

BEYOND THE PILL AND THE PLATE: HYDROTHERAPY AND ANTI-INFLAMMATORY DIET AS ADJUNCTIVE NATUROPATHIC INTERVENTIONS FOR HYPERTENSIVE DISORDERS OF PREGNANCY - A NARRATIVE REVIEW

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ABSTRACT

Background: Hypertensive disorders of pregnancy (HDP), including preeclampsia, contribute substantially to maternal and perinatal morbidity and mortality. Inflammation, endothelial dysfunction, oxidative stress, and altered cardiovascular regulation are central to their pathophysiology, creating interest in complementary interventions alongside conventional obstetric management.

Objective: This narrative review evaluates the biological mechanisms, available clinical evidence, therapeutic potential, and safety considerations of hydrotherapy and anti-inflammatory dietary interventions as adjunctive approaches for HDP.

Methods: Relevant literature was reviewed to examine hydrotherapy-related cardiovascular and autonomic responses, including blood pressure and heart rate variability, alongside the inflammatory, metabolic, and vascular effects of Mediterranean- and DASH-style dietary patterns. Evidence from pregnant and non-pregnant populations was considered, with emphasis on distinguishing pregnancy-specific findings from indirect physiological evidence.

Results: Anti-inflammatory dietary patterns demonstrate comparatively stronger pregnancy-specific evidence, suggesting potential benefits for maternal metabolic health, inflammatory regulation, endothelial function, and selected pregnancy outcomes. Hydrotherapy may influence peripheral circulation, vascular reactivity, blood pressure, and autonomic regulation; however, supporting evidence is predominantly derived from healthy or non-pregnant populations. Direct evidence establishing its effectiveness and safety in women with HDP remains insufficient.

Conclusion: Anti-inflammatory dietary interventions may offer supportive benefits when integrated with established obstetric care, whereas hydrotherapy remains investigational for HDP. Pregnancy-specific clinical trials with standardised intervention protocols and appropriate maternal-fetal monitoring are required before routine clinical implementation.

KEYWORDS: Hypertensive disorders of pregnancy; Hydrotherapy; Anti-inflammatory diet; Heart rate variability; Blood pressure

1. INTRODUCTION

Hypertensive disorders of pregnancy (HDP) are a leading cause of maternal and perinatal morbidity and mortality internationally, and encompass chronic hypertension, gestational hypertension, preeclampsia, eclampsia and HELLP syndrome. About 5–10% of pregnancies suffer from HDP, which can result in maternal complications including stroke, renal and liver dysfunction, and cardiovascular disease, and placental dysfunction, fetal growth restriction, preterm delivery and stillbirth. The underlying mechanisms that lead to their development include abnormal placentation, endothelial dysfunction, angiogenic imbalance, oxidative stress, immune dysregulation and chronic inflammation (Burton et al., 2019). Thus, Preeclampsia is a multisystem condition, and requires a multidisciplinary assessment and risk stratification (Chappell et al., 2021). Epigenetic changes can also play a role in disease predisposition and in the development of biomarkers (Crețu et al., 2026).

The current management for HDP involves early diagnosis, antihypertensive treatment, low dose aspirin to prevent HDP, fetal monitoring, calcium supplementation (if indicated), and prompt delivery. While these measures prevent negative consequences, they do not directly correct the underlying placental and vascular defects. The women who develop HDP also face higher long-term risk for cardiovascular and metabolic complications, so postpartum follow-up and

cardiovascular examination is recommended (Atallah et al., 2026). But there are inconsistencies in postpartum care still (Cairns et al., 2017). Proper measurement of maternal blood pressure is important for the detection of cardiovascular abnormalities and for the appropriate clinical management, along with the use of therapeutic interventions. Ankita et al. (2026) have examined differences between home and clinic blood pressure readings in pregnant women at high risk for preeclampsia, highlighting the importance of structured, home-based blood pressure monitoring for maternal cardiovascular monitoring. These findings underscore the need to consider measurable physiological responses as part of an assessment of adjunctive treatments for pregnant women with high blood pressure. Because inflammation, oxidative stress, and endothelial dysfunction contribute to HDP, supportive lifestyle and dietary strategies have gained attention. The inflammatory potential of diet may influence systemic inflammation, providing a rationale for anti-inflammatory dietary approaches in maternal health (Bahr et al., 2021). Healthy dietary patterns before and during pregnancy are also associated with favourable metabolic outcomes (Çobanoğullari et al., 2022).

Hydrotherapy has been considered a potential adjunctive approach because of its effects on vascular and autonomic responses. Passive hot-water immersion may increase vascular shear stress and alter cardiovascular responses (Amin et al., 2022), while heat-based interventions have been associated with improved vascular function in cardiovascular populations (Akerman et al., 2019). However, direct evidence in hypertensive pregnancy remains limited. Mediterranean and DASH diets are anti-inflammatory dietary patterns that have the potential to promote maternal cardiovascular and metabolic well-being by providing nutrient-rich foods and decreasing the inflammatory load. The compliance with Mediterranean diet in pregnancy has been linked to positive maternal and offspring outcomes (Amati et al., 2019). DASH-like eating plans can also aid in blood-pressure control and preeclampsia prevention (Baroutis et al., 2025), and benefits have also been noted on weight and chosen perinatal outcomes among women with metabolic disorders (Belfort et al., 2023). The correct sodium consumption during pregnancy is a controversial issue, and it is recommended to have personalized nutrition (Afsar and Elsurur Afsar, 2024).

This narrative review is an assessment of hydrotherapy and anti-inflammatory dietary interventions as adjunctive therapies in HDP, their biological pathways, existing evidence, safety issues and clinical implications. This review is supposed to critically synthesize existing evidence regarding these two supportive interventions and evaluate their possible value in addition to the existing obstetric management. It is innovative as it combines hydrotherapy and anti-inflammatory dietary interventions into one HDP-centered framework and compares the mechanistic foundation, the strength of evidence, safety profile, and the level of clinical applicability of the two interventions directly. The current review combines the two strategies, namely hydrotherapy and dietary intervention, in the context of HDP, unlike the past reviews which have focused mostly on the former or the latter, but not both. Such a comparative methodology can be useful in determining the interventions that have more solid evidence to be used adjunctively and those to be kept at the investigation stage.

2. METHODOLOGY

This narrative review aimed to critically examine the available evidence concerning hydrotherapy and anti-inflammatory dietary interventions as potential adjunctive approaches for hypertensive disorders of pregnancy (HDP). Relevant scientific literature was identified through searches of PubMed, Scopus, ScienceDirect, the Directory of Open Access Journals (DOAJ), and Google Scholar. The search strategy incorporated combinations of terms related to hypertensive disorders of pregnancy, preeclampsia, hydrotherapy, anti-inflammatory dietary patterns, cardiovascular regulation, and autonomic function. The principal search terms included "hypertensive disorders of pregnancy," "gestational hypertension," "preeclampsia," "hydrotherapy," "water-based therapy," "hydrothermal therapy," "water immersion," "Mediterranean diet," "DASH diet," "anti-inflammatory diet," "heart rate variability," "HRV," "blood pressure," "BP," "autonomic nervous system," "autonomic function," "autonomic regulation," "sympathetic activity," "parasympathetic activity," "inflammation," "oxidative stress," "endothelial function," and "maternal cardiovascular health." Boolean operators (AND and OR) were used to construct search combinations linking pregnancy-related hypertensive conditions with the interventions and physiological outcomes of interest.

