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Lifestyle management of hypertension: International Society of Hypertension position paper endorsed by the World Hypertension League and European Society of Hypertension

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Lifestyle management of hypertension: International Society of Hypertension position paper endorsed by the World Hypertension League and European Society of Hypertension

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Hypertension, defined as persistently elevated systolic blood pressure (SBP) >140 mmHg and/or diastolic blood pressure (DBP) at least 90 mmHg (International Society of Hypertension guidelines), affects over 1.5 billion people worldwide. Hypertension is associated with increased risk of cardiovascular disease (CVD) events (e.g. coronary heart disease, heart failure and stroke) and death. An international panel of experts convened by the International Society of Hypertension College of Experts compiled lifestyle management recommendations as first-line strategy to prevent and control hypertension in adulthood. We also recommend that lifestyle changes be continued even when blood pressure-lowering medications are prescribed. Specific recommendations based on literature evidence are summarized with advice to start these measures early in life, including maintaining a healthy body weight, increased levels of different types of physical activity, healthy eating and drinking, avoidance and cessation of smoking and alcohol use, management of stress and sleep levels. We also discuss the relevance of specific approaches including consumption of sodium, potassium, sugar, fibre, coffee, tea, intermittent fasting as well as integrated strategies to implement these recommendations using, for example, behaviour change-related technologies and digital tools.

Keywords: Blood pressure, hypertension, lifestyle, holistic approach, nutrition, diet, exercise, mindfulness, obesity, pollution

Abbreviations: ACE, angiotensin-converting enzyme; BP, blood pressure; CARDIA, Coronary Artery Risk Development in Young Adults; CI, confidence interval; CPAP, continuous positive airway pressure; CRF, cardiorespiratory fitness; CVD, cardiovascular disease; DALYS, disability-adjusted life years; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; ESADA, European Sleep Apnea Database; GLP-1, glucagon-like peptide-1; ISH, International Society of Hypertension; MBSR, mindfulness-based stress reduction; MET, one-metabolic equivalent increment; OSA, obstructive sleep apnoea; PRS, polygenic risk scores; RCT, randomized controlled trials; RPE, rating of perceived exertion; SBP, systolic blood pressure; SGLT2, sodium-glucose cotransporter-2; SSaSS, salt substitution and stroke study; WHO, World Health Organization

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I. INTRODUCTION

Hypertension is the single most significant modifiable risk factor for all-cause morbidity and mortality worldwide. Approximately 33% of the global population of 8 billion live with hypertension [1,2]. Lifestyle changes are the cornerstone of prevention and treatment of hypertension and both governments and industry are fundamental to endorse and implement these changes [3]. Moreover, lifestyle changes may not only reduce blood pressure (BP) and improve hypertension control but also improve cardiovascular and general health [4–11]. Patients also often view lifestyle changes as their highest priority area in their hypertension management [12]. Consequently, lifestyle modifications are the first-line recommendation in all major hypertension management guidelines to reduce the risk of CVD [13–17]. The importance of lifestyle changes in both treatment and prevention of hypertension is further emphasized in the ISH's Hypertension Zero Declaration [2] and the Society's public campaigns championing healthy lifestyle [18]. In addition to direct benefits, lifestyle modifications can also amplify the effect of the pharmacological treatment of hypertension, if needed [13]. Of importance, the well known lifestyle interventions such as change in diet, alcohol moderation, smoking cessation and aerobic exercise, have now been extended to less obvious strategies such as stress reduction, isometric exercise and reducing exposure to pollution [19–21]. Although lifestyle changes are effective, they remain difficult to implement and maintain long-term because many people live in environments that are not conducive to achieving and then sustaining a healthy lifestyle. Moreover, clinicians are often poorly trained in assisting patients to engage in healthy behaviours. This is further compounded by the paucity of information about lifestyle changes in people from different ethnic and cultural backgrounds and their health literacy and cultural beliefs concerning hypertension prevention and management. In this position paper, we discuss the updated evidence supporting the use of lifestyle interventions in patients with hypertension or people at risk of developing hypertension. Importantly, we also aim to

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provide unique global perspectives on ways to implement these changes, taking into consideration different ethnicities and age groups, to aid healthcare providers and the scientific community to navigate and apply the current knowledge.

II. PROCESS OF WRITING

This position paper summarizes recommendations compiled by an international panel of experts convened by the International Society of Hypertension (ISH) College of Experts from 18 countries. Separate groups of experts were then assigned specific topics based on their area of expertise and developed draft recommendations by consensus based upon review of the literature and existing guidelines. Revisions were made by all authors and then submitted for external review internationally. Both World Hypertension League and the European Society of Hypertension reviewed and endorsed the recommendations.

III. GENERAL RECOMMENDATION

We recommend lifestyle goals (summarized in Table 1 and Fig. 1) to prevent or delay the onset of high BP and to reduce CVD risk. Lifestyle modifications should be the first line of antihypertensive treatment in grade 1 hypertension. However, if BP control is not achieved with lifestyle changes alone, we recommend a combination of lifestyle modifications and antihypertensive medications for diagnosed hypertension as the former enhance the effect of treatment [22]. Importantly, pharmacotherapy should not be delayed when instituting lifestyle change in patients, for instance, in those with hypertension-mediated organ damage or at high level of risk for cardiovascular events [23]. Lastly, we recommend that healthcare providers and clinicians receive adequate training in working with patients to adopt lifestyle changes and take an active role in the implementation of these recommendations. These consensus recommendations are targeted towards primary care providers and public health programmers. In addition to the recommendations, we provide an international perspective to consider different resources, practices and cultural considerations for differing regions and implementation guidance at the individual and population level.

IV. WEIGHT MANAGEMENT

What is known and what is new?

Obesity is a worldwide epidemic with increasing prevalence in many countries. Over the past three decades, obesity prevalence in adults almost tripled worldwide, while in children and adolescents, the prevalence increased more than four-fold from 4 to 18% [24]. At the same time, globally, obesity-related deaths and disabilities have almost doubled. Obesity should be addressed with an extensive and encompassing methodology, including government and public health policies, clinical and self-directed approaches. Increased body mass measures have a well established causal effect on the development of hypertension, the risk of cardiovascular and kidney diseases as well

TABLE 1. Lifestyle modification for the management of hypertension recommended by the International Society of Hypertension

Recommendation	Action
Early start in life	Encourage healthy habits from childhood (governments/parents/carer)
	Increase awareness of healthy food types (parents/schools/governments)
Healthy eating	Increase consumption of vegetables, fresh fruits, fish, nuts, unsaturated fatty acids, low-fat dairy products and low consumption of red meat
	Reduce salt and sugar intake
	Increase dietary potassium intake
	Increase consumption of plant-based food and dietary fibre
	Improve food labelling (governments/policy makers)
	Implement food taxation (governments/policy makers)
Healthy drinking	Avoid or limit alcohol intake (if you do not drink, do not start)
	Avoid binge drinking
	Moderate consumption of unsweetened coffee and tea
	Consider hibiscus tea, pomegranate juice, beetroot juice and cocoa
Physical activity	Increase aerobic exercise and muscle strengthening exercise
	Increase incidental exercise
	Decrease prolonged periods of time seated
	Engage in regular physical exercise and avoid sedentary behaviour early in life
	Advocate for implementation of government and industry supported programs, environment, facilities, and infrastructure (governments/policy makers)
Healthy body weight	Ethnic-specific cut-offs for BMI and waist-to-height ratio or other indices
	Waist circumference and weight values to be monitored
Healthy stress levels and sleep	Improve sleep hygiene and increase quality sleep time
	Practice sleep stimulus control methods
	Promote mindfulness/stress reduction practice
	Consider meditation/yoga/breathing techniques
	Consider music therapy/self-soothing techniques/gratitude/acts of kindness
Reduce exposure to pollution and passive smoke	Promote smoking cessation
	Consider limiting time spent outdoors when pollution is high
	Consider ventilation systems with filtration
Use digital tools	Use apps to track calories, steps, and sleep patterns

Recommendations are aimed for individuals, unless stated otherwise.

