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Cold Water Swimming and Pregnancy: A Scoping Review and Consensus Recommendations

J Shawe[1,2,3] | M Felton[4] | JC Harper[5] | C Mark Harper[6,7] | R Stidson[8] | M Tipton[9] | S Blowers[1,10] | K Fraser[11,12] | S Hingley[13] | E McGrath[14] | G Bainbridge[15] | Massey Heather[9]

[1]Faculty of Health, University of Plymouth, Plymouth, Devon, UK | [2]Royal Cornwall Hospital NHS Trust Truro Cornwall, Truro, UK | [3]Department of Development & Regeneration, University of Leuven, Leuven, Belgium | [4]Department of Rehabilitation and Sport Sciences, Faculty of Health and Social Sciences, Bournemouth University, Bournemouth, Dorset, UK | [5]EGA Institute for Women's Health, University College London, London, UK | [6]Royal Sussex County Hospital, Brighton, UK | [7]Sørlandet Sykehus, Kristiansand, Norway | [8]Scottish Environment Protection Agency, Stirling, Scotland, UK | [9]Extreme Environments Laboratory, University of Portsmouth, Portsmouth, UK | [10]Cornwall Health Library Royal Cornwall Hospital Truro Cornwall, Truro, UK | [11]Princess Royal Hospital - University Hospitals Sussex, Brighton, UK | [12]Brighton and Sussex Medical School, Brighton, UK | [13]Chelsea and Westminster Hospital, Chelsea and Westminster NHS Foundation Trust, London, UK | [14]School of Geography, Earth and Environmental Sciences, University of Plymouth, Plymouth, UK | [15]The Bluetits Chill Swimmers Ltd., St. Davids, Pembrokeshire, UK

Correspondence: M Felton (mfelton@bournemouth.ac.uk)

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ABSTRACT

Introduction: Cold water swimming has increased in popularity and women wish to swim throughout pregnancy. There is a lack of evidenced-based guidance to make decisions about the safety of immersion in cold water during pregnancy.

Methods: Closed social media groups were asked for specific questions in relation to cold water swimming and pregnancy. This highlighted concerns including water temperature, risks to the mother and fetus, and water quality. To find evidence-based answers, a series of meetings brought together clinicians and researchers with expertise in cold water physiology, exercise physiology, fertility, obstetrics, neonatology, midwifery, water epidemiology, public health and representatives from the Open Water Swimming Society and an Open Water swimming social enterprise.

Results: Published data were examined via a scoping review process and four studies and eight reports were identified. Recommendations were made with evidence graded (mostly grade 4 expert opinion).

Conclusion: Research gaps highlight the need for research to enable accurate advice to determine whether it is safe for pregnant women to swim outdoors in cold water.

1 | Introduction

1.1 | Rationale

In the United Kingdom, physical activity during pregnancy is recommended at the same levels as the general population guidance, with 150 min of moderate-intensity exercise recommended every week [1]. Worldwide, 30 countries now have physical activity guidelines either specifically for pregnant women or inclusive of pregnant women [2], an increase from the nine countries with guidelines published before 2014 [3]. For uncomplicated pregnancies, there is no evidence that physical activity poses

harm to the baby [1] and physical activity during pregnancy can reduce rates of gestational diabetes [4], hypertension [5] and depression [6].

Swimming in heated swimming pools is popular during pregnancy due to the added benefits of the low-impact nature, associated with the weightlessness of being in water. Pregnant women perceive a range of health benefits from swimming including improving both physical and mental health, but crowded swimming pools were a barrier to participation [7]. Swimming and aquatic exercises are safe during pregnancy and may offer beneficial birth outcomes such as a reduction in preterm births [8], while also controlling heart rate and blood glucose levels, improving balance and mobility, and preventing excessive weight gain [9].

Cold water swimming, sometimes referred to as open water swimming, or wild swimming, has increased in popularity over recent years, especially since the COVID lockdown. The Outdoor Swimming Society website had 1 million unique visitors in 2022 which was an almost 50% increase from 2021 (Oliver Pitt, Personal Communication 2024). Their membership increased from 100,000 in January 2020 to 173,000 in 2022. The Bluetits Chill Swimmers have also noticed a huge increase in members; in 2020 when they became a social enterprise there were around five informal volunteer-led Bluetit community groups. They have experienced exponential growth and now have almost 200 Bluetit community groups (flocks) worldwide with over 100,000 members across all the groups (Gail Bainbridge, Personal Communication 2023).

1.2 | Benefits of Cold Water Swimming

The continuing surge in popularity of outdoor swimming is a testament to its perceived benefits. Besides the wonders of exercising in nature, often with a community of other swimmers, the benefits stem from the physical, physiological and psychological challenge presented by cold water immersion (CWI) [10]. For instance, immersing the body in cold water stimulates the sympathetic nervous system and the release of stress hormones [11] which may provide a 'post-swim high' [10]. The immersion or swimming in cold water may also be linked to improved mood and symptoms of depression and anxiety [12, 13].

Previous reviews have focused on the impact of cold water swimming and health benefits [10, 14, 15], but none of the published research at present has the rigour for inclusion in a systematic review of randomised control trials (RCTs), nor are there clear mechanisms of effect. At present, there is a lot of anecdotal and qualitative evidence of perceived benefits of outdoor swimming for improvements in mental and physical health conditions [16, 17] with some documented case studies [18, 19] and small exploratory studies [13, 20]. The continuing popularity of outdoor swimming may be the result of these perceived mental and physical benefits and requires further research.

Outdoor swimming coaching over the course of summer showed evidence of reduced symptoms of depression in a case study [18] and a single-arm study of 53 participants living with symptoms of depression showed reductions in symptoms of depression and anxiety following eight swim sessions, and this reduction in symptoms was present upon follow up 3 months after the completion of the course [13].

Other theories suggest that breath holding and face immersion in cold water (either before or after the cold shock response is complete) have an immediate and short-term effect through direct stimulation of the parasympathetic nervous system–the diving reflex [21]. This manifests as a lower heart rate, a calming effect on those with panic disorders [22] and may be one of the mechanisms through which benefits occur. If this mechanism is linked to the benefits, there may be no need to immerse the body in cold water and only briefly immersing the face is required. However, coincidental immersion of the whole body (including the face) and breath holding have been reported to evoke cardiac arrythmias associated with 'autonomic conflict' [23]–see the following section.

Cold water immersion can also reduce levels of inflammation [24]. This effect on inflammation may be one of the hypothesised mechanisms through which cold water swimming provides benefits [10]. Chronically raised levels of inflammation in the body resulting from the secretion of stress hormones such as cortisol are associated with, and can exacerbate, many common medical conditions ranging from hypertension, type 2 diabetes mellitus, inflammatory bowel disease and depression [25–27]. In theory, outdoor swimming may have the potential to reduce inflammatory responses, but RCTs are still required to establish the efficacy of CWI/outdoor swimming to manage the conditions and establish if the inflammatory change is the mechanism of action.

There are a number of other conditions where some anecdotal evidence is available of improved well-being in relation to pain, rheumatic disease, menopause and migraine [20]. Additionally, many participants also claim that outdoor swimming strengthens their immune system. There is evidence of changes in immune function markers (T and B lymphocytes and antioxidants) in those who immerse themselves in cold water [28, 29] but the clinical significance of these changes in immune markers or presentation of illness is not so clear-cut [30].

As well as a number of potential mechanisms that may stem from the physiological responses, social and psychological challenges are presented by CWI. These 'nature-based' or 'green and blue therapies' may support reductions in social isolation, improved mindfulness, a greater connection with nature, distraction, placebo effects and improved self-efficacy through achievement or completion of a challenge [10, 31, 32].