Representative search strings included ("hydrotherapy" OR "water-based therapy" OR "water immersion" OR "hydrothermal therapy") AND ("blood pressure" OR "heart rate variability" OR "HRV" OR "autonomic function" OR "autonomic regulation"); ("preeclampsia" OR "gestational hypertension" OR "hypertensive disorders of pregnancy") AND ("Mediterranean diet" OR "DASH diet" OR "anti-inflammatory diet"); and ("hydrotherapy" OR "water immersion") AND ("pregnancy" OR "preeclampsia") AND ("cardiovascular function" OR "blood pressure" OR "autonomic nervous system"). Preference was given to relevant peer-reviewed clinical studies, systematic reviews, narrative reviews, and evidence-based guidelines addressing physiological mechanisms, clinical outcomes, maternal and fetal safety, and potential therapeutic applications. Evidence from non-pregnant populations was considered primarily for mechanistic interpretation when pregnancy-specific evidence was unavailable. The selected literature was synthesised narratively to compare the biological rationale, available clinical evidence, safety considerations, and potential applicability of hydrotherapy and anti-inflammatory dietary interventions in hypertensive pregnancy.

3. Hypertensive Disorders of Pregnancy

3.1 Classification of Hypertensive Disorders of Pregnancy

Hypertensive disorders of pregnancy are commonly classified as chronic hypertension, gestational hypertension, preeclampsia, eclampsia, and HELLP (hemolysis, elevated liver enzymes, and low platelet count) syndrome. Chronic hypertension is present before pregnancy or develops before 20 weeks of gestation, whereas gestational hypertension develops after 20 weeks without features of preeclampsia. Preeclampsia is a state of high blood pressure with dysfunction

of maternal organs and/or the placenta. Eclampsia is the process of having seizures related to preeclampsia, whereas HELLP syndrome is a severe multisystem complication (Garovic et al., 2022).

3.2 Epidemiology and Global Health Burden

Hypertensive disorders of pregnancy is a worldwide complication of pregnancy affecting 5-10 percent of pregnancies and continues to be a significant source of maternal and neonatal morbidity and mortality. The burden on them could be higher in an environment where there is limited access to early diagnosis and special obstetric care. Women who have had preeclampsia are also at a higher risk of developing chronic hypertension and cardiovascular disease in the long run, and their children are also at a higher risk of developing future cardiovascular problems (Fox et al., 2019).

3.3 Maternal and Fetal Risk Factors

Maternal, fetal and placental factors that cause HDP development include nulliparity, advanced maternal age, obesity, diabetes, chronic hypertension, kidney disease, autoimmune disorders, multiple gestation and a history of previous preeclampsia. Placental abnormalities may also occur alongside fetal growth restriction, reflecting impaired placental perfusion and nutrient transport. Maternal nutritional status may influence placental health, suggesting that nutritional optimization could have a supportive role in prevention strategies (Di Martino et al., 2022).

3.4 Pathophysiological Mechanisms

The pathophysiology of HDP involves abnormal placentation and impaired uteroplacental perfusion, which may contribute to placental hypoxia. These changes can be linked to endothelial dysfunction, angiogenic imbalance, oxidative stress, chronic inflammation, immune dysregulation, and vascular abnormalities, which are linked to hypertension and maternal organ dysfunction. In recent years, there is also evidence that inflammatory and lipid metabolic changes in the placenta are involved in the biological pathways associated with preeclampsia and susceptibility to HDP (Hu et al., 2026). These mechanisms are interrelated, and serve as a biological underpinning for supportive interventions that focus on vascular and metabolic pathways. Hydrotherapy-related interventions have demonstrated cardiovascular effects in non-pregnant populations, providing mechanistic rationale for further investigation; however, their efficacy in women with HDP remains unestablished (Cullen et al., 2024).

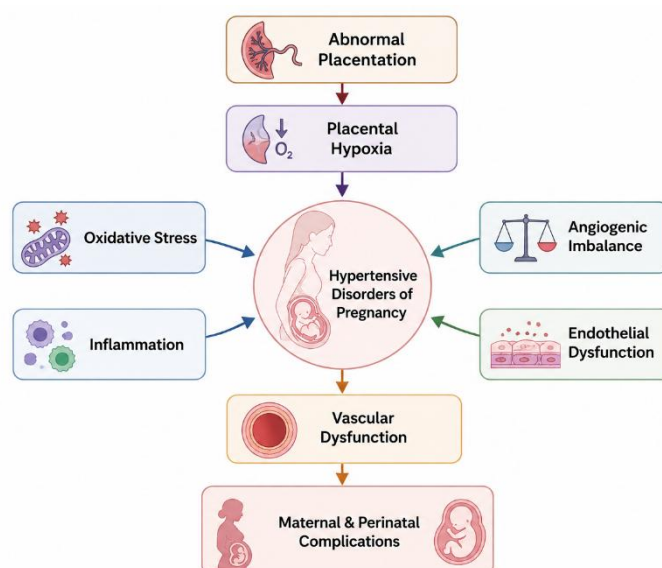


Figure 1. Pathophysiological Cascade of Hypertensive Disorders of Pregnancy

Figure 1 illustrates how placental dysfunction, oxidative stress, inflammation, angiogenic dysregulation, and endothelial injury may converge to produce vascular dysfunction and the clinical manifestations of HDP.

3.5 Maternal and Perinatal Complications

HDP are associated with serious maternal complications, including eclampsia, stroke, renal dysfunction, liver dysfunction, disseminated intravascular coagulation, placental abruption, and maternal mortality. Perinatal complications may include fetal growth restriction, preterm birth, low birth weight, NICU admission, and stillbirth. Women with previous preeclampsia also have an increased risk of persistent postpartum hypertension (Giorgione et al., 2021).

Dietary and lifestyle interventions have increasingly been investigated as adjunctive strategies in pregnancies at risk of placental dysfunction. Randomized evidence suggests that adherence to a Mediterranean dietary pattern during pregnancy may support placental and pregnancy outcomes in women at high obstetric risk. Such findings provide a rationale for further evaluation of nutritional interventions alongside conventional obstetric management rather than as replacements for established care (Crovetto et al., 2021).

