the Geriatric Diseases
	cycling, yoga, or swimming) for 30 min on 5–7 days per week.	at least 30 min/day or 180 min/week	exercise on 5–7 days per week) is recommended (Class I Level A)	dynamic exercise 5–7 days per week) is recommended. (class I level A)	less than 30 min of aerobic physical activity per day. The recommended activities include walking, jogging and swimming.
Exercise training	HIIT -short bursts of intense activity with subsequent recovery periods of lighter activity. Strength training also can help reduce BP. Performance of resistance/strength exercises on 2–3 days per week	NR	At least 30 min of moderate intensity dynamic aerobic exercise (walking, jogging, cycling, or swimming) on 5–7 days per week. Performance of resistance exercises on 2–3 days per week can also be advised, in healthy adults, gradual increase in aerobic physical activity to 300 min a week of moderate intensity or 150 min a week of vigorous intensity aerobic physical activity, or an equivalent combination thereof, is recommended. The impact of isometric exercises on BP and CV risk is less well established	It is recommended that isometric exercise or isometric exercise, such as lifting a heavy weight can be performed concurrently with aerobic exercise but should be avoided as BP may temporarily rise when BP is not controlled. (class I level A)	Vigorous exercise is not recommended for the elderly
Supervised exercise	NR	NR	NR		
Stress or psychological factors	Stress should be reduced and mindfulness or meditactation introduced into the daily routine.	NR	NR	Control of emotional stress important for the management and patient adherence of HTN.	Ensuring adequate sleep and improving sleep quality
Exposure to cold	NR	Exposure to cold should be avoided	NR	NR	Cold tolerance and capacity of BP regulation is poor in the elderly. Exposure to cold should be avoided.
Pollution	Evidence from studies support a negative effect of air pollution on BP in the long-term.	NR	NR	NR	NR

Continued

Table 1 *Continued*

Organization responsible for guideline development	International Society of Hypertension (ISH)	Japanese Society of Hypertension (JSH)	European Society of Cardiology/European Society of Hypertension (ESC/ESH)	Korean Society of Hypertension	Chinese Geriatric Society, National Clinical Research Centre of the Geriatric Diseases
Sleep	NR	NR	NR	NR	Ensuring adequate sleep and improving sleep quality are of great significance for improving quality of life, controlling BP and reducing complications of cardiovascular and cerebrovascular diseases.

BP, blood pressure; COI, conflict of interest; CVD, cardiovascular disease; DG, development group; GDG, guideline development group; Level 1 (L1) = meta-analyses. Randomized controlled trials with meta-analysis. Randomized controlled trials. Systematic reviews, Level 2 (L2) = observational studies, examples include: cohort studies with statistical adjustment for potential confounders, cohort studies without adjustment, case series with historical or literature controls, uncontrolled case series, statements in published articles or textbooks. Level 3 (L3) = expert opinion. Unpublished data, examples include: large database analyses, written protocols or outcomes reports from large practices. RCT, randomised controlled trials; HIIT, high intensity interval training.

Physical activity

All guidelines recommend regular physical activity, to lower BP and help with weight loss.

Exercise training can in fact improve the bioavailability of NO, endothelial function and attenuates insulin resistance.[21–23] All guidelines agree on aerobic exercise of moderate intensity. Recommended time per week dedicated to exercise varies between 150 and 350 min. Some guidelines discourage isometric exercise alone as this can cause an increase in BP, others specify the type of training (high intensity, high impact, aerobic vs. dynamic resistance).

Areas of disagreement

Body weight, body mass index, and body fat distribution

All guidelines recommend maintaining a healthy weight and avoiding a raised body mass index (BMI).

The ISH guidelines recommend ethnicity specific thresholds for BMI, keeping in consideration that some ethnic groups present higher cardiovascular risk even when patients are into ranges of weight considered safe for other ethnical groups.[24]

Most guidelines recommend an ideal BMI < 25 kg/m^2, but only few emphasize the risks of abdominal obesity by stating specific cut-offs for abdominal circumference or a waist-to-height ratio <0.5.