1.3 | The Risks of Cold Water Swimming

The risks of cold water swimming stem from the physical and physiological responses evoked by CWI; these risks are well-researched and well-documented [10, 33–35]. With the increase in popularity of cold water swimming, there has inevitably been an increase in related adverse incidents. Waves and currents provide a physical challenge, and participants need to be constantly aware of the risk of exhaustion.

The four stages of immersion in cold water associated with particular hazards include initial response, short-term responses, long-term responses and circum-rescue responses [33, 36, 37]. The immediate physiological responses to cold immersion (uncontrollable gasping and hyperventilation, tachycardia, hypertension), termed 'cold shock' [33] are initiated by cutaneous cold receptors and primarily mediated by the sympathetic nervous system. The respiratory responses can be a precursor to drowning. Heart rate, blood pressure, workload of the heart and stress hormone concentrations are increased, and arrhythmias may occur which may precipitate cardiac arrest in an individual with underlying cardiovascular disease. As noted, putting the face in cold water and breath holding can result in autonomic conflict and consequent cardiac arrest on immersion in cold water [23].

Whilst the responses peak in water temperatures between 15 and 10°C [34], the cold shock response can occur in much warmer water (25°C) and therefore most of the open water around the United Kingdom will be cold enough to evoke the cold shock response even in summer. With repeated immersions in water at a temperature of less than 20°C, typically six short (e.g. 5 min) immersions over a period of a few hours or days [38], the body habituates and this response is attenuated. As a result, peak levels of stress, as manifested by physical and biochemical markers, reduce the body's cold shock response. This is a medium- to long-term effect as 60% of this attenuated response is still present 14 months after the initial adaptation programme [35].

Other disturbing consequences of CWI include transient global amnesia whereby, for a period of minutes to 8–10 h, a swimmer loses their short-term memory [39]. This is rare, unpredictable and little studied. It tends to affect older people and is associated with a history of migraines [40]. Swimming-induced pulmonary oedema (SIPE) is evidenced by a cough, shortness of breath/dyspnoea, hypoxaemia and oedema. Risk factors include being female, hypertensive, swimming more than 1.2 miles and having a history of SIPE. It is thought to be caused by the central blood pooling, peripheral vasoconstriction caused by cold, tight wetsuits, excessive hydration and high-intensity exercise. Treatment includes recognising the condition early, sitting up, loosening wetsuits, insulation, pursed lip breathing and evacuation to hospital telling those you meet you may have SIPE [41].

The risks associated with immersion in cold water are not insignificant but can be mitigated by taking some simple precautions; having a health check, swimming in a group at sheltered locations and in calm conditions with clear exit points, getting in slowly and getting over the initial shock to the body before putting your head under, and limiting your exposure by time (e.g. 10 min maximum) rather than how good you feel [42].

1.4 | Objectives of Study and Review Questions

With the increase in popularity of cold water swimming, there are more women who wish to swim throughout their pregnancies. There appears to be a lack of evidenced-based guidance available for women to make decisions and for healthcare professionals to give advice and guidance about the safety of immersion in cold water during pregnancy. Evidence-based information is required as it is easy for information and guidance to be added to web sites, books, magazines, etc. without any scientific basis, and then become embedded as facts.

The objective of this study was to use social media to ask women what questions they had about outdoor swimming whilst pregnant and to examine published data via a scoping review. Scoping reviews are particularly useful in synthesising literature in emerging fields to map the extent, range and nature of available literature [43]. The hope was to find evidence-based answers to their questions and specifically; 'Is it safe for pregnant women to swim outdoors in cold water'?

Social media contact to gatekeepers of closed Facebook swimming groups was approved by the University of Plymouth Faculty Research Ethics and Integrity Committee (project ID FSER: 3894).

2 | Materials and Methods

A series of expert meetings were held virtually in 2022 and 2023 bringing together national expertise from a multidisciplinary group of researchers and clinicians including cold water physiologists, exercise physiologists, specialists in fertility, obstetrics, neonatology and midwifery, water epidemiology, public health, the Outdoor Swimming Society medical advisor, and an open-water swimming social enterprise.

The objectives of the meetings were to discuss key questions, to advance knowledge, evidence and practice in the area of cold water swimming and pregnancy and to identify areas of focus for collaborative work to produce consensus guidance on best practices for facilitating safe and healthy pregnancies whilst swimming.

The group then contacted gatekeepers of closed social media groups for permission to ask members if they had specific questions in relation to cold water swimming and pregnancy. Anonymous questions were received and grouped into themes by MF and HM to help develop a protocol for the search. A workshop of 11 women who swam during pregnancy in cold water was also held, and questions from participants were collated and added.

2.1 | Questions From Women Related to Cold Water Swimming

A summary of the topics women wanted more information about, relating to cold water swimming, is shown in Table 1, ordered by popularity of the topic.

2.1.1 | Physiology and Temperature

The most popular topic that women wanted more information on was the body temperature changes of both the mother and the fetus during cold water swimming and recommendations for the maximum duration of immersion in cold water. This was closely followed by questions about the physiological response of the baby while the mother undertakes cold water swimming (e.g.

TABLE 1 | Summary of topics asked by women on what they want to know about cold water swimming during pregnancy (ordered by frequency of number of questions asked in each topic).

Topic	Typical questions asked on the topic	Frequency
Temperature	Temperature changes in women and babies at different water temperatures. Recommended minimum water temperature or maximum duration of immersion at specific temperatures?	15
Physiological responses of the fetus	Physiological responses of the fetus to cold water–heart rate, foetal movement, cold water shock, effect on blood flow to the uterus?	11
Water quality	Water quality (pollution risks, temperature, water borne diseases, algae). Location of open water swimming–sea, rivers, lakes. Should women avoid putting their faces underwater due to the risk of infection?	8
Trimester	Differences in physiological response to cold water swimming and therefore guidance between trimesters.	7
Wetsuit/skins	Temperature control with/without wetsuits and/or skins during pregnancy. Consideration of wetsuits not fitting during pregnancy and tightness over the bump not being good for the fetus.	5
Experience of cold water	Difference in physiological response and/or guidance between regular swimmers (before start of pregnancy) and women starting during pregnancy.	4
Health conditions	Contraindications to open water swimming, e.g., pre-eclampsia, gestational diabetes, carpal tunnel, multiple pregnancy? Is this dependent on the trimester?	4
Birth outcomes	Impact of cold water swimming on delivery (complications, baby's position, placental position.)	3
Postnatal	Effect of cold water swimming on breastmilk supply. How long after birth before returning to the sea?	3
Swimming stroke	Which swimming stroke to use during pregnancy? Advice regarding front/back lying down and safest movements in relation to ligaments relaxing.	3
Sea conditions	Sea swimming–Should women stay within their depth and avoid waves to stop getting bumped around by them? Do sea sickness and nausea during cold water swimming change during pregnancy?	3
Temperature post-swim	Temperature regulation after swimming during pregnancy. Response to returning to core baseline temperature.	3
IVF	Cold water swimming during IVF treatments. Guidance that some activities should be limited prior to conception and early pregnancy. Should cold water swimming be limited? Can women restart swimming in the second trimester?	2
Specific pregnancy considerations	Additional considerations for cold water swimming when pregnant compared with pre-pregnancy. Are there signs that mean you should stop such as changes to breathing, heart rate or other physiological changes?	2
Mental health	Link between cold water swimmers and postnatal depression	1
Outdoor vs. indoor	Comparison of risks between outdoor and indoor swimming, such as risk of getting kicked during lane swimming but more space outside, risk of being stung by jellyfish.	1
Adipose fat changes	Will the adipose fat in the fetus/child increase with regular dips in low temps?	1

foetal heart rate, foetal movement, potential physiological shock and blood flow to the uterus).