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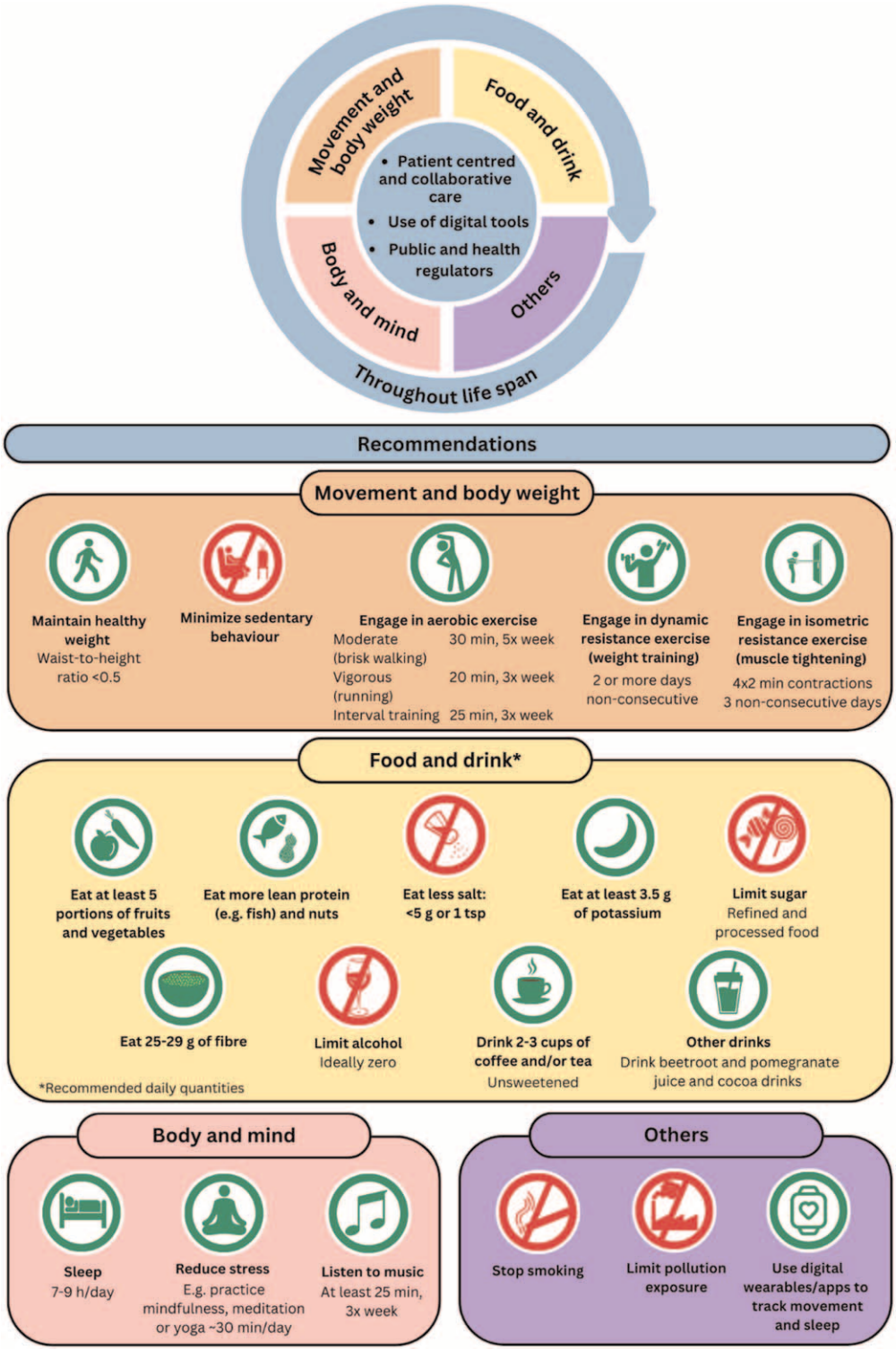

FIGURE 1 Lifestyle changes recommended in this position paper. In green are changes that should be encouraged, increased, and adhered to, for example, consumption of dietary fibre, improved sleep habits, increased exercise and adoption of mindfulness strategies. In red are changes to decrease or avoid, for example, smoking and alcohol use, sedentarism, consumption of refined sugars and salt and pollution exposure.

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as cardiovascular mortality [25–27]. A meta-analysis of 57 prospective cohort studies, pooling 2.3 million individuals, reported a 1–2-fold increase in risk of developing hypertension with the increment of various obesity indices such as body mass index, waist circumference and waist-to-height ratio [28]. In addition, obesity is also associated with a higher risk of developing other cardiometabolic disturbances, including insulin resistance, type 2 diabetes, dyslipidaemia and metabolic syndrome, which can improve with weight loss [27]. The effect of obesity on BP is additive to other lifestyle components such as physical inactivity, diet, smoking and alcohol consumption [29].

All major hypertension guidelines recommend weight loss for the management of BP among those with overweight or obesity [30]. Furthermore, several large epidemiological studies have shown an association between body weight and BP over the life course [31–34]. Weight gain from early ages and in adult life, related to nutrition and/or lack of physical activity, is an important risk factor for hypertension development [3]. Weight loss has been recommended for patients with hypertension who are obese as an effective nonpharmacological treatment approach.

However, long-term results of weight loss programmes are disappointing as patients often regain most of the weight initially lost. A gradual and moderate weight loss approach, with support of dieticians, is more likely to be maintained over a longer period of time. The use of calorie-intake reduction, weight loss medication therapy or bariatric surgery for patients with significant obesity is an effective, longer lasting strategy for weight loss [35–37]. Furthermore, emerging treatment option for obesity include semaglutide and other glucagon-like peptide-1 (GLP-1) receptor agonist in effective management of obesity [38,39].

Weight reducing diets in overweight people with hypertension, leading to a modest weight loss (3–10% of baseline body weight), decreased/discontinued dosage requirements of antihypertensive medications and reduced SBP and DBP by ~3 mmHg resulting in lower BP levels even without reaching ideal weight [40]. Additionally, a meta-analysis of randomized controlled trials (RCTs) reported an average reduction of 1 mmHg SBP and DBP per kilogram of weight loss [41]. The BP-lowering effect of weight loss is most likely a result of a decrease in sympathetic nervous system activity and an improvement in insulin sensitivity [42] and occurs independent of salt restriction. Importantly, weight reduction following bariatric surgery reduced mortality and morbidity related to CVD [43].

International perspective

Currently, there is no global consensus on optimal weight reduction and preventive strategies and advice are not tailored at individual level considering bias, socioeconomic status and socio-cultural barriers and beliefs to weight loss in different parts of the world. Formalized, structured and/or supervised weight loss programs are not always possible or available. Furthermore, barriers to accessing appropriate exercise or diet guidance and professional advice are prevalent in some socio-economic and cultural backgrounds and the dissemination of many nonscience-based diets tends to be more harmful to some individuals with underlying conditions.

Recommendation

1. Weight loss should be incorporated into everyday life, that is, increasing incidental exercise, walking, or cycling more, or playing sports regularly, sitting for less hours, and so forth.
2. Emphasis should be placed upon early-life intervention and health education programs to sustain a healthy weight throughout life [44].
3. A modest weight loss that can be maintained over a long period of time is recommended for people with hypertension along with calorie-intake reduction.
4. Weight loss interventions should be based on cognitive–behavioural strategies (e.g. appetite awareness training, a self-monitoring strategy in which individuals learn to identify internal cues of moderate hunger and fullness and to use these cues to guide their eating behaviour) [45].
5. Abdominal obesity should be managed. Ethnic-specific cut-offs for body mass index and waist circumference should be used. Alternatively, a waist-to-height ratio less than 0.5 is recommended for all populations [46].
6. The chosen type of weight loss programmes should be tailored, considering individual baseline weight, age, sex, comorbidities and situational context with support from a dietician.
7. Use of innovative approaches based on behavioural change technologies (e.g. apps, text messaging [47–49]) are encouraged for all people with overweight or obesity.

Implementation

Continual support for people with overweight or obesity is required to make a sustainable behavioural change and encourage healthy weight levels over the life course. The development of government-supported and industry-supported programmes, environment, facilities and infrastructure promoting healthy eating and weight reduction is paramount [50].

In the primary care of hypertension, healthcare providers should (whenever available) refer patients to appropriate weight loss programmes and prescribe individualized exercise and physical activity. Behavioural change techniques and coaching that include goal setting, monitoring and feedback should be considered to reduce overweight and maintain a healthy weight.

V. PHYSICAL ACTIVITY

What is known and what is new?

The CVD prevention and hypertension management guidelines [15,16,51–53] recommend exercise/physical activity across the lifespan, including childhood and adolescence, because of its demonstrated antihypertensive effects and also its favourable effects on other modifiable CVD risk factors. Guidelines follow current knowledge that regular engagement in physical activity leads to improved cardiorespiratory fitness (CRF) [54] and body habitus, as well as more favourable measures, of cardiometabolic health [55] and reduced inflammation [56], lowering the risk of

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developing hypertension and CVD. Importantly, recent pooled-data highlights a dose–response relationship between CRF and relative risk of hypertension where a one-metabolic equivalent increment (MET) in CRF is associated with 8% hypertension risk reduction [57]. Recent data from the UK Biobank are consistent with these observations, with an adjusted inverse dose–response relationship for CVD risk observed between accelerometer-measured physical activity and stroke incidence, coronary artery disease and CVD and all-cause mortality, with no upper limit of activity (intensity or volume) detrimental in those with established hypertension [58].

Evidence from RCTs suggest that exercise training interventions may provide equivalent reductions in BP to that of antihypertensive medication [59]. When exercise is combined with pharmacotherapy, the magnitude of BP reduction is greater than with medication alone [60]. Meta-analysis of randomized studies has shown that, indeed, aerobic and dynamic resistance training interventions of varying designs reduce office and daytime ambulatory BP, with greater reductions occurring in those with established hypertension (up to 8.3/5.2 mmHg office BP reductions) [61–64]. Isometric resistance training also significantly reduces BP, which is supported by several meta-analyses [61,65–67] and is included as a nonpharmacological therapy in the American College of Cardiology/American Heart Association Task Force Guidelines on the Primary Prevention of Cardiovascular Disease [68].

Exercise of moderate-to-high intensity (including aerobic and dynamic resistance training; see Supplementary Box 1, http://links.lww.com/HJH/C287, for example is considered safe and currently recommended for hypertension management [20,69–71]. Adding a time-efficiency aspect, emerging data indicate that high-intensity interval training (a form of exercise training, which consists of repeated short and intense exercise), appropriately prescribed and supervised, can provide comparable BP reductions to that of moderate-intensity exercise training [72,73]. However, even modest intensity physical activity such as walking will have a BP-lowering effect [74,75], as does isometric resistance training of the upper or lower limb performed at ~30% of maximal voluntary contraction [20].