Alcohol intake

All guidelines recognize an association between alcohol intake and raised cardiovascular risk profile or risk of hypertension, which is supported by strong evidence.[25]

They recommend a reduction of alcohol intake and avoiding binge drinking. There is disparity on the maximum daily amount. For example, European Society of Hypertension recommends less than 14 units per week for men and less than 8 units per week for women, while the American, Canadian, and Australian guidelines recommend alcohol consumptions is 2 standard drinks/day for men and 1.5 for women (with standard drinks having different amount of alcohol content per guidelines).

Coffee and tea

Most guidelines recommend moderate intake of coffee and tea and discourage but provide different thresholds for what is considered as excess intake. There are over 1000 chemical compounds in coffee. The most studied ones such as caffeine can influence BP in both directions: whilst caffeine is known to have an acute effect on increasing BP, long term moderate caffeine consumption may have beneficial CV effects and it is not completely discouraged in any guideline. However, the conclusions on long term effects derive mainly from observational studies with very few randomized, controlled studies or meta-analyses.[26]

Green or black tea consumption may also have a small but significant BP-lowering effect and some guidelines mention them as part of non-lifestyle dietary modifications.

Refined sugars and sweetened drinks

Only few guidelines directly mention sugars and sweetened soft drinks to be reduced in the diet.

Fibre intake

There was general recommended on increased dietary fibre intake, coming from fresh vegetables, fruit, and wholegrains. However,