Additionally, questions were related to the specific temperature of the water and, for example, whether the recommended minimum water temperature and durations of exposure are known.

2.1.2 | Water Quality

Information was also requested about water quality including risks of pollution, water borne disease and infection including potential differences for locations such as rivers, lakes and the sea.

2.1.3 | Pregnancy-Specific Risks

An overarching question across all topics was the need for information to be specific across the different stages of pregnancy, with future guidance providing trimester-specific information.

Other specific risks/considerations related to pregnancy were also asked including pregnancies conceived by in vitro fertilisation (IVF), the postnatal period, specific health conditions, birth outcomes, health benefits, use of wetsuits/skins and potential differences between those with more or less experience of cold water swimming.

2.2 | Search of the Published Works on Outdoor Swimming During Pregnancy

An initial literature search was performed in February 2022 by JS and Specialist Subject Librarian SB to identify articles on this topic, followed by analysis of the text words contained in the titles and abstracts, and of the index terms used to describe these articles. This informed the development of a search strategy including identified keywords and index terms which was adapted for each information source. The search strategy aimed to find both published and unpublished studies as well as articles of interest from sources of grey literature. Searches were updated in February 2023 and August 2023 with no extra papers found.

After consultation between JS and SB, it was decided that specific outcomes were not to be added as search term criterion, as all potential outcomes were to be considered for the scoping review.

We conducted a scoping review based on the approach of the Joanna Briggs Methods Manual for Scoping Reviews [44]. An outline protocol for the review was prepared and revised using input from the key stakeholders. The scoping review has been reported based on the PRISMA Extension for scoping reviews [45] in accordance with PRISMA guidance. Details of included and excluded studies are included in the PRISMA flowchart (Figure 1).

SB used a combination of free text terms and mesh headings in the following electronic databases from inception for both academic articles and grey literature: Medline (Ovid), CINAHL (EBSCOhost), PsycINFO (ProQuest), Embase (Ovid), Cochrane, BMJ Best Practice, JBI, UpToDate, TRIP, NICE Guidelines, Google Scholar and grey literature and organisational websites. The development of a search strategy included identifying keywords and index terms tailored to each information source. Identified articles were published both internationally and from the United Kingdom. Only studies published in English or translated from English will be included due to time and budgetary constraints. This scoping review considered studies that included these terms used with Bodleian terms of reference.

A summary of search terms is included in Table 2, and a full search strategy for each database and grey literature can be found in the Supporting Information. The reference list of all included studies was screened for any additional papers.

TABLE 2 | Summary of terms searched.

Terms Searched	
Open Water/ Swimming	Pregnan*/pregnancy/ 'prepregnancy'/ pre-pregnancy
River/Swimming	Gestational
Outdoor/Swimming	Pregnancy/Exercise
Cold Water Immersion	Maternal/swimming
Swimming/Ponds	human
Sea/Swimming	water
Pond/Swimming	adult
Reservoir/Swimming	'Exercise in pregnancy'
Wild/Swimming	Gestational mothers
Sea Conditions	Cold water/swimming
'Swimming in the wild'	conception

2.3 | Data Analysis

Articles resulting from these searches and any relevant references cited were downloaded into Endnote, duplicated and reviewed using RAYYAN software [46] by the team. Final decisions on inclusion were made by JS and JH and moderated by HM.

3 | Results

The initial search found 640 records. After removal of duplicates and records marked as ineligible by automation tools, 409 remained. Titles and abstracts were screened leaving 139 records for retrieval which were assessed for eligibility. Hand searching of references revealed two more relevant studies. Following this process, only six studies were identified as meeting the inclusion criteria associated with cold water swimming and pregnancy. As per the protocol, records were also sought via web-based resources and grey literature. Sixty-two records were found and after review, eight reports met the criteria for inclusion.

Papers were graded for quality and level of evidence (see Box 1) and are summarised in Appendix 1.

3.1 | Evidence and Recommendations

Literature that related to cold water swimming and pregnancy was sparse and highlighted two main areas: physiological response to cold water and pregnancy, and water quality as discussed below.

To make recommendations in relation to the safety of pregnant women swimming in cold water, the questions received from closed social media groups and the workshop were linked to the available evidence and to expert consensus agreement within the team. Table 3 gives a summary and any specific

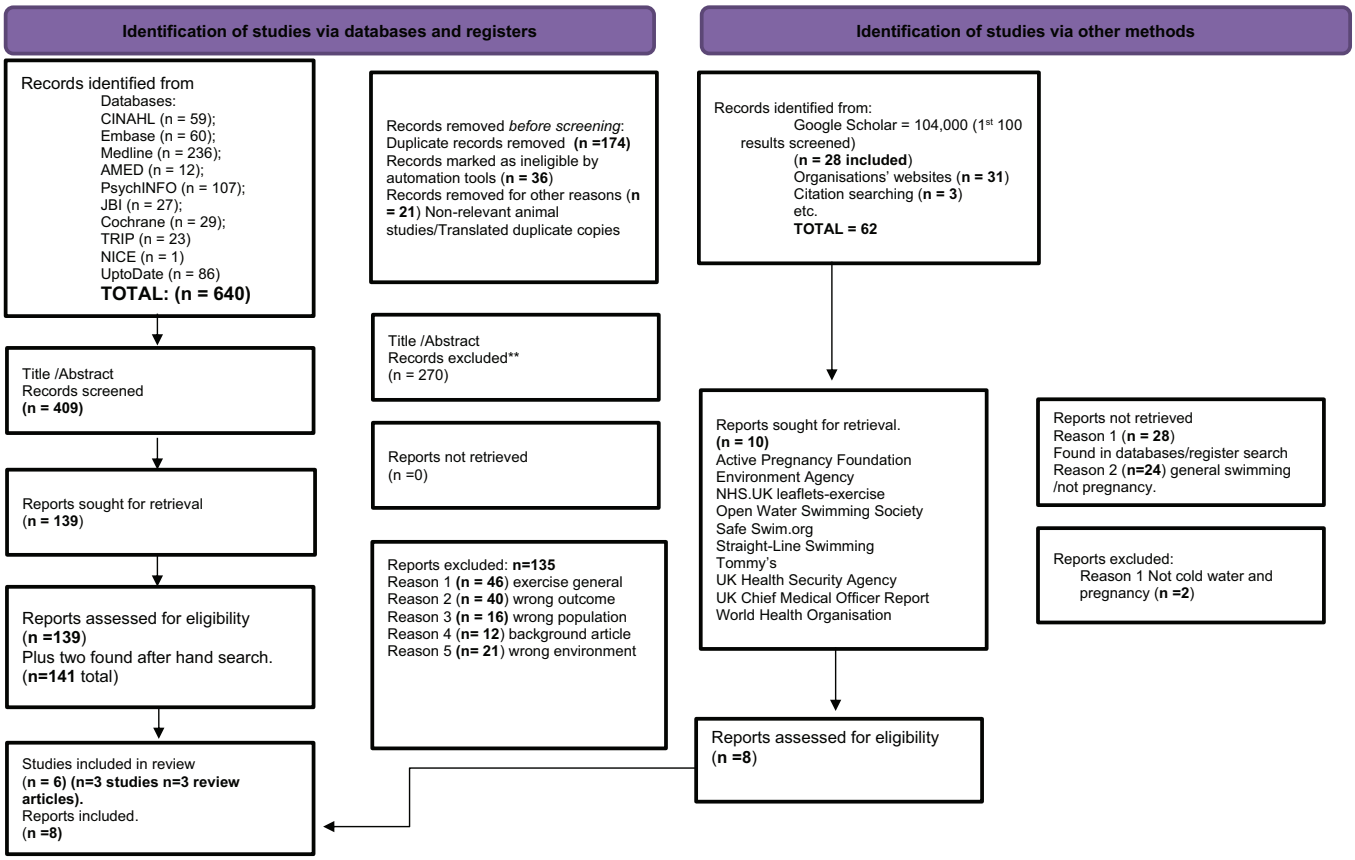

FIGURE 1 | PRISMA diagram shows the identification and screening process. *Source:* Page et al. [47].

recommendations. Unfortunately, due to lack of evidence, few of these relate to the specific stages of pregnancy as requested by women.