International perspective

Exercise as a therapy for hypertension is still not widely integrated into healthcare systems or insurance schemes worldwide. Indeed, socioeconomic and cultural barriers to structured exercise exist in many parts of the world [76], often combined with limited access to exercise facilities and lack of formalized physical activity guidance [77].

Neighbourhood safety, lack of community support, religious beliefs, financial position, employment, and social barriers may influence physical activity participation in certain groups with hypertension, especially ethnic minorities [78].

To overcome such barriers, individuals should be offered appropriate health education and be encouraged to use any means possible to be physically active, while creating facilities and programs that consider sensitive cultural needs [79,80]. Furthermore, healthcare practitioners need to receive training to assist people to reduce sedentary behaviour and adopt lifestyle changes.

Recommendation

1. All individuals should be encouraged to be physically active for the prevention or management of hypertension and CVD [16,51,52,68,81].
2. Emphasis should be placed upon early-life intervention (from childhood) and health education programmes to sustain physical activity throughout the life-course (Table 1) [44].
3. Both aerobic and dynamic resistance exercise or their combinations can be used in prevention and management of hypertension and CVD (Box 1) [70].

Box 1 General physical activity recommendations for general health, wellness and cardiovascular disease prevention in (a) adults 18–64 years and (b) individuals aged at least 65 years [355]

(a) Physical activity recommendations in adults (18–64 years)

Adults should aim to be active on most days, preferably all days of the week. This should include either:
- 150–300 min of physical activity per week performed at a moderate intensity, or
- 75–150 min of physical activity per week performed at a vigorous intensity, or
- An equivalent combination of moderate and vigorous physical activities.

AND
- Include resistance (muscle strengthening) exercise on at least two nonconsecutive days each week, and
- Increase incidental physical activity.

(b) Physical activity recommendations in older adults (+65 years)

- Perform at least 30 min physical activity at a moderate intensity on most, preferably all days, of the week.
- If 30 min is difficult to achieve currently, it is recommended to commence at 10 min once or twice daily, which can be progressively increased.
- Try to incorporate different activities over the week, which may include:
  - ***Aerobic (endurance) activities*** to maintain and improve cardiovascular health such as brisk walking, swimming, and cycling.
  - ***Dynamic resistance (muscle strengthening) activities*** to maintain and improve muscle and bone strength such as weight-based, body weight, and resistance band exercises.
  - ***Flexibility activities*** to assist with ease of movement such as stretching, yoga and tai chi.
  - ***Balancing activities*** to improve balance and prevent falls such as semi-tandem, tandem and single leg standing.
- Try and reduce the amount of time spent sitting by breaking the time up as often and feasible as possible and increasing the amount of incidental exercise.

4. Adults should engage in 150–300 min of moderate-intensity or 75–150 min of vigorous exercise, or an equivalent combination, weekly (Box 1 and see Supplementary Box 1, http://links.lww.com/HJH/C287 for examples) [82].
5. The chosen type of activity/exercise should be individually tailored, consider baseline fitness, comorbidities, pharmacological treatment, situational context and be progressive in nature (i.e. start slow and gradually build the amount/intensity of activity).

6. Emphasis should be on reducing daily sedentary time and increasing movement wherever possible [83].
7. Any type, amount and intensity of regular exercise/activity will be beneficial with minimum recommendations for maintenance of health and CVD prevention.

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Implementation

Regular exercise should start early in life, and children and adolescents should aim to be active most days, decrease screen time and sedentary behaviours. This can be promoted and motivated by parents, guardians and educators and be implemented through the educational system's regular activities.

Healthcare professionals should encourage activities that are enjoyable to increase adherence and sustain life-long activity. Governments and town developers should plan environments conducive and safer to walk, cycle and exercise at all ages.

It is crucial to provide support and education to people at all life stages and levels of readiness for exercise to empower people to initiate/increase physical activity. Consumer resources and wearable devices are available at low cost, and may assist with and prompt increased incidental exercise [84].

Although exercise is considered generally very safe for those with high BP, first-time exercisers or those with complex medical history or chronic disease should be encouraged to seek guidance and approval to exercise from a doctor and or seek referral to/consult an exercise physiologist.

Behavioural change techniques and coaching that include goal setting, monitoring and feedback may increase physical activity uptake, sustainability and intervention effectiveness [85].

VI. GENERAL NUTRITION

Diet plays an important role in the healthy functioning of the body. Many different dietary patterns are hailed as useful for improving BP control, most without adequate evidence to substantiate their benefits. Studies show no age-related rise in BP or atherosclerosis in isolated non-Westernized tribal populations that live as hunter-gatherers and gardeners in remote regions in Brazil and Africa and consume diets low in fat and salt and high in fruit and fibre [86,87].

The Dietary Approaches to Stop Hypertension (DASH) low-sodium [88,89] and the Mediterranean diet [90] are most widely acknowledged for their benefits to reducing BP and improving cardiovascular health, albeit not always being viable because of food costs, availability and insecurity, incompatibility with a culturally and ethnically diverse society or food allergies. Broadly, both recommend low saturated fat, low salt, high fibre (from wholegrains, fruits and vegetables) and adequate lean protein. Both align with the World Health Organisation (WHO) guidance to reduce the risk of noncommunicable disease [91]. Such approaches are evidence-based and endorsed in ACC/AHA (USA), European and NICE (UK) guidelines [17,51,68,92].

The DASH diet, rich in calcium, potassium, magnesium and micronutrients, emphasizes consumption of fruits, vegetables, low-fat dairy products and reduced saturated fat and cholesterol, is recommended as an effective dietary intervention to reduce BP and maintain a healthy weight [15,93,94]. The adoption of the DASH diet was accompanied by substantial BP reduction in adults with and without hypertension with greater BP lowering among African Americans [88]. In addition, vegetarian diet has also been associated with lower BP in comparison to unrestricted omnivore diets (no salt, sugar or saturated and trans-fat restrictions) [95]. Vegetarian diets have a higher portion of glutamic acid and plant-based protein, which has blood-pressure-lowering effects [96–98]. Moreover, higher content of fibre, antioxidants and potassium as well as lower saturated fat and sodium content in healthy vegetarian diets can contribute to a lower body mass index and BP readings [99–101]. Vegetarian diet is thought to reduce BP via several mechanisms, including improving blood viscosity, vasodilation and insulin sensitivity; by altering the baroreceptors, renin–angiotensin and sympathetic nervous system; by its antioxidant and anti-inflammatory properties and by changing the colony and strain of gut microflora [102–107].

It is recommended that adopting the DASH diet or similar composition diet (Supplementary Box 2, http://links.lww.com/HJH/C287), where calorie-appropriate intake is considered depending on age, sex, build and levels of physical activity, is essential for maintenance of a healthy weight and should be considered a part of local hypertension management guidelines and introduced to people at risk of developing hypertension.

Long-term health benefits will depend on people's ability to make long-lasting dietary changes as long-term adherence/persistence to DASH and other diets remains a major concern. However, many population-level dietary recommendations are not followed, for example, 12% of Europeans and only 5% of the Australian population achieve the recommended five serves of fruit and vegetables per day (one serve is equivalent to 75–150 g depending on the type) [108–110]. There are also several barriers to adoption or adherence to these diets, which include lack of education (both with respect to health and/or food and nutrition) on a population level and by healthcare providers, food availability, including food insecurity or cost and difficulty or unwillingness to adhere because of cultural heritage, beliefs and behavioural norms [111]. To achieve long-term dietary change, healthcare professionals require specific training in effective behaviour change techniques to assist their patients in adopting new behaviours. There have been efforts to address some of these issues (e.g. reshaping of the UK medicine curriculum [112,113] and introduction of continuing professional development programmes for medical professionals [114]); however, the general public may be confused by (social) media reports delivering conflicting nutrition information [115,116], which leads to uncertainty and lack of trust in nutrition advice given by qualified professionals. Furthermore, many healthcare professions' training does not incorporate sufficient nutrition education and training in their undergraduate and professional development courses [114] and clinicians report a lack of time and confidence to deliver

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comprehensive dietary and lifestyle advice during office visits [117]. These barriers need to be overcome if dietary approaches are to be implemented in preventive or primary healthcare and should start from an early age; methods such as targeted labelling, incentives (e.g. food vouchers) and policy change (e.g. taxation and fortification) are additional potential avenues but are widely debated by both the public and the food industry (Supplementary Box 3, http://links.lww.com/HJH/C287).

As nutrition research evolves, more complexity is realized. Looking beyond traditional macronutrients and micronutrients for health benefits might be important, for example, evidence suggests that cocoa flavanol intake could be beneficial for CVD risk prevention [118]. Further knowledge about how food components interact with each other could help maximize dietary approaches, for example, saturated fat in dairy may be less detrimental to CVD risk than in meat [119]. Evidence suggests that consumption of omega-3 fatty acids, found in fish, lowers BP, heart rate and triglycerides [120]. A recent dose–response meta-analysis suggests that the intake of 2–3 g/day of omega-3 fatty acids has optimal BP-lowering effects and more than 3 g/day might be beneficial for groups at higher risk of CVD [121]. An RCT showed independent additive effects of regular fish meals and weight reduction in people with overweight [122]. Unfortunately, consumption of omega-3 fatty acids is below recommended levels in a significant proportion of the population and fish meals should be considered as an alternative to daily meat meals as part of a healthy diet [123]. Emerging data suggest the gut microbiome is an important target for BP regulation [124,125], hence diets incorporating probiotics, prebiotics and/or postbiotics are essential. Indeed, this aligns with the relationship between fibre and BP control [126,127].