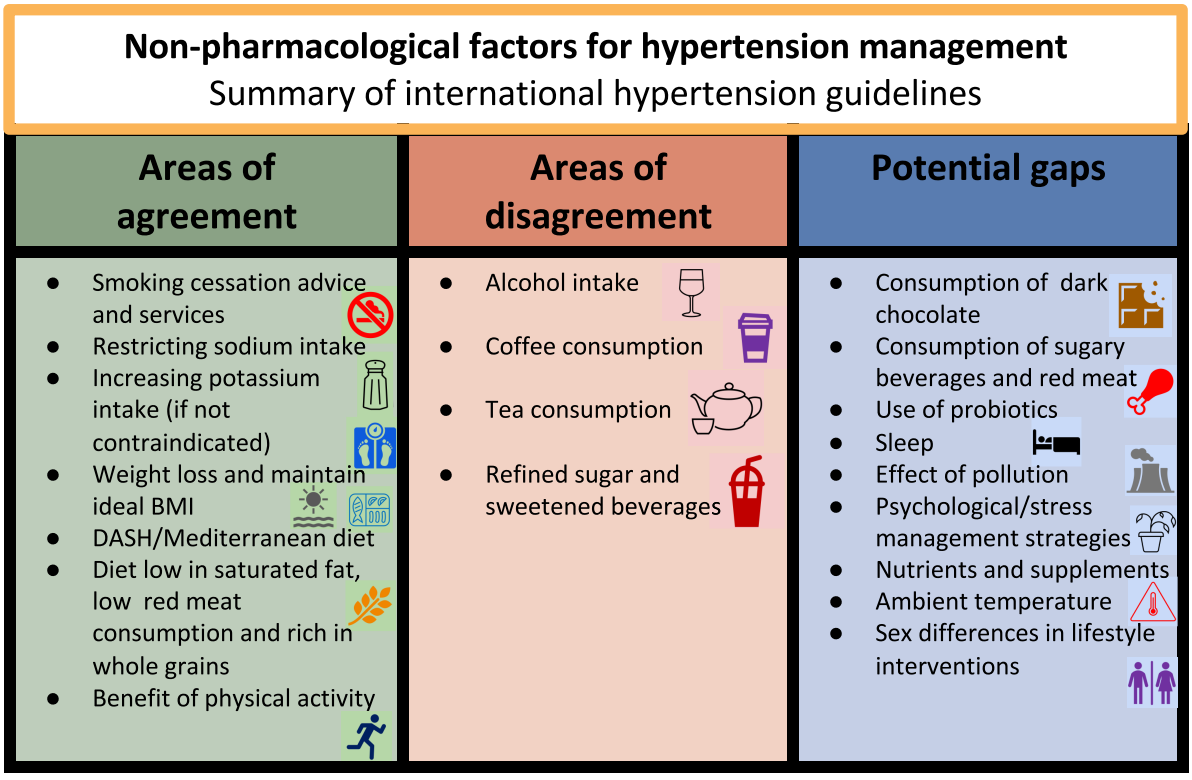

Figure 2 Summary of areas of agreement, disagreement, and gaps in knowledge in recommendations of non-pharmacological interventions for the treatment of hypertension in the included international guidelines.

some guidelines mention the lack of supportive evidence of fibres effects on BP.

Nutrients and supplements

There is significant disparity among guidelines in terms of recommendation for specific nutrients and supplements. In most cases, the recommendation is that some specific dietary patterns such as DASH diet should be encouraged as they can provide a balanced intake of minerals, vitamins, and nutrients. However, there is no strong evidence that supplementation of specific nutrients may have any benefit on BP.

Supervised exercise

Specific recommendation for supervised exercise in patient with chronic conditions such as uncontrolled diabetes and hypertension, severe aortic stenosis and angina is only recommended in the Chinese guidelines for hypertension in geriatric patients.

Environmental factors like temperature, pollution

Very few guidelines mention the role of environmental factors. Only the ISH guidelines mention the potential of air pollution, and the Japanese and Chinese guidelines on the impact of cold temperature.

Psychological factors, meditation/yoga/relaxation

Psychological factors include individual-level processes and meanings that influence mental states, and psychological interventions are non-pharmacological interventions focused on these psychological factors.

While majority of guidelines recommend including questions about psychosocial stress when taking hypertensive patients' history, only few guidelines mention that avoiding/reducing chronic emotional stress with relaxation techniques such as mindfulness and yoga, as evidence of their long-term benefits on hypertension is limited.

Sleep

All guidelines recommend including questions on sleep history and on apnoea. Some, like the Japanese ones, include poor quality/quantity sleep as possible contributing factor to raise BP and cardiovascular risk. The role of sleep apnoea as driver/causing factor of hypertension is emphasized in all guidelines and they all recommend its diagnosis if clinically suspected in symptomatic and/or overweight patients. However, only Chinese guidelines mention the importance of sleep (its duration and quality) in reducing BP and cardiovascular risk, alongside improving quality of life. Therefore, they include sleep as one of the lifestyle factors to address.

Discussion

We identified 10 rigorously developed hypertension guidelines that include recommendation on lifestyle changes and interventions as part of treatment or prevention of hypertension. We included all

relevant international guidelines and did not limit our search to Western countries.

There was consensus between guidelines about the importance of lifestyle in hypertension treatment and cardiovascular risk reduction, and these non-pharmacological recommendations remain the treatment cornerstone of hypertension regardless its stage.

Smoking cessation, avoiding obesity, adequate physical activity levels, limiting salt and saturated fats, and having a plant-based diet that includes wholegrain and limit red meats are substantially shared between the guidelines.

Salt intake reduction is one of the most robust recommendations across guidelines. However, there are some differences in terms of cut-off of daily salt intake.

Sodium can affect BP by increasing water retention,[27] systemic peripheral resistances,[28] and affecting sympathetic activity and endothelial function.[29]

Of note, assessment of daily salt intake can be difficult: the most accurate method remains the 24-h urinary sodium. In fact, about 94% of salt intake is excreted by kidneys. However, the day-to-day variability of salt intake can affect its accuracy if not repeated multiple times (at least in research settings). Other studies have tried to estimate sodium intake from spot urine Na measurements and validation of different formulas, but this can be less precise.