4. Hydrotherapy: Biological Basis and Therapeutic Potential

4.1 Principles of Hydrotherapy

Hydrotherapy is the therapeutic use of water at different temperatures and through different modes of application to induce physiological responses. It includes immersion, water-pressure or massage applications, douches, affusions, showers, compresses, packs, and alternating hot and cold applications. Its effects depend on water temperature, duration, body area

exposed, hydrostatic pressure, and mode of application. Warm water generally promotes vasodilation and peripheral circulation, whereas cold or alternating-temperature applications may produce different vascular and autonomic responses. Hydrotherapy may therefore have potential as a supportive intervention in pregnancy-related hypertension (Goddard et al., 2023).

4.2 Types of Hydrotherapy

Hydrotherapy can be classified according to water temperature, mode of application, and physiological effect. Temperature categories are approximate and may vary across naturopathy, physiotherapy, and balneotherapy literature; therefore, the exact temperature used should be reported whenever possible. Common modalities include sprays, douches, baths, packs, compresses, affusions, immersion-based and flowing-water applications, and Alternating Hot and Cold Therapy (Goddard et al., 2023; Mellado García et al., 2024).

Table 1. Approximate Classification of Hydrotherapy According to Water Temperature

Water Temperature Category	Approximate Temperature	Common Hydrotherapy Applications
Very cold / Ice-cold	<15°C	Ice packs, ice massage, cold compresses, cold affusions
Cold	15–25°C	Cold baths, cold packs, cold affusions, hip baths
Cool	25–30°C	Cool baths, local baths
Neutral / Indifferent	33–36°C	Neutral bath, immersion bath, underwater massage
Tepid / Lukewarm	36–38°C	Tepid bath, sponge bath, therapeutic immersion
Warm	38–40°C	Warm bath, fomentation, warm compresses
Hot	40–43°C	Hot packs, hot fomentation, hot baths
Very hot	>43°C	Specialized applications requiring careful supervision

The temperature ranges presented in Table 1 are approximate and may vary across naturopathy, physiotherapy, and balneotherapy literature. For clinical and research reporting, the exact water temperature used should be stated whenever possible because physiological responses also depend on treatment duration, body area exposed, hydrostatic pressure, and mode of application.

Forms and Modes of Application: Hydrotherapy may be classified into immersion therapies, water-pressure and massage therapies, compresses and packs, affusions and douches, flowing-water applications, and specialized hydrotherapy. Common applications include full-body and local baths, sitz/hip, foot, arm, spinal and arm-and-foot baths, whirlpool and therapeutic-pool applications, underwater massage, hydromassage, water jets, douches, Vichy shower, compresses, packs, affusions, showers, sprays, running-water and Kneipp applications, and Alternating Hot and Cold Therapy. Aquatic therapy, hydrokinesitherapy, and balneotherapy are also included. Sauna and steam therapies may be discussed alongside hydrothermal interventions, although they are not water-immersion therapies.

Sprays: Sprays involve localized water application, with physiological effects influenced by temperature and site of application. Neutral and cold spinal sprays have shown different autonomic responses, including changes in blood pressure, heart rate, and heart-rate variability in healthy volunteers (Goley et al., 2019; Avanthika et al., 2017).

Douches: Douches are jet streams of water under controlled pressure and temperature, which have thermal and mechanical actions depending on the type of application and time (Vijayaraghavan and Dhilip, 2022). Neutral pulmonary douche has also been investigated for its effects on pulmonary function in patients with bronchial asthma, further demonstrating that douche-based hydrotherapy can produce measurable physiological responses (Prajwal et al., 2024). Alternate whole-body douche has shown changes in heart rate and heart-rate variability in healthy volunteers, without significant blood-pressure reduction (Pavithira et al., 2020).

Neutral-Warm Baths: Neutral-warm baths combine thermal and hydrostatic effects that may influence peripheral circulation and vascular responses. Their effects vary with water temperature, immersion depth, body area exposed, and duration. Neutral spinal baths, warm foot baths, and hot arm-and-foot baths have shown acute cardiovascular and autonomic effects in non-pregnant populations (Goley et al., 2019; Kumar & Shetty, 2021; Vyas et al., 2020). Excessive heat may raise maternal and fetal safety concerns (Amin et al., 2022; Ravanelli et al., 2019).

Packs: Packs involve wrapping a body region with wet material to produce temperature-dependent physiological effects. Their response varies with temperature, duration, and body surface area exposed. Full wet sheet packs have shown changes in blood pressure and autonomic activity in healthy volunteers (Shetty et al., 2018).

Compresses: Compresses involve localized application of wet material at cold, neutral, warm, hot, or alternating temperatures. Neutral and cold spinal compresses have shown acute cardiovascular and autonomic responses in non-pregnant individuals (Bansal et al., 2022; Naik et al., 2023), while warm lumbo-sacral compression has demonstrated benefits for labour pain and labour outcomes in nulliparous women (Kaur et al., 2020).

Alternating Hot and Cold Therapy: Alternating Hot and Cold Therapy uses sequential warm/hot and cold exposure, producing repeated vascular and autonomic responses. Alternate whole-body douche has shown acute heart-rate and HRV changes in healthy volunteers without significant blood-pressure reduction (Pavithira et al., 2020). Repeated temperature changes may increase thermal and haemodynamic stress.

4.3 Cardiovascular and Hemodynamic Effects

Peripheral blood flow, cardiac output, and vascular resistance may be affected by the heat exposure, as may be cardiovascular responses. While relevant to the broader cardiometabolic health, the conclusions of this review by Mohanakrishnan et al. (2026) on hydrotherapy-based interventions in overweight and obese populations are not definitive for passive hydrotherapy in the context of pregnant women with HDP. Repeated passive heat therapy has also been associated with improvements in endothelial function, arterial stiffness, and blood pressure in non-pregnant adults (Brunt, Howard, et al., 2016). These effects vary with water temperature, modality, pressure, duration, and body area exposed, so hydrotherapy should not be treated as a uniform intervention. Neutral spinal bath, spinal spray, underwater massage, and hot arm-and-foot bathing have shown different cardiovascular and autonomic responses in healthy or non-pregnant populations (Goley et al., 2019; Soni et al., 2016; Vyas et al., 2020). Therefore, exact temperature and mode of application should be reported when evaluating cardiovascular responses (Amin et al., 2022).

4.4 Effects on Endothelial Function and Vascular Reactivity

Impaired vasodilation and elevated vascular resistance are important components of endothelial dysfunction found in hypertensive disorders of pregnancy. Thermal exposure during hydrotherapy can modulate vascular responses by affecting blood flow, shear stress and vasodilation, which is dependent upon temperature. Warm or hot applications may have a vasodilatory effect, while neutral, cold or alternating temperature may have another vascular and autonomic effect. Acute lower-limb heating has also been demonstrated to enhance vascular function in healthy adults, but this effect is not necessarily applicable in women with HDP (Cheng et al., 2021). Because vascular dysfunction is central to preeclampsia pathophysiology, these responses provide a mechanistic basis for further investigation of hydrotherapy, although direct clinical evidence in HDP remains limited (Hula et al., 2025).