3.2 | Physiological Response to Cold Water Immersion and Pregnancy

At present, there are no peer-reviewed publications of the physiological effect of whole-body CWI in pregnant humans. There are a small number of papers where pregnant women have either been exposed to cold air or stationary exposure to water less than thermoneutral (35°C) [49, 50]. In addition, there are case reports of accidental or therapeutic hypothermia in pregnant females [51, 52].

As yet, there is no published information on the impact of cold shock on pregnant females. However, a 20-min standing water immersion (28–29°C) was shown to reduce pedal oedema to a greater extent than seated rest on land with the legs elevated [49]. In this case, both of the interventions would contribute to the redistribution of body fluid. Reductions in restless leg syndrome were also found by immersion in water [50]. A greater reduction in symptoms occurred when immersing the legs to just above the knee for 10 min in cold water (20–25°C) compared to immersion in 40–45°C water. The rationale for using warm water may be related to the vasodilation response and greater blood and nutrient supply to the tissues, whereas CWI results in reduced sensations of muscular fatigue.

There is also evidence of elevated cortisol concentrations during pregnancy [53]. When pregnant and challenged using a 1 min cold pressor test (hand in ice cold water), no further elevation in cortisol concentrations (20 min post-test) was observed in 10 females. In contrast, matched non-pregnant controls had a significant increase in cortisol concentrations when exposed to the same stimulus [54]. This increase in cortisol was to similar values as the pregnant group when at rest. Therefore, it may be that the additional hand immersion (stress) did not result in any increase in cortisol in the pregnant group. Whereas for the control participants, hand immersion in cold water represented a significant additional stress, increasing cortisol levels to those of the pregnant group at rest. However, it is not known if this lack of cortisol response to hand cooling when pregnant would be replicated when the whole body was immersed. It may also be that continued repeated stressors would stimulate a reduced cortisol response as an adaptative response to the stressor occurs, thus it can be hypothesised that cortisol levels may be ameliorated as a consequence of long-term CWI [53].

Vascular and thermoregulatory responses were investigated when immersed in 30°C water during the first, second and third trimesters and 10 weeks post-partum [56–58]. Women statically immersed to the Xiphoid process had similar deep body temperatures when pregnant and post-partum. Although post-partum skin temperatures were higher and heat production lower than during pregnancy, it maybe that the response to static immersion in water 5°C below thermoneutral water temperatures during pregnancy is associated with a greater vasoconstrictor response

BOX 1. Quality and level of evidence [48]

1++	High-quality meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a low risk of bias
1–	Meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a high risk of bias
2++	High-quality systematic reviews of these types of studies, or individual, non-RCTs, case-control studies, cohort studies, cost benefit analysis studies, interrupted time series and correlation studies with a very low risk of confounding, bias or chance, and a high probability that the relationship is causal
2+	Well-conducted non-RCTs, case-control studies, cohort studies, cost benefit analysis studies, interrupted time series, and correlation studies with a low risk of confounding, bias or chance and a moderate probability that the relationship is causal
2–	Non-RCTs, case-control studies, cohort studies, cost benefit analysis studies, interrupted time series and correlation studies with a high risk–or chance–of confounding bias, and a significant risk that the relationship is not causal
3	Non-analytic studies (e.g. case reports, case series)
4	Expert opinion, formal consensus

and elevated metabolism, reducing heat transfer to the skin and maintaining heat storage within the greater body mass of the pregnant women, possibly conserving heat to protect the fetus. Yet when pregnant, increases in oxygen consumption and heat production occur at rest in thermoneutral air temperatures compared to post-partum [57, 58]. Consequently, it may be that these differences are due to anthropometric (increased body mass and body fat) changes occurring during pregnancy rather than adaptative physiological responses to immersion in cold water. During immersion, the greater body mass and fat distribution insulates deep tissues from the effect of cooling allowing the skin to cool without deep tissue cooling. However, there is a gap in thermophysiological research in terms of the impact of immersion at lower water temperatures which would result in vasoconstriction and how thermoregulatory responses to static immersion and exercise compare when gravid and non-gravid.

Most published cases of hypothermia during pregnancy were initiated in hospital settings for therapeutic reasons [59–62], where patients (n = 4) and their fetus (n = 4) were closely monitored, all but one case resulted in delivery of a healthy infant at or close to 40 weeks. In the one case that did not have a positive outcome [59], there may be a number of contributing causes for the spontaneous delivery of the still born 28 h after maternal cardiac arrest, these include the initial out-of-hospital cardiac arrest, prolonged time to return of spontaneous circulation, possible cocaine-induced vasoconstriction, and global myocardial hypokinesis that may have impaired uterine blood flow and contributed towards the still birth. There are also two reports of accidental hypothermia (tympanic temperature 30.3°C [51] and rectal temperature 29.8°C [52]), possibly related to cold air exposure, details have been provided in Appendix 2. In both instances, the hypothermic episode occurred late in the pregnancy (37 and 32 weeks) and a healthy infant was delivered (37 and 40+3 weeks, respectively). Unfortunately, no follow-up information was provided in either case. Despite the limited information, these findings suggest that hypothermia is not directly harmful to the fetus. However, it is known that maternal temperature and foetal heart rate are associated, with maternal hypothermia resulting in foetal bradycardia [63] and maternal rewarming with a return to the normal foetal heart rate range (~ 120 bpm) [51, 52, 63].

CWI can put a significant strain on the respiratory and cardiovascular system and cause fluid shifts within the body, increasing blood pressure significantly on immersion in cold water [33]. This can be particularly risky for hypertensive individuals. However, because the physiological changes associated with pregnancy vary so much across a pregnancy and between pregnancies, a blanket recommendation regarding CWI cannot be provided. Pregnant women with conditions that may be exacerbated by CWI (e.g. hypertension) should avoid CWI as should those with medical conditions that would preclude CWI when not pregnant. A current medical check-up is advised. It is further recommended not to start CWI/swimming during pregnancy.

With the present published data, it appears that a form of CWI (see below) should not be contraindicated for those who have been regularly exposed to cold water prior to pregnancy and remain healthy during it (with regular check-ups). It may also reduce symptoms of pedal oedema. In addition, although there is no clear evidence that prolonged immersion in cold water resulting in hypothermia is harmful to the fetus, it does slow foetal heart rate; therefore, for those who are regularly exposed to cold water, short dips (<10 min) in cool (>15°C) rather than cold water are recommended. The use of a wet suit may also help mitigate the deleterious effects of CWI.

3.3 | Water Quality

Open-water swimming can increase the risk of gastrointestinal illnesses which may cause diarrhoea and/or vomiting as well as respiratory, skin, ear and eye infections. Most symptoms of these illnesses caused by micro-organisms such as norovirus, giardia and cryptosporidium, will generally be mild. However, there is also a risk of more severe infections caused by micro-organisms such as E. coli O157 which may cause severe gastrointestinal illness and leptospirosis (Weil's disease), which can cause liver and kidney problems [64].

TABLE 3 | Summary recommendations.*Note*: The quality and level of evidence are recorded using the guidance given in Box 1, where only evidence from the general population was available, expert opinion was used to apply a ranking applicable to pregnant women. Due to a lack of specific trimester evidence, recommendations apply across all periods of pregnancy unless stated.