Personalized/precision nutrition approaches are also becoming widely appreciated [128], whether that be based on individuals' phenotype, genotype or even gut microbiota composition. Arguably they are harder to implement but may prove to be more effective. As the nutrition field advances, there needs to be a clear pathway for these recommendations to policy and clinical practice. We have included below separate sections for major nutritional components.

A. Salt

What is known and what is new?

High sodium consumption (over 2 g of sodium per day, equivalent to 5 g or one teaspoon of salt) resulting in increased BP is the leading dietary risk factor for death [129,130]. Sodium intake may influence BP by change of sodium–water homeostasis, vascular tone, immune cell homeostasis and tissue remodelling, but exact mechanisms remain subject of study [131]. The global mean sodium intake is estimated to be around 6 g/day [130], attributing to 1.89 million deaths and 44.87 million disability-adjusted life years (DALYS). Sodium is mainly consumed as salt, from processed foods or discretionary sodium added to food during preparation or at the table [129]. Meta-analysis of RCT examining sodium intake reduction to as low as 800 mg/day show a relatively linear decrease in BP [132,133]. Moreover, the weighted average reduction in dietary sodium intake from 3646 to 2690 mg/day in RCT was associated with approximately 26% reduction in CVD [134]. Notably, the decrease in BP is greater in people from black African ancestry, people of older age, or with higher BP levels but is also observed in differing ethnicities, people with normal BP and in children [134].

A recent meta-analysis of prospective cohort studies investigating multiple nonconsecutive 24 h urine samples to assess sodium intake (the current recommended standard) reported a linear association between sodium intake [1846–5230 mg (equivalent to 4.6–13.8 g salt) per day] and cardiovascular events [135]. Unfortunately, these studies do not define a recommended lower level of sodium intake. However, many community-based salt reduction programs resulted in decreased salt intake, increased awareness and lowered BP [8,94,129,136–138].

International perspective

About 80% of the salt intake in high-income countries comes from manufactured and processed foods, whereas the majority of consumed salt in low-income and middle-income countries is added during food preparation or at the table [111,129,139]. Unfortunately, a shift in the future is to be expected as dietary patterns are transformed by increasing production and consumption of processed foods, rapid urbanization and changing lifestyles [140]. Studies consistently show that salt consumption in most parts of the world is greater than recommended and require urgent action [129,135]. Sub-Saharan Africa and the Caribbean have the lowest consumption of sodium worldwide, just under 3 g/day; whereas, East Asia has the highest intake, close to 8 g/day [130].

Recommendation

1. Intake of less than 2 g sodium (~5 g salt or one teaspoon) per day (Supplementary Box 2, http://links.lww.com/HJH/C287) [129].

Implementation

Globally reduce mean salt intake in the population by 30% by 2025, as proposed by the WHO and supported by the World Health Assembly. Approaches should be tailored considering local context, especially in regards to differences in food and lifestyle-related behaviours, including the source of salt intake [141]. Adopting the WHO SHAKE package at country level provides a unique opportunity for salt reduction at population and individual levels [141]. Importantly, salt substitution with low sodium and high potassium alternatives may provide an opportunity to reduce BP at the population level [142]. Translation of fundamental research into practice is crucial as mechanisms explaining how sodium increases BP is partly understood [131] and assessment of salt intake on the individual level is poorly associated with actual daily intake – complicating the interpretation of the epidemiological link between estimated salt intake and health outcomes [143]. To this end, academic organizations and learned societies called on scientists, clinicians, healthcare providers and other stakeholders to support global efforts to implement the

reduction in salt [129,144]. The global actors' policy priorities and funding allocation need to align, making salt reduction at the population level a key priority. Finally, industry and governments play a major role in shaping salt consumption at the population level. Governments should follow the expert advice and introduce legislation decreasing sodium in processed foods which, in turn should be endorsed by the food industry [129].

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B. Potassium

What is known and what is new?

Enhancing potassium consumption lowers BP by direct effect on the vascular tone and stimulation of natriuresis [145]. The recent large randomized controlled salt substitution and stroke study (SSaSS) trial reported that increasing potassium intake as a sodium substitute – that is, replacing 25% sodium chloride with potassium chloride in salt – reduces the risk of stroke, CVD and death in patients with increased cardiovascular risk and low potassium intake and high sodium intake at baseline [142]. Potassium intake is reflective of healthy dietary patterns, as key sources of potassium include fruit, vegetables, nuts and legumes. The DASH diet recommends ~4.7 g potassium per day, possibly accounting for the BP-lowering effect reported. Dietary potassium, potassium supplements and implementation of salt substitutes reduce BP with little effect on the risk of hyperkalaemia in a healthy population [142,146].

Unlike comprehensive interventions that require implementing and long-term adherence to dietary or behavioural change, the use of salt substitutes containing potassium salt and/or adoption of potassium-rich diet may represent a more feasible intervention to implement [147]. Fruits, vegetables, legumes, fat-free or low-fat dairy foods and fish represent good natural dietary sources of potassium. Hyperkalaemia with higher potassium intake is a concern in certain populations such as people with advanced chronic kidney disease (excluded in the SSaSS trial), but the risk for developing clinically significant hyperkalaemia by increasing dietary potassium intake to recommended levels may be limited [148]. These individuals are at higher risk of adverse cardiovascular outcomes, and a modelling study demonstrates that there would be still a net benefit with consumption of a potassium salt in this setting [146].

International perspective

Estimates for potassium intake from cross-sectional studies show marked variations between countries ranging from 1.7 to 3.7 g per day, with highest consumption in Europe and lowest intakes in China [149] and indicate that most populations may benefit from increasing their daily potassium intake. BP reduction may depend on the population's background potassium and sodium consumption. Implementation of potassium salt substitutes in countries where the main source of salt consists of added salt during cooking at the household level (discretionary use) is expected to be more feasible and also more efficacious as compared with countries with usually very high potassium intake and low sodium consumption [147]. Importantly, a reduction of sodium salt consumption is paramount, as stated above, and the use of low-sodium salt substitutes should be encouraged.

Recommendation

1. The European Food and Safety Administration and the WHO recommend potassium intake of over 3.5 g per day for adults, while an intake of more than 4.7 g per day for adults is recommended by the National Academies of Sciences and Medicine [129,134]. Foods high in potassium include cooked white cannellini beans (1200 mg/cup), unsalted boiled spinach (840 mg/cup), avocado (708 mg/cup) and bananas (450 mg per medium fruit).
2. Individual food and nutritional needs because of lower body composition between sex and larger differences between body mass within and between populations need to be considered.

Implementation

It is important to emphasize a healthy diet rich in vegetables and fruits, which will increase potassium intake. Potassium-enriched salts are also commercially available and could be used for cooking instead of regular salt in settings where most of the added salt happens at the household level. For other settings, partnership with the food industry is required to implement the substitution of sodium with potassium in food processing while preserving taste and other requirements. Pricing policies that promote the adoption of healthier diets will reduce sodium while increasing potassium intakes and should be a global priority.

C. Sugar

What is known and what is new?

Sugar is one of the most commonly used commodities globally. The term 'sugar' is vague, usually referring to refined sugar, it can be found in most packaged and processed foods and is commonly unrecognized by consumers because manufacturers use terms such as glucose or sucrose in nutritional labels. Recent studies have highlighted common side effects that accompany consistent consumption of sugar [150]. Cardiometabolic changes are well established as one of the biggest risk factors of long-term sugar consumption [151,152]. Regular consumption of foods and drinks high in fructose (fruit juices, sugar-sweetened beverages, dried fruits, sweetened yoghurt, honey) [151,153] and high glycaemic foods (white potato, white rice) predispose to the development of non-alcoholic fatty liver disease and is strongly associated with cardiometabolic changes related to increased adiposity such as hypertension, dyslipidaemia and insulin resistance [153,154]. Importantly, consumption of added sugar is strongly associated with increased risk of CVD mortality and contributes to the international overweight and obesity epidemic related to chronic illnesses [155].

Monosaccharides, such as fructose and glucose, have similar chemical structures; however, their metabolic pathways differ in both enterocytes and hepatocytes impacting overall health [151,153,156]. High glucose concentration as

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well as high sodium in digested food are demonstrated to up-regulate the expression of sodium-glucose transporters. Therefore, the higher the consumption of sugar and salt, the more the gut absorbs glucose and sodium ('greedy gut') [152]. The same mechanism is observed in the kidney for re-absorption of glucose and sodium as for the expression of sodium-glucose cotransporter-2 (SGLT2) [152]. Recently, SGLT2 inhibitors have been highlighted not only in blood glucose lowering and body weight reducing effects but also for their renal and cardioprotective actions. It is recognized that SGLT2 inhibitors exert BP reduction possibly through renal sodium handling as well as body weight reduction [152,157].

International perspective

Diabetes linked with increased BP is rising, particularly in Asia. Furthermore, diabetes in Asians differs from that in Caucasians, commonly referred to as the "Asian phenotype" [158]. This phenotype is related to the impaired secretion of insulin by the pancreas and lower capacity of triglyceride storage by adipocytes [159].

Currently, 118 countries and jurisdictions (including Fiji, Germany, India, Mexico, Morocco, Nigeria, Qatar, South Africa, UK, Vietnam, some USA states) have introduced taxes on sugar-sweetened beverages, which have facilitated a decrease in sugar consumption, especially among those of lower socioeconomic backgrounds, and led to a trending decline in overweight and obesity rates, which could potentially contribute to lowering the BP levels [160–164].