4.5 Anti-Inflammatory and Antioxidant Mechanisms

Passive heat exposure may influence inflammatory and oxidative-stress pathways, with responses depending on the intensity and duration of thermal exposure. Systemic inflammation, oxidative stress, and NLRP3 inflammasome activation are established components of preeclampsia pathophysiology, providing a biological rationale for investigating whether hydrotherapy-related thermal responses could influence these pathways (Hsu et al., 2026).

4.6 Effects on Autonomic Nervous System Regulation

The temperature modulation of the autonomic nervous system by hydrotherapy is thought to include the regulation of sympathetic and parasympathetic nervous system activity. Heart rate variability (HRV), heart rate, and blood pressure (BP) are important physiological parameters used to assess cardiovascular and autonomic responses to hydrotherapeutic interventions. Healthy or non-pregnant subjects have shown HRV and related autonomic changes after neutral or cold spinal spray (Avanthika et al., 2017), spinal bath (Goley et al., 2019) and spinal compress (Bansal et al., 2022). However, whether or not these responses are clinically significant in women who develop hypertension during pregnancy is unclear and further pregnancy-specific studies are needed. The results are in support of the temperature × form/application × physiological-effect framework. Autonomic and vascular stimulation could also be achieved by alternating Hot and Cold Therapy.

Table 2. Potential Physiological Effects and Clinical Relevance of Hydrotherapy in HDP

Mechanism/Effect	Physiological Response	Clinical Relevance	Reference
Hydrotherapy	Vasodilation, increased perfusion	Potential support for peripheral circulation; HDP-specific clinical evidence remains limited	Goddard et al. (2023)
Sprays	Temperature-dependent autonomic and cardiovascular responses	Potential supportive cardiovascular effects; HDP-specific evidence remains limited	Avanthika et al. (2017); Goley et al. (2019)
Douches	Temperature-, pressure-, and application-dependent autonomic responses	Potential supportive effects; HDP-specific evidence remains limited	Pavithira et al. (2020); Vijayaraghavan & Dhillip (2022)
Neutral-warm baths	Thermal and hydrostatic effects on vascular, blood-pressure, and autonomic responses	Potential cardiovascular effects; HDP-specific evidence remains limited	Goley et al. (2019); Kumar & Shetty (2021); Vyas et al. (2020); Kjertakov & Petersen (2025)
Packs	Temperature-dependent changes in blood pressure and autonomic activity	Potential supportive effects; HDP-specific evidence remains limited	Shetty et al. (2018)

Compresses	Localized temperature-dependent changes in blood pressure and autonomic activity	Potential supportive effects; HDP-specific evidence remains limited	Bansal et al. (2022); Naik et al., (2023)
Alternating Hot and Cold Therapy	Sequential hot/warm and cold stimulation producing vascular and autonomic responses	Potential autonomic and circulatory effects; efficacy and safety for HDP remain unestablished	Pavithira et al. (2020)
Haemodynamic effects	Increased cardiac output, reduced vascular resistance	Potential support for cardiovascular function; direct HDP evidence remains limited	Amin et al. (2022)
Endothelial function	Potential influence on shear-stress-related vascular responses	Potential influence on vascular reactivity; pregnancy-specific evidence remains limited	Amin et al. (2022)
Potential anti-inflammatory effects	Proposed modulation of inflammatory and oxidative-stress pathways	Potential relevance to endothelial health; HDP-specific evidence remains limited	Hsu et al. (2026)
Autonomic regulation	Modality- and temperature-dependent autonomic responses	Potential role in cardiovascular regulation	Goley et al. (2019); Avanthika et al. (2017)
Safety considerations	Control of water temperature, treatment duration, hydration, and thermal exposure	Maternal and fetal safety	Ravanelli et al. (2019)

Table 2 is a summary of the temperature and modality related vascular, autonomic, circulatory, and safety aspects of hydrotherapy.

4.7 Current Evidence in Pregnancy and Hypertensive Disorders of Pregnancy

The hydrotherapy evidence amongst women with HDP is very minimal and mostly indirect with the majority of data being based on healthy volunteers, non-pregnant hypertensive groups or the study of pregnancy outcomes other than that of HDP. There are no sufficient randomized controlled trials that have proven the effectiveness of sprays, douches, neutral-warm baths, packs, compresses, or Alternating Hot and Cold Therapy in hypertensive pregnancy. Hydrotherapy, therefore, must only be investigative and supportive. It is important that future research note the precise temperature, duration, application mode, body area of exposure and maternal haemodynamic responses to enable meaningful comparison across protocols.

4.8 Safety Considerations and Clinical Precautions

Hydrotherapy should be used cautiously during pregnancy because excessive or prolonged thermal exposure may increase the risk of hyperthermia, dehydration, hypotension, and haemodynamic stress (Ravanelli et al., 2019). Safety depends on water temperature, treatment duration, body area exposed, hydration, maternal tolerance, and clinical monitoring. Very hot, very cold, and rapidly alternating applications should remain investigational in women with HDP until pregnancy-specific safety and efficacy data are available.

5. Anti-Inflammatory Diet as an Adjunctive Nutritional Strategy

5.1 Dietary Inflammation and Pregnancy

Nutrition forms an essential part of the physiological control of inflammatory and metabolic processes in pregnancy. Dietary insufficiency with high consumption of processed food, fatty products, and carbohydrates might induce oxidative stress, impaired function of the endothelium, and inflammatory processes, which may increase susceptibility to hypertensive disorders of pregnancy. A systematic review and meta-analysis reported that greater dietary inflammatory potential is associated with adverse pregnancy outcomes, including preeclampsia and hypertensive disorders of pregnancy (de Freitas et al., 2022). More recent evidence has also linked a higher periconceptional Dietary Inflammatory Index with hypertensive disorders of pregnancy and their subtypes (Jancsura et al., 2025). Similarly, preconception dietary inflammatory status has been associated with hypertensive disorders of pregnancy, suggesting that dietary inflammatory exposure before pregnancy may also contribute to HDP risk (Kyojuka et al., 2022). Preeclampsia is viewed as a

multifactorial disease with involvement of inflammatory, angiogenic, and vascular pathologies, so nutritional modulation of these processes may have an important supportive role (Ives et al., 2020).

5.2 Anti-Inflammatory Dietary Patterns

Dietary patterns that have an anti-inflammatory effect include the Mediterranean diet, DASH diet, and whole food plant-based diets. These dietary patterns focus on consuming lots of fruits, vegetables, legumes, whole grains, nuts, seeds, and unsaturated fat in order to avoid consumption of processed foods and excess sodium. Following such dietary patterns may increase dietary antioxidant intake, support endothelial function and metabolic regulation, and contribute to lower systemic inflammatory burden. Plant-derived foods within these patterns also provide phytochemicals such as polyphenols and flavonoids, which are relevant to antioxidant and anti-inflammatory mechanisms in naturopathic and complementary care (Bharath et al., 2026). Prospective research indicates that following such dietary patterns in pregnancy may be associated with a reduced risk of selected pregnancy-related complications (Li et al., 2021).