General advice	All safety requirements that apply to people who are not pregnant should be followed and if new to CWI then wait until after pregnancy to start this activity. It may be helpful to consider completing the Get Active Questionnaire for Pregnancy (GAQ-P) [78] before continuing general physical activity during pregnancy. Anyone with pregnancy complications or medical conditions is recommended to have a discussion with their medical team. Women are advised to wait until after the 6-week postnatal check and until any wounds and stitches are healed before swimming. Always ensure you have the necessary training, knowledge and skills for outdoor swimming, especially in open water (sea, rivers and lakes). Always ensure you swim with lifeguards around if possible, or at least with others or in a group so you are not alone. Swim close and parallel to the shore and be aware of the risks of tides, waves and currents. Prior to entering the water, identify clear exit points from the water. Consider easy access to medical support for chosen locations. Check the weather forecast before outdoor swimming and avoid swimming while pregnant if the water is too cold or in adverse weather conditions.

Question	Issue	Recommendations
Water temperature	Cold water shock may occur at water temperature below ~25°C [79]	Slow entry into the water. Get over any potential initial cold water shock before putting head under water. Avoid extended breath holds with face immersion (level 2- [33, 80, 81] Refrain from immersing/swimming in cold water with raised blood pressure as this may be exacerbated by cold water [33] Foetal heart rate decreases during CWI–it is unknown if this is harmful (level 3 [63]) *Third trimester-specific*: May help foot or ankle swelling (pedal oedema) (level 2- [49])
Time in water	Hypothermic body can lose heat rapidly in cold water [82] CWI can reduce neuromuscular function and increase gait variability [83, 84] and may be exacerbated in pregnancy when already experiencing reduced mobility when pregnant	Attention is still needed in spring when the air temperature may be quite warm, but the water remains cold. If you feel it is too cold, do not get in/ or get out if you have decided it is too cold for you (level 4) Limit exposure to 10 min maximum but if you feel very cold, unwell or incapacitated in any way before 10 min you must get out of the water immediately (level 2+ [42, 85]) *Post swim*: The body continues to cool on exit (level 2+) so it is important to plan a warm routine, spending time on rewarming, drying and ensuring lips and fingertips feel warm and are functioning. Have a warm rather than hot drink as perception may be altered if very cold or hypothermic and there is a risk of burning (level 4)
Clothing *Wetsuits/skins*	General recommendations Prevention of swimming-induced pulmonary oedema–SIPE [level 4]	Wear a suitable costume, wetsuit or skins. Wear gloves and a hat as heat is lost from the head (level 4) Use a fluorescent safety marker (level 4) Use water shoes for stability walking in and out of the sea (level 4). CWI can increase gait variability which may increase the risk of falls [84] Avoid very tight wetsuits which may cause constriction (level 4) *Post swim*: Loosen wetsuits when not in water (level 4) Dry yourself immediately and put on a warm robe (level 4). Be aware of 'after drop' or continued cooling where your temperature may continue to drop after you get out of the water (level 4) Wear layers of warm clothes which trap air and keep in warmth, even in summer weather as you may feel cold when you get out of the water (level 4)

(Continues)

TABLE 3 | (Continued)

Question	Issue	Recommendations
Water quality	Increased risk of GI, skin eye and ear infections [69]	Select locations where the water quality is monitored, meets standards and there are no local warnings in place against swimming (level 4)
	Bacterial infections such as Weil's disease (leptospirosis) cross the placenta and can affect both mother and baby [64]	Avoid bathing on higher risk days which follow heavy rainfall (1–2 days) and in water with blue-green algal blooms or scums (level 4)
		Avoid bathing close to known inputs, including watercourses, as these can be sources of pollution from agricultural land and urban areas (level 4)
		Do not swim if waters are broken (level 4)
		Contact your midwife, doctor or obstetrician if you know that you came in contact with contaminated water, particularly if you feel there is a risk of Weil's disease (level 4)
		Post swim: Thoroughly shower after the swimming to help remove any possible effluent that may be present on the skin. Dry ears carefully after swimming (level 4)
Swimming strokes and advice		There is limited evidence regarding swimming strokes during pregnancy (level 4)
		Despite advice often seen in leaflets suggesting that breaststroke may exacerbate pelvic girdle pain and/or cause back pain, no research evidence was found to support this (level 4)
		Backstroke is also advised against later in pregnancy as lying on your back causes compression of major blood vessels during the third trimester (level 4)
		Buoyancy varies as pregnancy progresses and therefore different swimming strokes may be more comfortable at different phases throughout pregnancy. It is a personal preference, finding a swimming stroke that feels comfortable is therefore recommended (level 4)
Breastfeeding		*Postnatal*: If breastfeeding or if harvesting colostrum then consider washing before breastfeeding even if in good quality water (level 4)
Health conditions see also Tipton et al. [42]		1. *Preconception*: Assisted conception IVF–take advice from health care providers. Do not start cold water immersion for the first time (level 4)
		2. *Antenatal pregnancy-related conditions to avoid cold water immersion or swimming*:
		Any condition which means you are under obstetric rather than midwife care. Wait until that appointment to ask your Obstetrician about cold water immersion (level 4)
		Low blood pressure is common in the first trimester and may cause fainting (level 4)
		Hyperemesis: It may cause low blood pressure and fainting (level 4)
		Hypertension: Pre-existing, pregnancy-induced hypertension or preeclampsia as cold water immersion may increase blood pressure (level 4)
		Gestational diabetes: Need to be mindful of blood sugar levels which may fall with extended immersion [86]. Therefore, women with gestational diabetes should monitor blood glucose levels before and after immersion and immerse for a short period of time (10 min maximum). Consider having a snack 30 min–1 h before immersion and if low blood glucose is measured, do not immerse, or eat something and wait to immerse until blood glucose has increased to normal levels (level 4)
		Low-lying placenta/placenta previa (level 4)
		Presence of a cervical suture (or other concerns related to preterm labour) (level 4)
		3. *Post-natal*:
		Vaginal/perineal trauma–sutures should take around 7–10 days to dissolve and should be healed before open water swimming (level 4)
		Caesarean section–Advised to wait until after the 6-week check with GP to avoid the risk of wound infection or herniation (level 4)
		Wait for postnatal BP issues to resolve/medication to have been stopped (level 4)

Abbreviations: BP, blood pressure; CWI, cold water immersion; CWS, cold water swimming; GI, gastrointestinal; SIPE, swimming-induced pulmonary oedema.

A study on the effect of gastroenteritis during pregnancy on neonatal outcome concluded that acute gastroenteritis during pregnancy was not associated with any adverse outcome for the newborn except for a slight decrease in the duration of pregnancy (range −0.18 to −0.3 weeks) and an increased risk of preterm birth in mothers with several episodes of gastroenteritis [65].

In many countries, such as the United Kingdom, European Union Member States, the United States, Australia and Canada, recreational and bathing waters are monitored and protected from sources of pollution known to be a risk to bathers' health [66, 67]. In Europe, many coastal and inland waters known to be popular bathing locations are designated as bathing waters [66]. These are monitored through the locally determined bathing season for the faecal indicator organisms intestinal enterococci and *Escherichia coli*, micro-organisms that are used to indicate the degree of faecal contamination of the environment. Each bathing water is classified annually as excellent, good, sufficient or poor, with the upper limit of the good classification relating to an average probability of one case of gastroenteritis in 20 exposures and approximately one case of acute febrile respiratory illness in 50 exposures [68]. Pregnant and nursing mothers may be more sensitive to water quality issues [69], but there is not enough evidence to support a recommendation of a specific classification that pregnant women and nursing mothers can safely swim in.