Recommendation

1. Reduce or limit sugar intake both in raw form and in processed food, drinks and sweets (Supplementary Box 2, http://links.lww.com/HJH/C287).

Implementation

Governments should introduce a simpler food labelling system, such as 'traffic light' or 'health stars' to simplify the understanding of nutritional values by consumers. Meanwhile, it is important to educate the public on the importance of nutritional labels as sugar is present in most packaged food items, even the savoury type and especially low-fat products. This includes learning to read the nutrition label and recognize the terminology/wording for 'sugars'. There should be more emphasis on replacing fruit drinks for whole fruit (which contains fibre that can help in slowing the spike in blood sugar levels). Finally, everyone should be able to recognize that all forms of sugar are calorically equal, regardless of its origins, that is, table sugar, honey, jaggery or coconut sugar and that the main difference between refined sugar and other forms of sugar is the lack of essential micronutrients in the former.

D. Fibre

What is known and what is new?

Dietary fibres are carbohydrates with a minimum degree of polymerization that are neither digested nor absorbed in the small intestine [165]. Low intake of whole grains, fruits, nuts, seeds, vegetables and, thus, overall fibre are some of the top dietary risks attributed to death globally, especially due to CVD [166]. A recent meta-analysis of 15 RCTs comparing fibre intake in 1064 patients and 988 controls showed an average 1.3 mmHg [95% confidence interval (CI):−2.5 to −0.04] decrease in SBP [127]. However, studies using around 135 million person-years of data found that high fibre intake reduced all-cause and cardiovascular mortality by 15–30% [127,166]. The effect of high fibre intake on CVD is mainly because of its high degree of fermentation by the gut microbiota, resulting in the release of short-chain fatty acids, which act on immune-dependent and independent mechanisms (e.g. vasodilation) [125,165,167]. A recent phase II RCT showed that short-chain fatty acids reduced SBP in untreated people with hypertension [167].

International perspective

Inadequate fibre consumption is a worldwide concern and often seen as a result of diets rich in processed foods and low in whole foods. The Westernized diet, characteristic of USA and Canada and the Westernization of traditional European diets (high in fat, refined grain and sugar and low on milk, fruits and vegetables) can be linked to an increase in CVD [168,169]. This contrast between low-fibre and high-fibre intake and its relationship with the incidence of CVD is also observed in Australia [168–170]. Interestingly, the high-fibre diet ingested by African hunter-gatherers seems to result in a protective gut microbiome and high production of short-chain fatty acids, preventing the development of chronic illnesses [171].

Lastly, undernutrition, present widely in sub-Saharan Africa and South Asia, also leads to an imbalance of the gut microbiota and morbidities, especially in childhood [168].

Recommendation

1. Fibre intake of 25–29 g/day conferred the greatest risk reduction, but dose–response data suggested more than 30 g/day results in additional benefits [127].

Implementation

Considering most people consume less than 20 g/day of fibre, community awareness programs, policies and tax incentives to promote an increase intake of foods high in fibre is recommended.

The consumption of high-fibre foods, particularly those high in fermentable fibre, should be increased, and substitutions be made instead of refined grain products (with low fibre content) to reach the recommended daily intake. For instance, lentils (16 g fibre per cup) and other beans such as edamame (9 g fibre per cup) are rich in fibre. Other foods high in fibre include brassica vegetables (kale, cabbage, cauliflower and broccoli – which contain an average of 5 g fibre per cup), blueberries (4 g fibre per cup), avocado (10 g fibre per cup) and whole grains (Supplementary Box 2, http://links.lww.com/HJH/C287) [172,173]. Importantly, people on diets with restrictive intake of carbohydrates (e.g. gluten-free diet) are at increased risk of poor fibre intake [174]. Lastly, the addition of high fibre flours (e.g.

beans, high amylose maize starch, green banana) in baked goods can also help increase fibre intake [172,173,175].

E. Alcohol

What is known and what is new?

The relationship between alcohol intake and high BP was established over a century ago [176], albeit clarity on the mechanisms involved is still lacking. Large-scale observational studies report that the incidence of hypertension increases with any amount of alcohol consumed by men and with more than two standard drinks per day by women [177]. Moreover, a systematic review and meta-analysis of 36 RCTs, described a significant reduction in BP associated with a decrease in alcohol consumption in people with hypertension who consumed three or more drinks per day in a dose-dependent manner [178]. The largest reduction in BP [SBP: −5.5 mmHg (95% CI: −6.7 to −4.3) and DBP: −4.0 mmHg (95% CI: −4.7 to −3.3)] was reported in individuals with a baseline consumption of six or more drinks per day. Additionally, both trial data and observational literature support the hypertensive effect of binge drinking [179,180].

Even though previous observational data have suggested a decrease in CVD with light drinking compared with abstainers, these analyses are limited by selection bias and confounding with other associated health behaviours [181]. Mendelian randomization studies do not support the purported protective effects of moderate alcohol consumption and suggest that the lowest risks for cardiovascular outcomes are in abstainers and that any amount of alcohol uniformly increases BP [181,182].

International perspective

Patterns of alcohol intake vary widely across the world, in terms of frequency, type of alcohol (e.g. beer, wine, spirits), and associated behaviours. Globally, the annual average consumption of pure alcohol per person is 6.18 l (the equivalent of 1 l of wine per week at 12% alcohol content) [183,184]. Consumption varies from particularly low across North Africa and Middle East (close to zero) to high in Europe (highest as 15 l per person annually or the equivalent of over two bottles of wine per week in the Czech Republic) [183,184]. Binge or heavy drinking (defined as consuming at least 60 g of pure alcohol or six standard alcoholic drinks on one occasion in the past 30 days) also varies internationally, and is more common in parts of Central and West Africa, as well as Russia [184]. Sex and gender differences in alcohol consumption (men drinking more) are wider when the average consumption in a country is low (e.g. in North Africa and Middle East) [184]. The type of alcoholic beverage consumed also varies, with spirits being predominant in countries such as India, Philippines and China, whereas beer is commonly consumed in Eastern Europe and wine in Western Europe [184].

Recommendation

1. Alcohol consumption should be zero for the best cardiovascular outcomes (Supplementary Box 2, http://links.lww.com/HJH/C287) [185]. However, the recommended daily upper limit for alcohol consumption is two standard drinks for men and 1 for women (10 g alcohol/standard drink), while acknowledging that there is no safe limit for alcohol consumption to prevent hypertension and adverse cardiovascular outcomes.
2. Binge drinking should be avoided [185].

Implementation

Explicit assessment of alcohol intake should be a routine part of the history in the initial diagnosis and subsequent management of hypertension. The effect of counselling alone is uncertain, though data from several RCTs support the effect of brief interventions such as motivational interviews in reducing alcohol intake [186,187].

F. Non-alcoholic beverages

What is known and what is new?

Coffee and caffeinated drinks such as tea have beneficial effects on BP and overall cardiovascular health [188]. Drinking coffee shows a consistent nonlinear association with the reduced risk in cardiovascular mortality with the greatest benefits seen with three cups a day [189]. A recent study in the UK Biobank showed that those drinking two to three cups per day of coffee or tea 32 or 28%, respectively, have reduced risk of having a stroke and dementia when compared with nondrinkers [190]. It appears that a consumption greater than three cups daily is safe but the benefits (in terms of reduction in cardiovascular risk) were less apparent [189]. Interestingly, an inverse dose–response in coffee consumption has been associated with a 2% risk reduction of hypertension (relative risk = 0.98, 95% CI: 0.98–0.99) for each cup of coffee ingested daily [191]. In contrast, a Japanese study reported that consumption of more than two cups of coffee daily increased risk of CVD mortality in people with grade 2–3 hypertension [192]. This increased risk was not observed amongst green tea drinkers [192]. Increased coffee consumption has also been associated with increased risk of aortic valve stenosis in a Swedish prospective population study [193].

Emerging data also suggests the benefits of the consumption of nitrate compounds found in beetroot juice in lowering BP. A recent meta-analysis showed beetroot juice significantly decreases SBP but not DBP in patients with arterial hypertension [194]. Interestingly, the BP-lowering effects of beetroot juice in SBP and pulse pressure are enhanced when combined with grapefruit juice [195]. Other beverages that can be beneficial include karkade (hibiscus) tea, pomegranate juice and cocoa [196]. In contrast, the regular consumption of energy drinks, which have large amounts of caffeine [197], and liquorice root tea [198] promote a spike in SBP and heart rate leading to metabolic changes. The effects of prolonged consumption of energy drinks have not been determined but may be relevant to individuals at risk of CVD.

International perspective

Coffee and tea consumption varies between countries worldwide. However, studies suggest that coffee and tea intake may be accompanied by smoking, which may

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revoke their benefits and could also be associated with BP differences in regions with high smoking rates.

Recommendation

1. Moderate regular coffee consumption (three to four cups per day) does not adversely affect BP and the cardiovascular system and can be moderately beneficial [81,199,200].
2. The addition of nitrate-rich beverages, such as beetroot juice, pomegranate juice and cocoa, may be considered.

Implementation

The moderate consumption of unsweetened coffee and tea can be assessed by healthcare professionals and recommended for potentially cardioprotective and/or BP-lowering effects.

VII. INTERMITTENT FASTING

What is known and what is new?

Fasting is the voluntary abstinence or restriction of food and/or drink consumption for short or long time periods. For over a thousand years, fasting has been used across the world for cultural, traditional, religious or health reasons. More recently, the use of short-term, intermittent fasting became a popular strategy for weight loss and improving metabolic health. This strategy gained interest with the recognition that periods of energy consumption have extended to predominately later into the evening, and this time factor, may contribute to chronic disease epidemics including obesity and hypertension [201,202].