5.3 Functional Nutrients and Bioactive Components

Nutrients such as omega-3 fatty acids, fiber, polyphenols, antioxidants, calcium, magnesium, potassium, and vitamins D, C, and E may contribute to vascular, metabolic, and immune homeostasis during pregnancy. These nutrients can support antioxidant defenses, endothelial function, inflammatory regulation, and placental development, although their effects depend on dietary adequacy, baseline nutritional status, and the specific nutrient involved. Plant-derived bioactive compounds are also increasingly being explored through advanced delivery approaches to improve their stability, bioavailability, and therapeutic potential (Bharath et al., 2026). Emerging research now suggests that maternal adherence to the Mediterranean diet during pregnancy may influence neonatal DNA methylation, indicating that dietary bioactive factors may exert epigenetic effects extending beyond pregnancy (Küpers et al., 2022).

5.4 Gut Microbiota, Metabolism, and Maternal Immune Homeostasis

Maternal gut microbiome has been identified to play a very crucial role in the regulation of metabolism, tolerance and inflammation in pregnancy. Diet-induced changes in the microbial community socially regulate the generation of short-chain fatty acids, intestinal permeability, and immune signaling; consequently, these responses can impact maternal vascular activity. Microbiome-focused naturopathic approaches, including probiotics, fermented foods, and microbiome-targeted strategies, further highlight the potential role of microbial modulation in supporting metabolic and immune homeostasis (Felin Paul et al., 2026). Immune dysregulation is an important contributor to the pathophysiology of hypertension in preeclampsia, as increased inflammatory cell activity and cytokine signaling may promote endothelial dysfunction and vasoconstriction (LaMarca et al., 2016). Modulation of inflammation through dietary and microbiome-related strategies may therefore have potential as a complementary supportive approach, although pregnancy-specific clinical evidence remains limited.

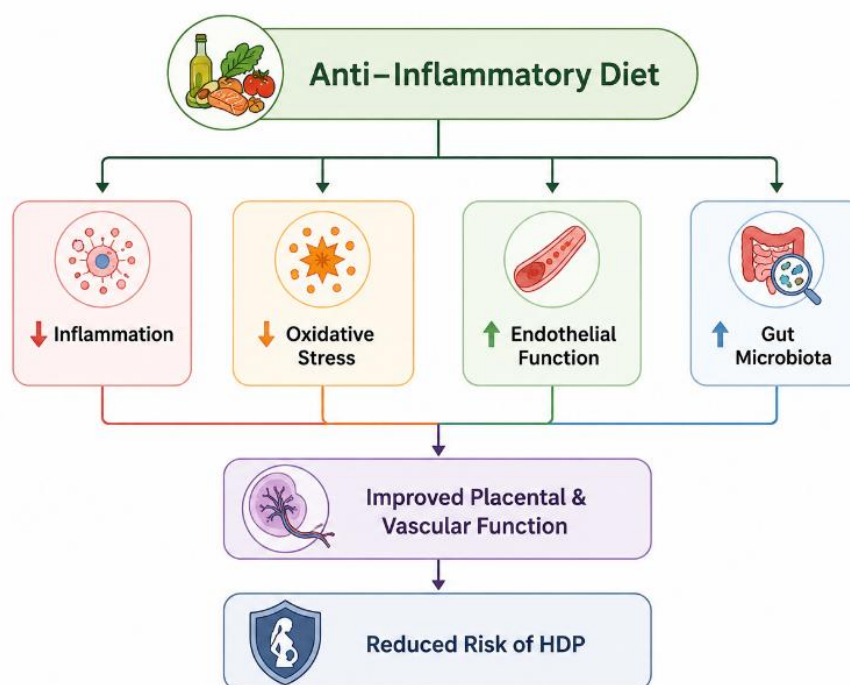


Figure 2. Mechanisms of Anti-Inflammatory Diet in HDP

As shown in Figure 2, the mechanisms behind anti-inflammatory diets involve many different pathways, such as inflammation, oxidative stress, endothelial dysfunction, and gut microbiota. These mechanisms can explain the results of the studies of dietary interventions presented in the next section.

5.5 Current Evidence Supporting Anti-Inflammatory Dietary Interventions in Hypertensive Pregnancy

There is an increasing body of literature supporting anti-inflammatory dietary interventions as complementary strategies for reducing the risk of hypertensive disorders of pregnancy and supporting maternal metabolic and cardiovascular health.

Evidence for Mediterranean- and DASH-type dietary patterns suggests potential benefits for maternal blood-pressure regulation, metabolic health, and selected pregnancy outcomes; however, the magnitude of benefit may vary according to population characteristics, baseline nutritional status, adherence, and study design. Greater adherence to a Mediterranean-style dietary pattern has been associated with a lower risk of preeclampsia (Minhas et al., 2022). A systematic review and meta-analysis of randomized clinical trials also reported beneficial effects of the DASH dietary pattern on selected maternal and pregnancy outcomes, including preeclampsia (Li et al., 2020). Because preeclampsia involves interacting placental, immune, angiogenic, and inflammatory mechanisms, dietary approaches that influence inflammatory and metabolic pathways may have biological relevance as supportive strategies (Jung et al., 2022). Network meta-analysis also suggests that dietary and nutritional interventions may complement established prophylactic strategies and evidence-based obstetric care in reducing preeclampsia risk (Liu et al., 2023).

6. Integrative Mechanisms of Hydrotherapy and Anti-Inflammatory Diet

Hydrotherapy and anti-inflammatory dietary interventions may influence several biological processes involved in HDP through distinct but potentially complementary mechanisms. Their joint impact on systemic inflammation, endothelial dysfunction, oxidative stress, angiogenic balance, bioavailability of nitric oxide, vascular function, and maternal cardiovascular regulation are summarized in Figure 3 and discussed in this section.

Their future clinical applicability will be determined by the suggested physiological processes, quality of the evidence that is specific to pregnancy, and safety profile.