Bathing water quality may be temporarily reduced due to factors such as heavy rainfall, which can cause overflows of diluted sewage from combined sewer overflows and can wash harmful pathogens from agricultural land and urban areas to rivers and seas. Bathers may be at a higher risk of becoming ill when using bathing water at this time compared to normal conditions. Predictive bathing water quality models are being increasingly used to make water quality forecasts, which are then made available to the public through beach signage, websites and mobile applications to enable people to make informed choices on using the water [70–72].

Health risks at rivers and other open water locations that are not designated as bathing waters may be higher than at designated bathing waters. If these locations are managed, this is likely to be to protect fish and wildlife, not people. They can contain levels of sewage, faeces from livestock and pollution from farming or industry which would not be acceptable in designated bathing waters [64]. There are various types of algae that occur naturally in all-natural waters, but evidence suggests the one that poses the greatest risk to health is blue-green algae (cyanobacteria) in freshwaters. Contact with freshwater blue-green algae in the form of blooms and scum can lead to symptoms such as skin rashes, eye irritation, vomiting, diarrhoea, fever and muscle and joint pain. Toxins produced by freshwater blue-green algal blooms are poisonous to wild and domestic animals and can cause severe illness and death. Blue-green algal blooms and scum are not always toxic; however, it is not possible to tell from their appearance whether they are harmful. Risks can be reduced by avoiding swimming in water with blue-green algal blooms or scums in freshwaters [64, 73].

Weil's disease is a form of a bacterial infection also known as leptospirosis that is carried by animals, most commonly in rats and cattle. Infection of humans usually occurs when open wounds are immersed in relatively stagnant water contaminated with rat or cattle urine. It can be contracted from contact with any fresh or untreated water including ponds, canals, lakes and rivers. Those most at risk of infection are open-water swimmers who expose their whole body to possible infection. The bacteria are unable to survive in salt water, so there is no risk of infection with Weil's disease from swimming in the sea [74]. A systematic review exploring how leptospirosis affects pregnancy found that while most patients survived an infection of leptospirosis in pregnancy, serious adverse foetal outcomes were more common. A clear need was identified to improve early diagnosis and treatment by asking early, treating early and reporting well [75].

To conclude, risks of illness due to poor water quality when swimming in open waters can be reduced by selecting locations where the water quality is monitored, meets standards and there are no local warnings in place against swimming, avoiding bathing on higher risk days which follow heavy rainfall and in water with blue-green algal blooms or scums, and avoiding bathing close to known inputs, including watercourses, as these can be sources of pollution from agricultural land and urban areas.

3.3.1 | Additional Risks and Benefits in Pregnancy

In terms of water safety, the practical advice recommended by Tipton et al. [42] still applies, including going swimming with a group. It may also be worth considering the location of the outdoor swim and choosing locations where medical support can be easily accessed if needed. With regard to swimming strokes used when pregnant, there were no research studies or evidence found. This is despite leaflets and web resources from the grey literature search suggesting that breaststroke should be avoided as the leg action required and hip abduction may worsen pelvic girdle pain [76, 77]. Backstroke has also been advised against later in pregnancy in the grey literature as lying on your back causes compression of major blood vessels during the third trimester [76, 77].

3.4 | Implications and Research Gaps

From the recommendations (Table 3), the level of evidence is mostly based on consensus expert opinion. Therefore, all areas are in need for further research; however, taking into consideration the questions prioritised by women on social media, the specific research gaps have been identified from this work. These are listed below, in no specific order of priority.

3.4.1 Research Priorities and Questions

- The physiological impact of short-term CWI on the baby and women's health. In terms of acute responses such as maternal heart rate and blood pressure, and foetal heart rate, as well as longer term health of mother and baby, including pregnancy and birth outcomes.
- How does short-term CWI affect mother and baby in the different trimesters?

- Is there an optimum dose of cold (temperature and duration)?
- Does CWI impact the success of IVF treatment?
- If experiencing morning sickness should CWI be undertaken? Can CWI change the symptoms of morning sickness (reduce or make them worse)?
- Does pregnancy increase the risk of adverse events, arrhythmias, SIPE, and global transient amnesia?
- Are pregnant women at greater risk from poor quality bathing water?
- Does CWI benefit mental health in pregnancy and prevent postnatal depression?
- Does CWI have the potential to reduce inflammatory responses? Can inflammatory-related conditions in pregnancy be managed by CWI?

4 | Conclusion

In summary, swimming outdoors, as with any activity, comes with both benefits and risks, and it is important to weigh up the balance of the two. That said, as more and more people attest, the perceived benefits to both mental and physical health appear significant, although the studies reporting this are often underpowered and lacking meaningful control (e.g. another activity). Our analysis of the published scientific data has shown that there is a paucity of studies that answer the many questions women have about outdoor swimming during pregnancy and that can enable health professionals to give accurate advice to pregnant women who want to swim outdoors. We have used available literature and expert opinion to make recommendations for CWI related to pregnancy and the post-partum period. The scoping review has identified the research gaps in this field and highlights the need for more research in this area so that we can give women accurate advice on whether it is safe to swim in cold water whilst pregnant.

Disclosure

The views and opinions expressed in this publication are those of the contributors and are not necessarily the views and opinions of the contributors' host organisation. While every effort has been made to ensure the accuracy of the information provided, neither host organisations nor its employees and agents can be held responsible for any inaccuracies or omissions in this publication, whether caused by negligence or otherwise.

Ethics Statement and Patient Consent

Approval was obtained from the University of Plymouth Faculty Research Ethics and Integrity Committee (Project ID FSER: 3894), as part of a wider project. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors have nothing to report.

References

1. UK Chief Medical Officers. "Physical Activity Guidelines," UK Government Department of Health of Social Care, 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832868/uk-chief-medical-officers-physical-activity-guidelines.pdf.

2. M. Hayman, W. J. Brown, A. Brinson, E. Budzynski-Seymour, T. Bruce, and K. R. Evenson, "Public Health Guidelines for Physical Activity During Pregnancy From Around the World: A Scoping Review," *British Journal of Sports Medicine* 57 (2023): 940–947, https://doi.org/10.1136/bjsports-2022-105777.

3. K. R. Evenson, R. Barakat, W. J. Brown, et al., "Guidelines for Physical Activity During Pregnancy: Comparisons From Around the World," *American Journal of Lifestyle Medicine* 8, no. 2 (2014): 102–121, https://doi.org/10.1177/1559827613498204.

4. G. Bennett, N. King, K. Redfern, and B. C. Breese, "Supervised Physical Activity and the Incidence of Gestational Diabetes Mellitus: A Systematic Review and Meta-analysis," *The Journal of Maternal Fetal & Neonatal Medicine* 36, no. 1 (2023): 2155043, https://doi.org/10.1080/14767058.2022.2155043.

5. M. Danielli, C. Gillies, R. C. Thomas, et al., "Effects of Supervised Exercise on the Development of Hypertensive Disorders of Pregnancy: A Systematic Review and Meta-Analysis," *Journal of Clinical Medicine* 11, no. 3 (2022): 793, https://doi.org/10.3390/jcm11030793.

6. L. He, K. L. Soh, F. Huang, et al., "The Impact of Physical Activity Intervention on Perinatal Depression: A Systematic Review and Meta-analysis," *Journal of Affective Disorders* 321 (2023): 304–319, https://doi.org/10.1016/j.jad.2022.10.026.

7. M. G. Backhausen, M. Katballe, H. Hansson, A. Tabor, P. Damm, and H. K. Hegaard, "A Standardised Individual Unsupervised Water Exercise Intervention for Healthy Pregnant Women. A Qualitative Feasibility Study," *Sexual & Reproductive Healthcare* 5, no. 4 (2014): 176–181, https://doi.org/10.1016/j.srhc.2014.09.005.