Reduction of salt intake can be difficult without implementation of public health measurements and governmental actions aimed at the food and beverage industry and reduction of salt and preservatives such as sodium glutamate.[30] In support to this, the SSaSS study proved the safety and efficacy of using a salt substitute (75% sodium chloride and 25% potassium chloride by mass) in 600 villages in rural China for almost 5 years, resulting in a significant reduction of cardiovascular outcomes and BP reduction.[31]

Obesity can directly cause hypertension via multiple mechanisms, such as activation of the sympathetic nervous system and renin-angiotensin-aldosterone system, increased inflammation, and insulin resistance.[32] Visceral fat accumulation has a more significant impact on cardiovascular risk as it can affect glucose and fats metabolism and correlate to progression of atherosclerosis via metabolic and immunological mechanisms.[33–35] Nevertheless, assessment of visceral fat besides measurement of waist circumference is not adopted in routine clinical practice.

The dietary patterns recommended are slightly different, with the DASH diet and the Mediterranean one being the ones with stronger level of evidence (from randomized clinical trials) and therefore more often (though not unanimously) recommended.

The Mediterranean diet encourages intake of fruit, vegetables, cereals, nuts, and seeds, with olive oil as main source of fats vs. a low consumption of red meat and saturated fats.

The DASH study demonstrated that a diet rich in fruit, vegetables, and low-fat dairy products helped in reducing levels of total and saturated dietary fat and lowered BP.[36]

The advice on intake of meat products is less clearly defined and more generic, and not uninformedly recommended among analysed guidelines. These areas may require further research for to enable more rigorous recommendation on their role in hypertension management.

Another significant area of disagreement includes the amount of sugar in the diet. High sugar intake may indirectly affect BP by inducing features of metabolic syndrome, including insulin resistance and impaired NO production. We also note a lack of recommendations on ultra-processed food, that is quite relevant in both rich, western countries and in lower income countries. Ultra-processed foods are defined as drink or food products made of several ingredients which, besides salt, sugar, oils and fats, include food substances not used in culinary preparations, in particular flavours, colours, sweeteners, emulsifiers and other additives used to replicate sensorial qualities of unprocessed or minimally processed foods or to mask unwanted qualities of the product.[37] They have high amounts of salt, total fat, saturated fat, and trans-fat, free sugar, and high energy density, and low fibre and micronutrients content. Of note, they contribute to more than half of all calories in the US diet.[38] While they contribute to obesity, due to its composition this type of food can also contribute directly to hypertension with some recent evidence supporting this.[39,40]

Coffee intake is not discouraged in most guidelines, but recommended thresholds are different, and none of the guidelines mention the method of preparation. It is in fact known that different brewing methods affect the content of antioxidants and other components in coffee.[41,42]

In reference to this, a recent study from Biobank UK has showed that moderate coffee consumption was associated with favourable cardiovascular outcomes, but also that regularly consuming decaffeinated coffee was associated with lower all-cause mortality as compared to zero coffee drinkers, suggesting that the benefit may only be partly attributable to caffeine content.[43]

There were also differences identified in the recommendations thresholds for what is considered acceptable alcohol intake. Cut-offs for limited alcohol intake were generally based on a variable interpretation of observational studies.

The major points of disagreement among guidelines were inclusion of recommendation on novels factors that correlate to hypertension, including environmental factors like pollution or temperatures changes, and individual factors like stress and sleep, due to different levels of evidence.

Environmental factors may not be strictly considered as lifestyle factors or choices, and they could be more related to geographical place of living and have regional connotations which could be reflected in local guidelines.

The effects of environmental pollution on BP and cardiovascular risk are well known. Several meta-analyses have confirmed that increases in ambient fine particulate matter ($PM_{2.5}$) by 10 mg/m^3 are associated with 1–3 mm Hg elevations in BP in the short term. Longer-term exposure is correlated to chronic hypertension, likely via endothelial dysfunction, systemic inflammation, autonomic imbalance.[44] This is particularly relevant because about 90% of world-wide population is exposed to pollution levels exceeding WHO air quality guidelines.[45]

Another recent meta-analysis confirmed the association of particulate and gaseous air pollutants with hypertension, stronger in men than women and potentially modified by geographical and socio-economic factors.[46]

Interestingly, despite evidence proving sex differences among lifestyle factors and effects on BP, guidelines do not currently discuss this.