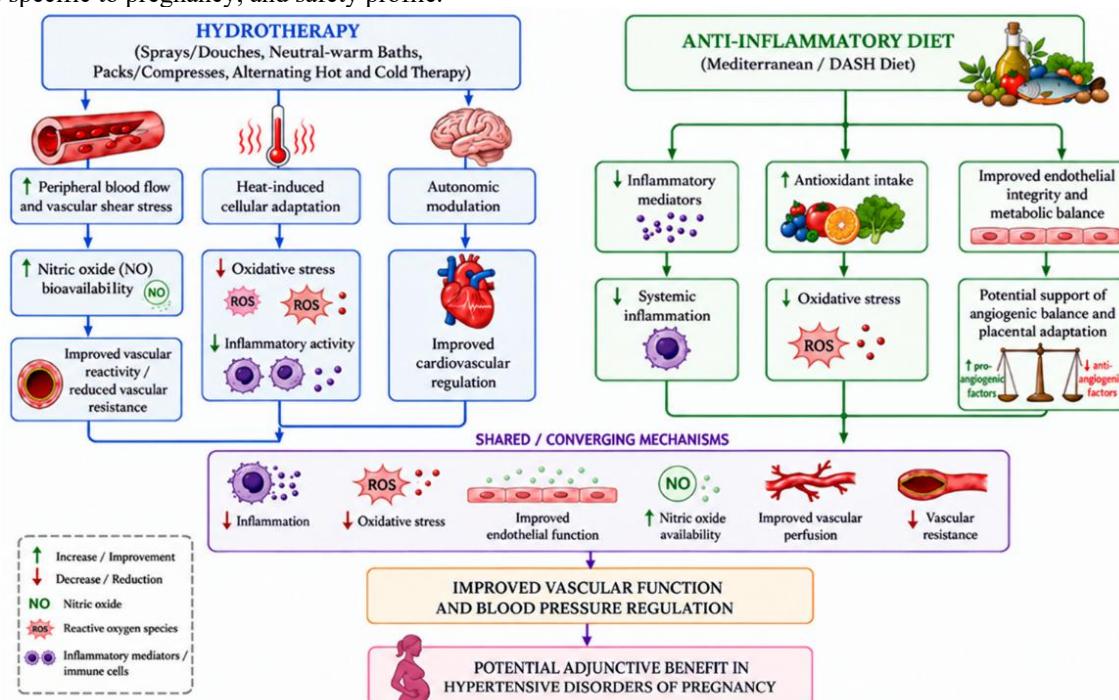


Figure 3. Mechanistic Basis of Hydrotherapy and Anti-Inflammatory Diet in Hypertensive Disorders of Pregnancy

Figure 3 demonstrates that hydrotherapy may act through circulatory, thermal, vascular, and autonomic pathways, whereas anti-inflammatory dietary patterns act through anti-inflammatory, antioxidant, metabolic, endothelial, and angiogenic mechanisms. These pathways may converge to support endothelial function, nitric oxide availability, vascular perfusion, and cardiovascular regulation.

6.1 Modulation of Systemic Inflammation

Hydrotherapy and anti-inflammatory diets could have various effects on inflammatory processes. Exposure to heat could trigger defensive reactions in cells and affect blood circulation, whereas nutrient-dense foods could be used to adjust the activity of inflammatory cytokines and act as antioxidants. Sufficient intake of one-carbon metabolism-related nutrients such as folate, vitamin B6, vitamin B12, and choline has been associated with a lower risk of preeclampsia (Ma et al., 2022).

Mediterranean and DASH-type dietary patterns have comparatively stronger pregnancy-specific evidence and may influence inflammatory mediators, oxidative stress, endothelial function, and maternal metabolic regulation. Their overall safety profile is favourable when nutritional adequacy is maintained, although caution is required with high-dose isolated supplements (Baroutis et al., 2025; Sharma et al., 2025).

6.2 Improvement of Endothelial Function

Endothelial dysfunction is a hallmark of preeclampsia. Hydrotherapy may influence endothelial function through vascular shear stress and nitric oxide-mediated responses, while anti-inflammatory diets may support endothelial health through antioxidant intake, improved lipid balance, and reduced inflammation. Together, these approaches may support vascular homeostasis, although evidence remains stronger for dietary interventions (Magee et al., 2022).

Hydrotherapy modalities such as sprays and douches may produce temperature-dependent vascular and autonomic responses; however, current evidence is derived mainly from healthy non-pregnant individuals, limiting direct application to women with HDP (Avanthika et al., 2017; Goley et al., 2019; Pavithira et al., 2020; Vijayaraghavan & Dhillip, 2022).

6.3 Reduction of Oxidative Stress

Excessive reactive oxygen species and oxidative stress contribute to placental dysfunction and vascular injury in hypertensive pregnancy. Thermal exposure has been proposed to influence endogenous antioxidant and cellular stress-response pathways, whereas anti-inflammatory dietary patterns provide bioactive compounds and antioxidants that may help reduce oxidative stress. Mediterranean dietary patterns have been associated with fewer adverse pregnancy outcomes (Makarem et al., 2022).

6.4 Regulation of Angiogenic Balance

Disturbance in the balance of pro-angiogenic and anti-angiogenic factors is an important feature of preeclampsia and may contribute to impaired placental development and reduced uteroplacental perfusion. Hydrotherapy has not been established to directly regulate angiogenesis, although effects on vascular perfusion and inflammation provide a theoretical mechanism. Extra virgin olive oil and nuts are part of the Mediterranean dietary interventions that have been shown to have positive relationships with maternal metabolic and offspring outcomes (Melero et al., 2020).

6.5 Enhancement of Nitric Oxide Bioavailability

Nitric oxide has significant roles in vasodilation, endothelial integrity and placentation. Nitric oxide deficiency could also be one of the causes of the vasoconstriction and high vascular resistance in preeclampsia. Nitric oxide bioavailability may be influenced by passive heat exposure through vascular shear stress, and repeated passive heat therapy has been associated with improved nitric oxide-dependent microvascular dilation in non-pregnant adults (Brunt, Eymann, et al., 2016). Neutral and warm-water immersion can also have an effect on peripheral vascular tone and redistribution of hydrostatic fluids, although existing evidence is mostly based on non-pregnant groups, and its applicability to blood-pressure regulation in HDP is unclear (Ravanelli et al., 2019; Mellado García et al., 2024).

6.6 Improvement of Vascular Function and Blood Pressure Regulation

Hydrotherapy and anti-inflammatory dietary manipulations might have various effects on vascular health. Heat can have the effect of elevating peripheral blood flow and decreasing vascular resistance and balanced nutrition can aid endothelial activity and electrolyte balance. Nevertheless, there is not much direct evidence that hydrotherapy can reduce the blood pressure in women with HDP (Mellado García et al., 2024).

Hydrotherapy modalities such as packs, compresses, and alternating hot and cold applications have shown acute vascular and autonomic responses in healthy or non-pregnant populations, but these findings do not establish blood-pressure reduction or clinical efficacy in HDP (Shetty et al., 2018; Bansal et al., 2022; Naik et al., 2023; Pavithira et al., 2020; Ravanelli et al., 2019).