8. M. Juhl, M. Kogevinas, P. K. Andersen, A. M. Andersen, and J. Olsen, "Is Swimming During Pregnancy a Safe Exercise?," *Epidemiology (Cambridge, Mass.)* 21, no. 2 (2010): 253–258, https://doi.org/10.1097/EDE.0b013e3181cb6267.

9. J. M. Cancela-Carral, B. Blanco, and A. López-Rodríguez, "Therapeutic Aquatic Exercise in Pregnancy: A Systematic Review and Meta-Analysis," *Journal of Clinical Medicine* 11, no. 3 (2022): 501, https://doi.org/10.3390/jcm11030501.

10. M. J. Tipton, N. Collier, H. Massey, J. Corbett, and M. Harper, "Cold Water Immersion: Kill or Cure?," *Experimental Physiology* 102, no. 11 (2017): 1335–1355.

11. P. Huttunen, N. G. Lando, V. A. Meshtsheryakov, and V. A. Lyutov, "Effects of Long-Distance Swimming in Cold Water on Temperature, Blood Pressure and Stress Hormones in Winter Swimmers," *Journal of Thermal Biology* 25, no. 1-2 (2000): 171–174.

12. H. Massey, H. Denton, C. Davies, C. M. Harper, and P. Gorczynski, "Mood and Wellbeing of Novice Open Water Swimmers and Controls During an Introductory Outdoor Swimming Programme. A Feasibility Study," *Lifestyle Medicine* 1, no. 2 (2020): e12, https://doi.org/10.1002/lim2.12.

13. A. Burlingham, H. Denton, H. Massey, N. Vides, and C. M. Harper, "Sea Swimming as a Novel Intervention for Depression and Anxiety—A Feasibility Study Exploring Engagement and Effectiveness," *Mental Health and Physical Activity* 23 (2022): 100472, https://doi.org/10.1016/j.mhpa.2022.100472.

14. T. M. Kolettis and M. T. Kolettis, "Winter Swimming: Healthy or Hazardous? Evidence and Hypotheses," *Medical Hypotheses* 61 (2003): 654–656.

15. B. Knechtle, Z. Waśkiewicz, C. V. Sousa, L. Hill, and P. T. Nikolaidis, "Cold Water Swimming—Benefits and Risks: A Narrative Review,"

International Journal of Environmental Research and Public Health 17 (2020): 8984, https://doi.org/10.3390/ijerph17238984.

16. M. Pound, H. Massey, S. Roseneil, et al., "How Do Women Feel Cold Water Swimming Affects Their Menstrual and Perimenopausal Symptoms," *Post Reproductive Health* 30, no. 1 (2024): 11–27, https://doi.org/10.1177/20533691241227100.

17. H. Massey, P. Gorczynski, C. M. Harper, et al., "Perceived Impact of Outdoor Swimming on Health: Web-Based Survey," *Interactive Journal of Medical Research* 11 (2022): e25589.

18. C. van Tulleken, M. Tipton, H. Massey, and C. M. Harper, "Open Water Swimming as a Treatment for Major Depressive Disorder," *BMJ Case Reports* 2018 (2018): bcr–2018–225007.

19. T. B. Mole and P. Mackeith, "Cold Forced Open-water Swimming: A Natural Intervention to Improve Postoperative Pain and Mobilisation Outcomes?" *BMJ Case Reports* 2018 (2018): bcr–2017-222236.

20. P. Huttunen, L. Kokko, and V. Ylijukuri, "Winter Swimming Improves General Well-being," *International Journal of Circumpolar Health* 63, no. 2 (2004): 140–144, https://doi.org/10.3402/ijch.v63i2.17700.

21. M. de Burgh Daly and J. E. Angell-James, "The 'Diving Response' and Its Possible Clinical Implications," *Internal Medicine* 1 (1979): 12–19.

22. P. Kyriakoulis, M. Kyrios, A. E. Nardi, R. C. Freire, and M. Schier, "The Implications of the Diving Response in Reducing Panic Symptoms," *Frontiers in Psychiatry* 12 (2021): 784884.

23. M. Shattock and M. J. Tipton, "Autonomic Conflict″: A Different Way to Die on Immersion in Cold Water?" *Journal of Physiology* 590, no. 14 (2012): 3219–3230.

24. B. Bonaz, V. Sinniger, and S. Pellissier, "Anti-inflammatory Properties of the Vagus Nerve: Potential Therapeutic Implications of Vagus Nerve Stimulation," *The Journal of Physiology* 594 (2016): 5781–5790.

25. B. E. Sands, "Biomarkers of Inflammation in Inflammatory Bowel Disease," *Gastroenterology* 149, no. 5 (2015): 1275–1285.e2, https://doi.org/10.1053/j.gastro.2015.07.003.

26. Y. Z. Liu, Y. X. Wang, and C. L. Jiang, "Inflammation: The Common Pathway of Stress-Related Diseases," *Frontiers in Human Neuroscience* 11 (2017): 316, https://doi.org/10.3389/fnhum.2017.00316.

27. D. M. Patrick, J. P. Van Beusecum, and A. Kirabo, "The Role of Inflammation in Hypertension: Novel Concepts," *Current Opinion in Physiology* 19 (2021): 92–98, https://doi.org/10.1016/j.cophys.2020.09.016.

28. L. Janský, D. Pospíšilová, S. Honzová, et al., "Immune System of Cold-Exposed and Cold-Adapted Humans," *European Journal of Applied Physiology* 72 (1996): 445–450, https://doi.org/10.1007/BF00242274.

29. A. Lubkowska, B. Dołęgowska, Z. Szyguła, et al., "Winter-Swimming as a Building-Up Body Resistance Factor Inducing Adaptive Changes in the Oxidant/Antioxidant Status," *Scandinavian Journal of Clinical and Laboratory Investigation* 73 (2013): 315–325, https://doi.org/10.3109/00365513.2013.773594.

30. N. Collier, M. Lomax, M. Harper, M. Tipton, and H. Massey, "Habitual Cold-Water Swimming and Upper Respiratory Tract Infection," *Rhinology* 59, no. 5 (2021): 485–487.

31. H. Denton and K. Aranda, "The Wellbeing Benefits of Sea Swimming. Is It Time to Revisit the Sea Cure?" *Qualitative Research in Sport, Exercise and Health* 12, no. 5 (2020): 647–663.

32. Environment Agency, "Health and Wellbeing Benefits of Blue Space: Lived Experience," 2024, https://www.gov.uk/government/publications/health-and-wellbeing-benefits-of-blue-space-lived-experience.

33. M. J. Tipton, "The Initial Responses to Cold-Water Immersion in Man," *Clinical Science (London, England: 1979)* 77, no. 6 (1989): 581–588.

34. M. J. Tipton, D. A. Stubbs, and D. H. Elliott, "Human Initial Responses to Immersion in Cold Water at 3 Temperatures and Following Hyperventilation," *Journal of Applied Physiology* 70, no. 1 (1991): 317–322.

35. M. J. Tipton, I. B. Mekjavic, and C. M. Eglin, "Permanence of the Habituation of the Initial Responses to Cold-Water Immersion," *European Journal of Applied Physiology* 83 (2000): 17–21.

36. F. S. Golden, G. R. Hervey, and M. J. Tipton, "Circum-Rescue Collapse: Collapse, Sometimes Fatal, Associated With Rescue of Immersion Victims," *Journal of the Royal Naval Medical Service.* 77 (1991): 139–149.

37. F. S. Golden and GR Hervey (1981). "The After-drop and Death After Rescue From Immersion in Cold Water." In *"Hypothermia Ashore and Afloat*, ed. Adam JA. (Aberdeen: Aberdeen University Press, 1981): 37–56.

38. C. Eglin, G. Butt, S. Howden, T. Nash, and J. Costello (2015), "Rapid Habituation of the Cold Shock Response," (paper presentation, Proceedings of the 16th International Conference on Environmental Ergonomics, Portsmouth, UK June 29–July 3, 2015).