There are various forms of intermittent fasting, including alternate day fasting where caloric intake varies on alternate days; daily time-restricted eating includes usual eating during an 8–12 h window and abstinence of food for the remaining time; and modified fasting where caloric intake is restricted on certain days (e.g. 5 : 2 diet) and *ad libitum* on other days of the week. Religious fasting, such as during the month of Ramadan, is a form of daily time-restricted fasting, where food and drink including medications are restricted from dawn until dusk.

It is postulated that intermittent fasting triggers a metabolic switch from hepatic glucose metabolism to adipose-derived ketone production during fasting periods.

Independent of weight loss, fasting lowers sympathetic nervous system activity, suppresses inflammation and improves glucose regulation [203]. Longer term clinical data on the safety and efficacy of intermittent fasting is emerging but is still limited. Several small studies demonstrate reduced BP among those who lose weight during intermittent fasting [204,205]. However, in a large clinical trial comparing intermittent fasting with reduced caloric intake versus a general calorie-restricted diet, both strategies were associated with reduced weight and BP, but there was no significant difference between the groups [206]. In a meta-analysis of 33 studies ($n = 3213$), fasting was associated with lower BP at end of Ramadan compared with before Ramadan, among those with diabetes, normotension and hypertension but no change in BP in those with chronic kidney disease [207]. Further, there was no statistically significant increase in worsening renal outcomes associated with fasting [208,209]. However, these studies included generally low-risk or moderate-risk groups, and these results may not be extrapolated to high-risk patients including those with end-stage renal disease or severe or uncontrolled hypertension.

International perspective

Fasting is practiced around the globe across multiple regions, and the effects on health and BP can be affected by additional factors, including environmental climate, temperature, food availability, duration of daylight, culture and religious beliefs (e.g. Ramadan or Lent). Further, the timing of meals is heavily influenced by culture and region with some cultures typically consuming dinner after 10 pm. Finally, fasting is implemented for a variety of reasons and the patient-centred outcomes may extend beyond physical health, weight loss and BP. Therefore, the acceptability of intermittent fasting needs to consider the patient's personal preference. Lack of adequately powered longer term RCTs of fasting limit our understanding on the long-term effects of this strategy.

Recommendations

1. Intermittent fasting with calorie restrictions may be beneficial for weight loss and BP reduction but is not superior to general calorie-restricted diet. Therefore, use of intermittent fasting should depend on patient preferences, and other considerations.
2. Fasting, including during Ramadan or Lent, is generally safe in low-risk to moderate-risk populations.

Implementation

Patients with chronic conditions should seek guidance from their healthcare provider before initiating fasting.

VIII. STRESS REDUCTION AND MINDFULNESS

What is known and what is new?

Psychosocial stress is associated with an increased risk of hypertension and cardiovascular events [210,211]. Patients with psychological distress may develop a sudden increase in BP, which may usually normalize when the distress is relieved [212]. However, people who suffer from stress related to posttraumatic stress disorder have an increased risk of hypertension and history of poor medication adherence [213,214]. Importantly, post-COVID-19 pandemic-related stress, anxiety and depression may contribute to poorer BP control in patients with hypertension [215–218]. Stress is also associated with unhealthy habits such as poor diet or overeating and weight gain, heavy drinking and/or smoking and sedentary behaviours, increasing risk of hypertension and CVD [211].

Stress reduction can be achieved through a number of strategies, such as meditation, progressive muscle relaxation, yoga, deep breathing exercise and mindfulness [211]. In recent years, mindfulness practices, defined as the

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awareness, including self-understanding, wisdom and compassion that comes from intentionally focusing on the present moment, have received interest as an alternative approach for the treatment of chronic diseases [219,220].

The mindfulness-based stress reduction (MBSR) program has been demonstrated to have a broad efficacy in improving physical and mental well being, as well as promoting office BP reduction [19,219]. A recent meta-analysis encompassing 12 studies reported that MBSR lessons of at least 8 weekly sessions of MBSR and over 30 min of meditation practices daily reduced stress, mood swings and SBP and DBP by 6.6 and 2.5 mmHg, respectively, in patients with hypertension [19].

A systematic review also reported that 45 min of yoga every day reduced SBP by 6.5 mmHg and DBP by 2.8 mmHg after a 12-week program [221].

Cognitive behavioural therapy helps individuals to identify and change negative thoughts and behaviours that contribute to stress. A meta-analysis of 15 RCTs revealed a reduction in SBP (8.7 mmHg), DBP (5.8 mmHg), cholesterol levels, depressive and anxiety symptoms and improved sleep [222]. Alternatively, other stress reduction techniques such as deep breathing, progressive muscle relaxation, self-soothing, gratitude and acts of kindness, learning problem-solving and goal-setting techniques can reduce stress levels and are better accepted than MBSR by some patients [7,210,223]. In addition, increasing physical activity, social connectedness and sleep hygiene (where warranted) can also be explored.

Overall, the best stress reduction interventions to reduce BP and hypertension are those that are maintainable and can be combined into daily life. A mixture of different approaches, such as MBSR, exercise and yoga, may be most effective and tolerated by individuals with hypertension. Importantly, it is vital to consult a healthcare professional to determine the best approach for each individual.

Another systematic review also reported that listening to music 1×/day to 3×/week showed a trend towards lower SBP and DBP by 10 and 6 mmHg, respectively [224]. Moreover, patients with hypertension who listened to 25 min of classical music over a 4-week period showed an average decrease of 6.6 mmHg in SBP [225].

International perspective

Evidence suggests that MBSR did not differ in reducing BP in patients between eastern and western countries [19]. Estimates for MBSR sessions from cross-sectional studies show a variation between countries ranging from 90 min/session in Iran [226] to 120 min/session in Spain over 8 weeks [227]. These studies indicate that patients with hypertension may benefit from practicing MBSR to reduce mental stress and BP, yet data on long-term BP effects and impact on future CVD risk are unknown.

Recommendation

1. Practice stress reductions techniques at least 3 h per week to reduce mental stress and BP [226,227].
2. Alternatively, practice activities such as yoga, meditation or tai chi at least 45 min a day [221].
3. Listen to music once a day to three times a week for at least 25 min [224].

Implementation

All healthcare professionals should assess psychological distress in all their patients with hypertension via visualized analogue scales or screening tools.

Patients with hypertension should seek to reduce stress and improve overall well being using mindfulness techniques. MBSR is a safe option and well accepted practice [19].

IX. SLEEP

What is known and what is new?

Sleep hygiene is important for vital function maintenance. Meanwhile, poor sleep hygiene, including that related to behavioural deviations, and sleep disruptions are associated with adverse health effects [228,229]. Inadequate sleep duration, both acute and chronic sleep deprivation and sleep disorders cause sympathetic hyperactivity resulting in blunted BP regulation, mainly absence or reversal of nocturnal BP dipping and/or nocturnal hypertension [229–231]. Sleep characteristics, including sleep quality, sleep duration and sleep efficiency, are associated with the risk of hypertension based on office BP [68,232]. According to the Coronary Artery Risk Development in Young Adults (CARDIA) study, shorter sleep duration and lower sleep efficiency were associated with higher office BP and BP increase over 5 years follow-up [233]. Prospective study from the UK Biobank showed that healthy sleep (sleep duration 7–8 h, no insomnia, no snoring, no excessive daytime sleepiness, early chronotype) is associated with lower incident hypertension risk [234] and, in hypertensive patients, it is inversely associated with the incidence of cardiometabolic morbidities, including coronary heart disease, diabetes mellitus and stroke [235]. Mendelian randomization analyses suggest potentially deleterious effects of more frequent daytime napping on cardiometabolic health (BP and abdominal obesity) [236]. A retrospective analysis from the UK Biobank suggested that frequent daytime napping is associated with a 12% increased risk of developing high BP [237]. Although both night-time sleep and daytime napping are associated with the decline in BP [238], and single cohort studies demonstrate negative association between daytime nap duration and hypertension presence [239], the evidence on long-term outcomes is lacking. Aligning sleep behaviours with endogenous circadian rhythms may be important in increasing SBP dipping, particularly if a part of the sleep period overlaps with the circadian peak in BP that occurs early in the evening [233,240,241].

Abnormal sleep patterns and obstructive sleep apnoea (OSA) are often associated with cardiometabolic risk factors, such as obesity, insulin resistance, impaired lipid and glucose metabolism, atherosclerosis and chronic inflammation [242–245]. Lifestyle factors and lifestyle interventions (in particular, weight reduction, diet, exercise training) significantly affect OSA severity metrics [246,247]. Salt intake might play a significant role in OSA severity in states associated with fluid retention and its redistribution in recumbent position (in particular, resistant hypertension and hyperaldosteronism) [248].

Sleep-disordered breathing, in particular, OSA, is considered a leading cause of secondary hypertension [249] and a risk factor for nocturnal and also resistant hypertension in up

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to 85% of cases [17]. However, the antihypertensive effect of OSA treatment through the use of continuous positive airway pressure (CPAP) or other oral appliances is rather modest, comprising of a decrease in only 2–4 mmHg and depends on a number of other factors, including pretherapy BP, adherence and tolerance to the procedure (more than 6 h per night) and daytime sleepiness [250,251]. The effects of OSA treatment on metabolic disorders are partly inconsistent; it appears that some OSA patients' subgroups might benefit more than others [252]. An analysis from the European Sleep Apnea Database (ESADA) cohort demonstrates that some drug classes (beta-blockers in monotherapy or in combination) are associated with the better BP control in OSA patients depending on few clinical characteristics (age, gender, obesity) [253]. There is limited evidence on the association between habitual snoring at least four nights/week and around 1.5-fold increased incidence and prevalence of hypertension [254–256].