Table 3. Mechanistic and Clinical Effects of Hydrotherapy and Anti-Inflammatory Diet in HDP

Target	Hydrotherapy	Anti-Inflammatory Diet	Potential Clinical Relevance	Reference
Inflammation	May influence inflammatory pathways	May lower inflammatory mediators	Potential reduction in inflammation	Hsu et al. (2026); Ma et al. (2022)
Endothelial function	May influence endothelial vascular responses	May improve endothelial integrity	Potential improvement in vascular function	Amin et al. (2022); Magee et al. (2022)
Oxidative stress	Potentially influences oxidative-stress pathways	Provides antioxidants	Potential reduction in oxidative injury	Makarem et al. (2022)
Angiogenesis	Potential indirect influence through vascular perfusion	Supports placental adaptation	Potential support for placental function	Melero et al. (2020)
Blood pressure	May influence circulation	Supports metabolic balance	Potential support for BP regulation	Goley et al. (2019); Mellado García et al. (2024)
Cardiovascular health	May influence autonomic function	May support metabolic regulation	Potential cardiovascular support	Mellado-García et al. (2023)

Table 3 summarizes the distinct and potentially complementary mechanisms through which hydrotherapy and anti-inflammatory dietary interventions may influence HDP-related pathways.

6.7 Potential Synergistic Effects in Maternal Cardiovascular Health

Hydrotherapy and anti-inflammatory dietary approaches may support maternal cardiovascular health through complementary mechanisms, with hydrotherapy primarily influencing circulatory and autonomic responses and diet targeting inflammatory, oxidative, endothelial, and metabolic pathways. Hydrotherapy during labour has been reported as generally safe under appropriate clinical conditions, although this evidence does not establish efficacy for HDP (Mellado-García et al., 2023).

Overall, anti-inflammatory dietary interventions have stronger pregnancy-specific support, whereas hydrotherapy requires further HDP-specific evaluation (Ergin et al., 2024; Mellado García et al., 2024).

7. Clinical Translation into Obstetric Practice

7.1 Adjunctive Role Alongside Evidence-Based Medical Management

Anti-inflammatory dietary measures and hydrotherapy are the complementary treatment modalities of hypertensive disorders during pregnancy. Evidence-based management of HDP, including antihypertensive medications, prophylactic low-dose aspirin when indicated, maternal-fetal surveillance, and timely delivery, remains the mainstay of clinical care. Lifestyle-based interventions may support vascular function, inflammatory regulation, and maternal metabolic health in pregnant women with chronic hypertension or other cardiometabolic risk factors (Goddard et al., 2023). Recent research indicates that a Mediterranean diet may contribute to maternal cardiovascular health during pregnancy (Morales Suárez-Varela et al., 2023).

7.2 Patient Selection and Individualised Care

Proper patient selection is important for the safe use of complementary approaches in pregnant women. Maternal risk assessment should consider age, BMI, previous obstetric history, comorbidities, HDP severity, gestational age, and fetal status before hydrotherapy or nutritional modification is considered. Nutritional guidance should also account for micronutrient deficiencies and maternal metabolic status. Vitamin D supplementation may be beneficial when maternal deficiency is identified during pregnancy (Palacios et al., 2019).

7.3 Practical Considerations for Clinical Implementation

Implementation of complementary practices in obstetrics requires clear clinical protocols, patient education, and appropriate monitoring. Dietary counseling should support adoption of an anti-inflammatory dietary pattern using culturally acceptable and locally available foods. Hydrotherapy should be applied using clearly defined treatment parameters, appropriate clinical supervision, and consideration of maternal tolerance. Understanding vascular inflammation and placental dysfunction in preeclampsia may also help provide a biological basis for evaluating supportive therapeutic strategies (Pogula et al., 2024).

7.4 Safety Monitoring During Pregnancy

Complementary interventions during pregnancy require maternal and fetal monitoring, including blood pressure, fetal growth, maternal symptoms, hydration, and pregnancy progression. Home blood-pressure monitoring is another way of assessing maternal cardiovascular status and of detecting abnormal blood-pressure patterns in pregnancy. Ankita et al. (2026) examined the difference between home and clinic blood-pressure readings of 200 pregnant women with hypertension or at risk for preeclampsia. Their results showed that there were significant differences in measurements taken at home by the mothers compared to those taken in the clinic, thus suggesting that structured home blood-pressure monitoring can be a valuable addition to the traditional antenatal monitoring. However, home monitoring should not be used as a substitute for routine obstetric assessment and clinically indicated maternal and fetal monitoring. Hydrotherapy should avoid excessive heat and prolonged exposure to reduce the risk of hyperthermia and hypotension. Early identification of high-risk women through first-trimester screening is also important for timely preventive care and appropriate clinical monitoring (Poon et al., 2019).

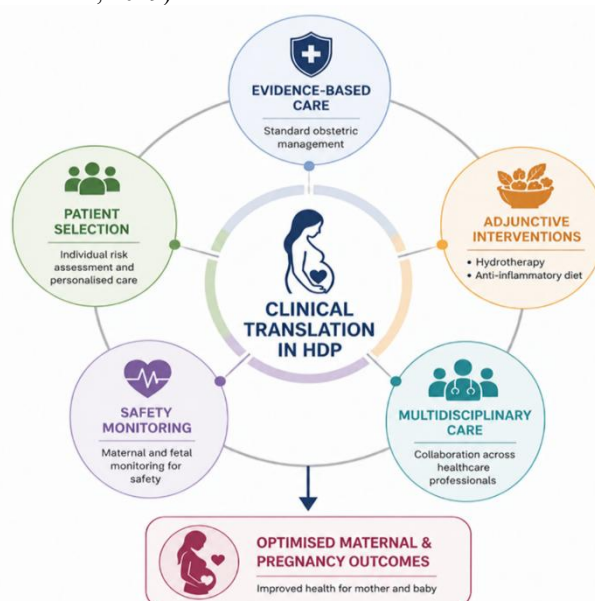


Figure 4. Clinical Translation of Adjunctive Interventions in HDP

Figure 4 summarizes the key requirements for clinical translation, including evidence-based treatment, appropriate patient selection, safety monitoring, and interdisciplinary collaboration.

7.5 Multidisciplinary and Integrative Maternal Healthcare

Treatment of hypertensive disorders of pregnancy involves cooperation of obstetricians, maternal-fetal medicine experts, dietitians, physiotherapists, midwives, and other medical practitioners. Individualized integration of medical and lifestyle intervention can be facilitated by this multidisciplinary approach. Future contributions to scientifically-based complementary care can be further facilitated by advances in the knowledge of placental malfunction, immune disbalance, epigenetic control, biomarkers, and targets of treatment (Procopciuc et al., 2026; Phipps et al., 2019). Suguna et al. (2026) emphasised the importance of multidisciplinary collaboration, individualised care, and health-system integration in managing complex healthcare needs. Although not specific to hypertensive disorders of pregnancy, their findings support a coordinated approach integrating supportive lifestyle and naturopathic interventions with conventional maternal healthcare.

8. Therapeutic Opportunities and Clinical Considerations

8.1 Evidence Supporting Adjunctive Naturopathic Interventions

Naturopathic therapies, especially, anti-inflammatory dietary and lifestyle therapies can be used alongside conventional management of hypertensive disorders of pregnancy as they would focus on inflammation, oxidative stress, endothelial dysfunction and vascular dysregulation. The most supported by the evidence are the Mediterranean-style dietary patterns that are linked to reduced risks of preeclampsia, gestational diabetes, and excessive gestational weight gain (Sharma et al., 2025).