Most evidence derives from small mechanistic and observational studies in public health, as it is hardly practical to design and conduct a randomized trial in the field. Nevertheless, only the International

Society of Hypertension guideline mentions avoiding pollution as lifestyle measurement. This is likely due to society's specific approach on developing practical global world-wide guidance, regardless of specific population or resources.

It could also be considered as general, world-wide factor that may require national and global changes and interventions rather than individual actions.

The International Society of Hypertension and the Japanese Hypertension Society guidelines are the only ones that mention the negative effect of cold temperatures on BP, and recommend avoiding cold, when possible, in hypertensive patients.

BP is known to have seasonal variations. Whilst it is generally known that cold may raise BP, and that during winter the cardiovascular risk of single individuals and populations is higher, warm weather may have effects on BP in both directions: in warm seasons BP may be lower, but patients may also observe an increase due to lack of sleep or sense of unease.[47] This is particularly relevant in connection with global warming. The lack of recommendation in other guidelines on avoiding cold is due to lack of robust evidence from trials and only due to evidence from observational studies. Moreover, one could speculate that climate related effects on hypertension are not influenced by personal choices and could not be considered strictly as lifestyle intervention targets.

Depression and anxiety have a close relationship with hypertension and cardiovascular disease with a prevalence of about 30% among hypertensive patients.[48] Interestingly, a recent study found a positive effect of use of 9 antihypertensive agents on risk of depression .[49]

Similar to previous systematic review findings for cardiovascular risk reduction in general, only few guidelines recommend assessing and avoiding stress or include relaxation techniques in a multidisciplinary, comprehensive management of hypertension.[7]

Few trials have been published on the subject: for example, the HARMONY study was a randomized, controlled trial examining the efficacy of an 8-week mindfulness-based stress reduction programme for BP lowering among unmedicated stage 1 hypertensive participants.[50] However, the numbers of participants enrolled remained quite small. Other trials included yoga/psychological factors as part of multiple synchronous interventions including diet and exercise, therefore it is difficult to generalize, extrapolate guidance from these trials.[51]

Strengths and limitations

To the best of our knowledge, this is the first systematic review focused on the non-pharmacological intervention recommendation included in contemporary international hypertension guidelines that were rigorously developed. We did not limit the guidelines to those developed from Western countries or developed continents, but also global guidelines and guidelines from Asian and Middle Eastern countries, which would keep in mind the diversity of lifestyles, habits, and ethnicity-related cardiovascular risk differences.

Although we assessed the guideline development process, we did not assess the clinical validity of the recommendations as this is not currently included in the AGREE II instrument and as it was beyond the scope of this review. We focused lifestyle interventions and advice and not pharmacotherapy to avoid overlap with previous publications in this area.

Another limitation is given by the fact that our search strategy only included single interventions and did not include any holistic lifestyle change programme. A global approach (diet plus exercise, salt reduction and weight loss for example) has been proved to be more effective than single interventions on one habit or risk factor, and this is mentioned in most of the guidelines included in this review.

Conclusions

Current guidelines agreed on the importance of non-pharmacological factors in the management of hypertension including lifestyle advice and interventions. There was consensus on recommendations for numerous factors such as limiting dietary salt intake, increased physical activity, smoking cessation and dietary patterns, as key components in the management of hypertensive patients but also as part of public health measurements.

Recommendations on psychological factors, role of food supplements, sleep, sex differences and environmental factors are currently limited and may require further study to enable clearer recommendation in the guidelines.

Supplementary material

Supplementary material is available at *European Journal of Preventive Cardiology* online.

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Data availability

The data underlying this article are available in the article and in its online supplementary material. Any additional data will be shared on reasonable request to the corresponding author.

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