Recent studies suggest that irregular sleep timing [242,243], circadian disorders (including shift-work) [231], insomnia [257,258], parasomnias, periodic limb movements [258], central hypersomnias [259] and daytime napping [260] are associated with hypertension and other adverse cardiometabolic profiles. However, the evidence is scarce for any definite conclusions.

International perspective

Local, national and ethnic sleep-related traditions (e.g. polyphasic sleep, siesta, midnight sun patterns) as well as predisposing factors (i.e. ethnic/racial differences in sleep apnoea prevalence) should be considered [261–264]. Furthermore, sleep duration contributes to racial disparities in hypertension risk [265,266].

In general, data on daytime napping is limited; however, in countries with siesta tradition, it should not exceed 30 min daily.

In countries with midnight sun, the behavioural approaches are useful and should be recommended including the use of blackout blinds and sleep masks at night, as well as blue light blockers or sunglasses in the evening.

Mendelian randomization studies show an association between sleeping patterns and BP increase. Interestingly, genetic architecture of daytime napping is shared with BP traits [236], and genetically predicted short sleep duration is associated with risk of hypertension [232]. Meanwhile, data is less established related to genetically predicted longer sleep duration [232,267].

Recommendation

1. Weight control should be considered to improve sleep quality and management of sleep disorders (specially OSA).
2. Sleep hygiene should be addressed and implemented routinely [228,229,268,269]. Sleep duration of 7–9 h per night is recommended for adults [228,229, 268,269].
3. Sleep hygiene approaches include appropriate sleep environment, regular sleep timing, sleep routine to prepare for sleep, avoidance of food intake, caffeine, alcohol and cigarettes close to bedtime and at night, exposure to bright light and exercise during the day and their restriction before sleep.
4. Stimulus control and building a strong association between the bed/bedroom and sleep should be implemented: go to bed only when you are sleepy; establish a sleep routine; apply the 20 min rule (i.e. if you cannot get to sleep in 20 min, get up and go to another room and do nonstimulating activities).
5. Daytime napping for more than 30 min should not be routinely recommended given its effects on sleep pressure and nocturnal sleep and the lack of long-term outcome evidence.
6. Shift-workers might require an individualized approach to develop sleep–wakefulness patterns. Ambulatory BP monitoring should be considered for diagnosis and follow-up evaluations to assess nocturnal BP patterns.
7. Screening of sleep disorders (in particular, OSA [245]) should be performed in resistant hypertension, in patients with nocturnal hypertension and/or abnormal BP dipping. If applicable, treatment should be implemented, focusing on lifestyle changes and use of specific treatment (CPAP, oral appliances) to aid good sleeping habits.
8. People with known sleep disorders (snoring, OSA, insomnia, etc.) should undergo regular BP measurement. Ambulatory BP monitoring should be considered for BP nocturnal pattern evaluation.

Implementation

All healthcare professionals should be encouraged to evaluate sleep in a multimodal manner [270] (sleep satisfaction, timing, efficiency, duration, alertness, sleep disorders) in all patients with the involvement of partners/relatives, when needed. In case of abnormal sleep habits and/or sleep patterns, personalized counselling about the role of sleep in BP management and advice on modification of sleep habits should be implemented. Clear and achievable goals should be set in collaboration with the patient, potential challenges and barriers and motivating strategies should be discussed and strategies implemented. Patients experiencing persistent sleep difficulties ($\geq$4 weeks) should be referred to a sleep specialist for further evaluation and management. Cognitive behavioural therapy for insomnia is beneficial for patients with hypertension, improving sleep quality and decreasing SBP and DBP by 8.6 and 5.6 mmHg, respectively [222].

At policy level, regulations of working schedules and educational programs in the sleep field must be promoted. Population-based awareness programs addressing healthy sleep must be supported.

X. SMOKING

What is known and what is new?

Smoking is not directly involved in the pathogenesis of essential hypertension but can cause acute increase of BP and is a known independent and strong risk factor for CVD. Smokers may have white coat and masked hypertension in the clinic, which is present on daytime ambulatory or home

BP monitoring [271]. Smoking affects the cardiovascular system structurally and functionally through interaction of hundreds of substances present in cigarettes and other tobacco products [272]. It serves as a major risk factor for atherosclerosis as evidenced from population studies [273,274].

Emerging data reveals the use of electronic cigarettes (e-cigarette) leads to acute increase of BP so we recommend against their use [275].

International perspective

Tobacco is the number one risk factor for global attributable deaths in men and the sixth in women [276]. Importantly, tobacco smoking, including second hand (passive) smoking, is within the top five risk factors for burden of disease worldwide, except sub-Saharan Africa [277].

Global prevalence of smoking has significant geographic, age and gender variation. Countries in Asia and Oceania have the highest prevalence of tobacco smoking among men while higher prevalence among females is seen in America and Western Europe [278].

Recommendation

- Smoking (including e-cigarettes) cessation is strongly recommended for its well established health benefits [274]. Importantly, strategies and approaches to avoid weight gain following smoking cessation should be implemented.
- Key target populations are those already exposed to smoking and those yet to be exposed, composed largely of young generations.
- Brief intervention counselling and motivational interviewing techniques in healthcare centres is shown to be very effective in tobacco cessation [279].

Implementation

Smoking cessation is the key factor in lowering risk impact on health. Enablers to quit smoking must be created through all levels, from the grass root healthcare settings to policy levels. At the healthcare centre level, brief intervention counselling for smoking and other tobacco use must be the standard practice care of any health service delivery model. Healthcare providers can be trained on simple modules of motivational interviewing techniques to reach the broader community. All patients must be assessed for smoking and on readiness to quit. Readiness to quit must be followed up till successful and continuing smoking cessation.

At policy level, population-based control programs can be administered. Policy regulations such as tobacco taxation, and separation of smoking and nonsmoking areas at public places must be sustained and expanded. Population-based awareness and advocacy programs addressing harmful effects of smoking must be advocated.

XI. POLLUTION EXPOSURE

What is known and what is new?

Each year, air pollution causes millions of premature deaths globally and is recognized as a modifiable risk factor for CVD, respiratory disease and cancer [280–283]. Air pollution is a complex mixture of thousands of gaseous and particulate matter components, with the primary source of urban air pollution coming from motor vehicle exhausts [284].

The main components of air pollution associated with detrimental health effects are airborne particulate matter (especially fine particulate with an aerodynamic diameter $\leq 2.5\,\mu m$) and gaseous substances including ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide [285].

Inhaled ultrafine particulate matter rapidly passes from the lungs into the systemic circulation [286] where acute BP-raising effects are exerted through vasoconstriction of conduit arteries, systemic inflammation, endothelial dysfunction and autonomic nervous system imbalance [21,282, 287–289].

Epidemiological studies show a strong correlation between chronic exposure to elements of air pollution and increased BP, as well as incident hypertension and organ damage associated with hypertension [290–296]. Human experimental data also demonstrate a dose–response relationship between air pollution and SBP [297].

Reducing population exposure to air pollution would significantly improve health, reduce mortality and lower health system expenditure [298,299].

Emerging data also indicates that noise pollution may correlate with increased risk of hypertension [300], and reducing exposure to noise could help control BP. More data with adjustment for confounding variables is needed to evaluate this relationship more comprehensively [301].

International perspective

Air quality has improved in high-income countries but has worsened in most low-income and middle-income countries alongside increased urbanization and growing economies [283].

Inequity regarding increased air pollution exposure is experienced by the poor and disempowered, and women and children in low-economic settings where polluting fuels have to be used for cooking, heating and lighting [302].

Policy makers internationally should follow the WHO Global Air Quality Guidelines and Good Practice Statements to inform evidence-based legislation and policies to improve air quality and mitigate population exposure to air pollution [283]. Use public transport, or travel by walking or cycling in preference to car or motorcycle to reduce pollution at population level should be encouraged. These guidelines should be used by healthcare professionals and medical societies to raise awareness and advise the public and patients [283,302]. Individuals can reduce exposure to air pollution by modifying the location, timing and type of outdoor activity [303–305].

Recommendations

1. Exercise in parks and gardens away from busy roadways.
2. Limit time spent outdoors during highly polluted periods.
3. Avoid inefficient burning of biomass for domestic heating.

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4. Consider using ventilation systems with filtration for homes in high pollution areas.

Implementation

The greatest benefits to health can be achieved through national level policies that reduce air pollution at the point of source. These policies are specific to context and place, and must be applied across sectors, including transport, urban planning, industry, agriculture, energy and power generation [302].

Governments must play a major role by engaging widely at regional, national and international levels to advise policy options to prevent air pollution exposure and attain the greatest health benefits for communities [283,302].

XII. NONPRESCRIPTION MEDICINE AND NUTRITIONAL SUPPLEMENTS

What is known and what is new?

Nonprescription medicines include an array of medications ranging from anti-inflammatories to herbal medications. Herein, we focused on specific nutrient supplements and their relationship with BP, excluding herbal medicines and nonnutritional foods.