8.2 Clinical Benefits and Potential Applications

Adjunctive naturopathic therapies can help maternal wellbeing potentially by enhancing vascular physiology, endotheliality, oxidative homeostasis and metabolic activity. Hydrotherapy can be beneficial in terms of circulatory and relaxation effects, and anti-inflammatory dietary interventions can be helpful in terms of cardiovascular and metabolic well-being. One of the key processes in preeclampsia is angiogenic dysregulation (Rana et al., 2022).

8.3 Safety Considerations

The use of hydrotherapy and dietary interventions ought to be tailored based on clinical status of the mother and applied with proper professional guidance. Hydrotherapy should be used cautiously in order to reduce maternal and fetal risk and dietary interventions should not restrict nutrition unnecessarily. Recent clinical recommendations endorse lifestyle interventions as supplements to drugs and maternal-fetal surveillance (Sinkey et al., 2020).

8.4 Limitations of Current Evidence

Although there are plausible biological mechanisms, there is limited evidence of hydrotherapy in hypertensive pregnancy disorders due to the absence of sufficiently designed randomized controlled trials. Hydrotherapy research covers a broad spectrum of interventions (aquatic exercise, passive immersion and other hydrotherapy uses), widely varied study populations, and varied outcome measures. Mohanakrishnan et al. (2026) did a systematic review of water-based therapies for overweight and obesity and observed that the diversity created methodological challenges in comparing the different therapies. The results of these studies, however, are not directly applicable to pregnant women with hypertension because of significant differences in patient population demographics and clinical results. Pathophysiology of preeclampsia is also multifactorial and complex and may also make the assessment of isolated adjunctive interventions and interpretation of their clinical outcomes more complicated (Rodrigues et al., 2026). Thus, additional pregnancy-specific studies are required to establish standardized hydrotherapy regimes and elucidate clinical effectiveness in HDP women.

Table 4. Clinical Considerations for Adjunctive Interventions in HDP

Aspect	Key Consideration	Reference
Evidence	Adjunctive lifestyle interventions may complement standard obstetric care.	Sharma et al. (2025)
Clinical benefits	May support vascular function and maternal cardiovascular health.	Morales Suárez-Varela et al. (2023)
Safety	Use under supervision with appropriate temperature and nutritional monitoring.	Sinkey et al. (2020)
Evidence limitations	Limited pregnancy-specific evidence for hydrotherapy, particularly for HDP treatment.	Goddard et al. (2023); Mellado García et al. (2024)
Clinical integration	Individualised, multidisciplinary implementation is recommended.	Rana et al. (2019)
Guideline adherence	Complementary therapies should follow established obstetric recommendations.	Sutton et al. (2018)

The key considerations to clinical use are summarized in Table 4, such as the strength of evidence, safety, supervision, and multidisciplinary implementation.

8.5 Practical Considerations for Clinical Integration

Naturopathic interventions should be clinically integrated in line with the existing obstetric guidelines and with maternal risk assessment on a case-by-case basis. The choice of complementary methods should aim at the severity of the disease, the level of gestation, comorbidity, and the general clinical appropriateness in the multidisciplinary care (Rana et al., 2019; Sutton et al., 2018).

9. Future Perspectives

9.1 Emerging Evidence

Studies are ongoing to further refine the concept of HDP by developing placental biology, endothelial dysfunction, angiogenic signaling, oxidative stress, and immune regulation. Such mechanisms can help to develop more specific preventive and therapeutic approaches. New findings also indicate that combining molecular knowledge with the rightly chosen lifestyle changes can enhance multimodal management of preeclampsia (Torres-Torres et al., 2024).

9.2 Research Priorities

Future studies need to focus on multicenter randomized controlled trials that assess the effectiveness of hydrotherapy and anti-inflammatory dietary interventions on women with HDP. To determine safety and efficacy, standardized protocols, extended follow-up, and clinically pertinent maternal and fetal outcomes are required. Vascular, inflammatory, metabolic, and placental biomarkers also should be evaluated in studies to better understand the underlying mechanisms and enable the creation of more personalized preventive and therapeutic approaches (Yang et al., 2024).

9.3 Translational Potential

Translation of complementary approaches into obstetric practice requires evidence of clinical effectiveness, safety, feasibility, and cost-effectiveness. Future studies should determine whether integrating hydrotherapy and anti-inflammatory nutrition with standard obstetric care may improve maternal cardiovascular and pregnancy outcomes. Personalized nutritional supplementation based on individual risk profiles also warrants further investigation, particularly as recent network meta-analysis suggests that some nutritional supplements may reduce preeclampsia risk (Wang et al., 2026).

9.4 Implications for Clinical Practice

Evidence-based lifestyle and nutritional interventions may complement standard antenatal treatment when supported by adequate clinical evidence and appropriate maternal assessment. Personalized nutritional strategies, including calcium supplementation in women with low dietary calcium intake and selected use of magnesium, may help reduce preeclampsia risk in appropriate populations (Woo Kinshella et al., 2022; Yuan et al., 2022).

9.5 Concluding Perspectives

Future management of HDP will likely combine advances in molecular medicine with evidence-based lifestyle interventions to support more personalized maternal care. Established obstetric treatment, including appropriate antihypertensive therapy and maternal-fetal surveillance, should remain the priority, while hydrotherapy and anti-inflammatory nutrition may be considered only as adjunctive approaches. Evidence supporting active treatment of hypertension during pregnancy reinforces the importance of maintaining established medical management (Tita et al., 2022).

10. CONCLUSION

Hypertensive disorders of pregnancy remain a major concern because of their effects on maternal cardiovascular health, placental function, and perinatal outcomes. This review highlights the potential role of hydrotherapy and anti-inflammatory dietary approaches as adjunctive strategies within established obstetric care. The evidence reviewed suggests that anti-inflammatory dietary patterns, particularly Mediterranean- and DASH-style diets, have comparatively stronger pregnancy-specific support and may support metabolic balance, endothelial function, inflammatory regulation, and maternal cardiovascular health. Conversely, the vascular, circulatory, autonomic and stress-regulatory effects of hydrotherapy in women with hypertensive disorders of pregnancy are plausible, although the current evidence remains sparse and is mostly inferred to non-pregnant populations or pregnancy-based studies exploring other outcomes. As such, hydrotherapy cannot be considered a treatment of HDP at this time but an experimental method of support. Both methods are supposed to be adopted as supplementary, but not substitute to accepted antihypertensive therapy, maternal-fetal observation, and other evidence-based obstetric interventions. The most needed area of research in the future is well-designed clinical trials, standardized hydrotherapy regimens, well-defined dietary interventions, and long-term evaluation of maternal and neonatal outcomes. On the whole, the existing data points to the increased clinical confidence of anti-inflammatory dietary interventions, whereas hydrotherapy needs additional evaluation with regard to pregnancy to be used more widely.

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