Although the link between vitamin intake and hypertension is indicated, evidence-based research studies are scarce. Studies suggested multivitamin supplementation decreases high-BP-related mortality [306,307]. However, these effects were not observed in middle-aged and older women [308]. Several studies support the role played by hydrosoluble vitamins in maintaining both SBP and DBP in various populations [309–311] and a meta-analysis of 29 RCTs revealed that vitamin C supplementation reduced SBP and DBP [312]. Circulating micronutrient status is associated with adiposity, SBP and cardiometabolic risk factors, such as vitamin D with obesity parameters in women [313–315], imposing alternative pathways for the vitamin D role in sustaining optimal BP. Importantly, vitamin D metabolism is dependent on the appropriate intake of calcium and magnesium. It was reported that daily magnesium supplementation lowers BP [316]. Furthermore, a meta-regression also indicated a decrease in BP with long-term potassium supplementation of 3500 mg/day, especially in subjects not taking antihypertensives [317]. Similarly, chlorogenic acids, compounds contained in apples, coffee, tomatoes and other vegetables, might decrease BP, also indirectly through effects on adiposity, then hypoglycaemic, hypouricemic effects and similar [318].

Additionally, intake of functional foods based on onion and garlic, rich in flavanols, as well as catechin-containing green tea with angiotensin-converting enzyme (ACE) inhibitory properties, can be a food-based nutritional strategy to aid BP management and CVD prevention [319].

Importantly, extensive research on the impact of these supplementations is needed and evidence of effects on BP is still minimal.

International perspective

Lack of adequately powered RCTs does not allow streamlined and efficient implementation process for the suggested intake of dietary supplements and nonprescription medications for BP optimization.

Micronutrient and bioactive intake personalization based on individual characteristics, mainly related to ethnicity and genetic background, is an envisaged strategy for the future of hypertension primary prevention.

Recommendation

1. Vitamins, minerals and micronutrients intake should be obtained as part of a healthy, nutrient-rich and balanced diet.
2. Health supplements are not a replacement for a balanced diet and are not recommended as a treatment to hypertension.

Implementation

Considering interpersonal variability in response to a nutrient intake, preexisting health concerns and dietary preferences, a personalized approach to nutrition and supplementation is essential for the nutritional management of hypertension, while focusing on higher intake of certain micronutrients (as part of a normal diet) and functional foods.

XIII. BEHAVIOURAL INTERVENTIONS, DIGITAL HEALTH AND WEARABLES

What is known and what is new?

Behavioural intervention is an effective approach for the treatment of CVD [320,321]. A recent large-scale systematic review [322], including 150 RCTs identified the clinically supervised Patient Self-Management Support, frequently based on Wagner's Chronic Care Model, the most dominant intervention method [323]. Importantly, many chronic illnesses share the same modifiable behavioural lifestyle risk factors.

Behavioural habits known to modulate cardiovascular risk and BP control include oral hygiene practices as both dental care access and periodontitis are independently linked to hypertension and target organ damage [324]. This relationship is independent of socioeconomic status [325].

The use of digital technologies for prevention and/or treatment of health conditions, termed digital health interventions, is an emerging and promising approach to support people with hypertension [326,327].

Recent studies showed clinically modest but significant effects of digital interventions to reduce SBP, improve medication adherence and lifestyle behavioural changes longer term [328,329].

Use of personalization through digital health (e.g. electronic health records or mobile devices to support health practices) interventions can, especially aid in the delivery of timely precision medicine strategies and be delivered directly by the healthcare practitioner and/or digitally, through the utilization of end-user manual inputs and/or digital system-derived inputs [330].

Providing a dynamic and adaptive hypertensive digital intervention into the future that can adjust its responses when the individual changes (in real-time) should better facilitate behaviour change outcomes [331–333]. Additionally,

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antihypertensive digital interventions that can minimize the amount of manual end-user input may also increase patient adherence [328,330,332], especially through the consistent use of validated digital wearables to support and maintain lifestyle modifications. There is, however, a need to ensure that any digital BP device has its accuracy validated, and we caution the use of unvalidated devices.

Importantly, digital health approaches should not supplant the role of clinicians but are tools that clinicians and patients can use to improve the efficiency and effectiveness of clinical objectives. Digital health platforms enable the efficient exchange of clinical data and clinician–patient interactions to achieve effective lifestyle modifications.

International perspective

Behaviour change techniques are included in the medical curriculum for healthcare providers in many countries [334–336] reinforcing the importance of chronic illnesses burden control through effective population-based intervention programs.

The US Centres for Disease Control and Prevention websites contain a large compendium of local and global studies centred on the benefits of behavioural interventions upon modifiable risk factors for chronic disease prevalence and outcomes.

Recommendations

1. Healthcare providers should be trained in behaviour change approaches and digital support technologies to facilitate action and control hypertension [337].
2. Behavioural changes should be comprehensive and encompass oral hygiene improvement and maintenance to prevent periodontitis and improve BP control [324].
3. Continuous use of validated digital wearables and digital tools to improve symptom awareness, introduce potential reminders (e.g. for medication intake or promote increased incidental exercise), aid behaviour change (e.g. goal setting, decision support, self-monitoring, which may integrate wearable data, reminder and alert systems, digital support conversational agents to improve user adherence, motivation and self-efficacy, intervention personalization programming) should be encouraged.
4. Introduce communication technologies to facilitate professional guidance and input or social support (digital spaces to communicate with healthcare providers or peers, SMS messaging) as a standalone digital intervention or integrated into a multicomponent intervention [326].

Implementation

The use of digital health interventions that incorporate behaviour change models and include personalization is the most promising but reliable RCTs showing efficacy are lacking.

Data collection, either using manual or system-based input, can be achieved through smart programming and/or artificial intelligence software to continually personalize digital intervention (e.g. offering relevant tailored content, sending reminders about targets or encouragement if motivation is declining, alerting the patient (and practitioner) if symptoms are deteriorating), in real-time.

Lastly, the greater inclusion of wearables and integration of smarter programming and artificial intelligence into such interventions is predicted to strengthen behaviour change and improve health outcomes [332,338].

XIV. HOLISTIC APPROACH TO BLOOD PRESSURE PREVENTION ACROSS THE GLOBE

What is known and what is new?

Urbanization is considered a major contributor to the rising prevalence of hypertension worldwide. Higher prevalence of hypertension in urban areas includes socioeconomic and lifestyle changes that increase the diagnosis of overweight, obesity, smoking and diabetes [339]. Other mechanisms are thought to involve psychosocial stress in urban residents resulting from financial stress, redefinition of cultural identity and movement away from traditional coping mechanisms, including social support from extended family. These changes have been reported in different epidemiological studies worldwide [340].

Another study shows the relationship between education and lifestyle and healthcare changes [341]. The risk factors for unhealthy nutritional habits, stress, poor working conditions or inadequate access to education and appropriate medical services are present in a large part of the urban population [342], but evidence is lacking in the rural population. Furthermore, these risk factors are more pronounced between gender differences.

There is undeniable need to change our current standards of lifestyle approach, such as an integral treatment of hypertension patients. Implementation of HEARTS-WHO model based on the premise that a person needs wholesome care and not just the treatment for the disease should be implemented. The holistic and wholesome patient care approach takes into consideration all patient aspects, including physical, emotional, social, economic, cultural and religious/spiritual needs to provide the most appropriate advice and treatment [343].

International perspective

Worldwide, factors are similar, although inequalities in health access between populations have been described [344–346], and several studies have shown that diagnosis, control and treatment of hypertension are worse in rural areas than in urban areas [347]. Indigenous populations worldwide experience a huge gap in access to general health and health treatments and mortality [348], including CVD and diabetes [347,349,350]. This divide is observed as a combination of racial discrimination, poverty, lifestyle and access to services due to geographical isolation [348,351]. Socioeconomic differences between poorer and richer countries and populations also impact general health access and CVD morbidity and mortality [346,351].

Recommendation

1. Implementation of holistic care for patients, as evidenced in Bhutan, Latin America, Canada and some

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countries in Africa, to provide the optimal treatment and management of BP [23,352–354].
2. Improve access to BP diagnosis, treatment and management in regional and rural areas.

Implementation

Healthcare providers should consider a holistic, multicomponent approach addressing many lifestyle changes simultaneously. Comprehensive hypertension lifestyle changes such as exercise, education, nutritional habits and policies should be targeted for both rural and urban areas.

Exercise and nutritional habits according to culture, ethnicity and religion should be considered in populations around the world to achieve equitable population outreach.

Differential work must be done on vulnerable populations to adequately identify the necessary policies to be implemented and maintained.

XV. OVERALL SUMMARY AND A GLIMPSE INTO THE FUTURE FOR ASSISTED LIFESTYLE INTERVENTIONS

In this position paper, we presented recommendations that support a healthy lifestyle to manage and maintain a healthy BP – more exercise, less salt, sugar and saturated fats in diet, more fruit, vegetables, and dietary fibre, no smoking and alcohol. We also presented emerging evidence for newer modalities and discussed the potential for increased use of digital technologies to help improve lifestyle behaviours in a personalized way. Indeed, there are many mobile phone 'apps' that can be used to help track movement, diet and habits. These technologies can be used for weight management, assessment of meal composition and calorie content by scanning meals using phones. They can also be used to help individuals meditate and reduce stress. These apps are international in scope and reach and will play an important part in encouraging interventions. These technologies will probably integrate the next 'more efficient' step in precision lifestyle interventions alongside assessment by genetic components using polygenic risk scores (Supplementary Box 4, http://links.lww.com/HJH/C287), which has the potential to be used to calculate risk of CVD and allow early personalized approaches to treatment. Importantly, data to support many of these revolutionary interventions are scarce and larger studies are essential to assess efficacy.

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Conflicts of interest

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