39. J. Williamson and A. Larner, "Transient Global Amnesia," *British Journal of Hospital Medicine* 76, no. 12 (2015): C186–C188, https://doi.org/10.12968/hmed.2015.76.12.C186.

40. K. H. Lin, Y. T. Chen, J. L. Fuh, et al., "Migraine Is Associated With a Higher Risk of Transient Global Amnesia: A Nationwide Cohort Study," *European Journal of Neurology* 21 (2014): 718–724, https://doi.org/10.1111/ene.12346.

41. S. Spencer, J. Dickinson & L. O. Forbes, and R. Factors, "Prognosis and Prevention of Swimming-Induced Pulmonary Oedema: A Systematic Review," *Sports Medicine–Open* 4 (2018): 43, https://doi.org/10.1186/s40798-018-0158-8.

42. M. Tipton, H. Massey, A. Mayhew, and P. Morgan, "Cold Water Therapies: Minimising Risks," *British Journal of Sports Medicine* 56, no. 23 (2022): 1332–1334.

43. Z. Munn, M. D. J. Peters, C. Stern, et al., "Systematic Review or Scoping Review? Guidance for Authors When Choosing Between a Systematic or Scoping Review Approach," *BMC Medical Research Methodology [Electronic Resource]* 18 (2018): 143, https://doi.org/10.1186/s12874-018-0611-x.

44. E. Aromataris and Z. Munn, *JBI Manual for Evidence Synthesis*, (Adelaide, JBI, 2020), https://synthesismanual.jbi.global.

45. A. C. Tricco, E. Lillie, W. Zarin, K. K. O'Brien, H. Colquhoun, D. Levac, et al., "PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation," *Annals of Internal Medicine* 169 (2018): 467–473.

46. M. Ouzzani, H. Hammady, Z. Fedorowicz, and A. Elmagarmid, "Rayyan — A Web and Mobile App for Systematic Reviews," *Systematic Reviews* 5 (2016): 210, https://doi.org/10.1186/s13643-016-0384-4.

47. M. J. Page, J. E. McKenzie, P. M. Bossuyt, I. Boutron, T. C. Hoffmann, C. D. Mulrow, et al., "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews," *BMJ* 372 (2021): n71, http://www.prisma-statement.org/, https://doi.org/10.1136/bmj.n71.

48. Royal College of Obstetricians and Gynaecologists. *Developing a Green-Top Guideline*. London: RCOG; 2020.

49. J. M. Irion and G. L. Irion, "Water Immersion to Reduce Peripheral Edema in Pregnancy," *Journal of Women's Health Physical Therapy* 35, no. 2 (2011): 46–49.

50. H. Jafarimanesh, K. Vakilian, and S. Mobasseri, "Thermo-Therapy and Cryotherapy to Decrease the Symptoms of Restless Leg Syndrome During the Pregnancy: A Randomized Clinical Trial," *Complementary Therapies in Medicine* 50 (2020): 102409, https://doi.org/10.1016/j.ctim.2020.102409.

51. S. B. Usman and V. Menon, "Avoiding Caesarean Section in Maternal Hypothermia Associated With Marked Fetal Distress," *Emergency Medicine Journal* 25, no. 3 (2008): 177–177.

52. M. Rosenthal, V. Poliquin, and A. Yu, "Maternal Hypothermia From Environmental Exposure in the Third Trimester," *International Journal of Circumpolar Health* 79, no. 1 (2020): 1710894.

53. A. B. Abou-Samra, M. Pugeat, H. Dechaud, et al., "Increased Plasma Concentration of N-terminal β-lipotrophin and Unbound Cortisol During Pregnancy," *Clinical Endocrinology* 20, no. 2 (1984): 221–228.

54. M. Kammerer, D. Adams, B. V. Castelberg, and V. Glover, "Pregnant Women Become Insensitive to Cold Stress," *BMC Pregnancy and Childbirth* 2, no. 1 (2002): 1–5.

55. L. Gundle and A. Atkinson, "Pregnancy, Cold Water Swimming and Cortisol: The Effect of Cold Water Swimming on Obstetric Outcomes," *Medical Hypotheses* 144 (2020): 109977.

56. F. K. Lotgering, W. E. Spinnewijn, and H. C. Wallenburg, "Swimming and Diving by Pregnant Women," *Fetal and Maternal Medicine Review* 8, no. 3 (1996): 165–171, https://doi.org/10.1017/S0965539500001595.

57. R. G. McMurray, V. L. Katz, M. G. Berry, and R. C. Cefalo, "The Effect of Pregnancy on Metabolic Responses During Rest, Immersion and Aerobic Exercise in the Water," *American Journal of Obstetrics and Gynecology* 158, no. 3 (1998): 481–486.

58. R. G. McMurray and V. L. Katz, "Thermoregulation in Pregnancy," *Sports Medicine (Auckland, N.Z.)* 10 (1990): 146–158, https://doi.org/10.2165/00007256-199010030-00002.

59. K. Stånge, M. Halldin, and H. M. Schaer, "Hypothermia in Pregnancy," *Obstetric Anesthesia Digest* 3, no. 3 (1983): 85.

60. J. C. Rittenberger, E. Kelly, D. Jang, K. Greer, and A. Heffner, "Successful Outcome Utilizing Hypothermia After Cardiac Arrest in Pregnancy: A Case Report," *Critical Care Medicine* 36, no. 4 (2008): 1354–1356.

61. E. F. Wible, J. S. Kass, and G. A. Lopez, "A Report of Fetal Demise During Therapeutic Hypothermia After Cardiac Arrest," *Neurocritical Care* 13, no. 2 (2010): 239–242.

62. A. Chauhan, H. Musunuru, M. Donnino, M. T. McCurdy, V. Chauhan, and M. Walsh, "The Use of Therapeutic Hypothermia After Cardiac Arrest in a Pregnant Patient," *Annals of Emergency Medicine* 60, no. 6 (2012): 786–789.

63. M. E. Jadhon and E. K. Main, "Fetal Bradycardia Associated With Maternal Hypothermia," *Obstetrics and Gynecology* 72, no. 3 pt. 2 (1988): 496–497.

64. UK Health Security Agency, "Guidance Swim healthy," 2019, https://www.gov.uk/government/publications/swim-healthy-leaflet/swim-healthy.

65. J. F. Ludvigsson, "Effect of Gastroenteritis During Pregnancy on Neonatal Outcome," *European Journal of Clinical Microbiology & Infectious Diseases* 20 (2001): 843–849.

66. European Commission, "Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 Concerning the Management of Bathing Water Quality and Repealing Directive 76/160/EEC," *Official Journal of the European Union* 64 (2006): 37–51.

67. Environmental Protection Agency, *Recreational Water Quality Criteria; U S Environmental Protection Agency* (Washington, DC, Environmental Protection Agency, 2012).

68. D. Kay, J. Bartram, A. Prüss, et al., "Derivation of Numerical Values for the World Health Organization Guidelines for Recreational Waters," *Water Research* 38, no. 5 (2004): 1296–1304.

69. World Health Organisation (2021). *Guidelines on Recreational Water Quality. Volume 1: Coastal and Fresh Waters* (Geneva: World Health Organization, 2021), https://www.who.int/publications/i/item/9789240031302.

70. Scottish Environment Protection Agency "Bathing Waters: Predictions," Scottish Environment Protection Agency, 2024, https://www2.sepa.org.uk/bathingwaters/Predictions.aspx.

71. Environment Agency, "Bathing Water Quality," 2024, https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html.

72. Safe swim, Safeswim, 2024, https://www.safeswim.org.nz.

73. Public Health Scotland, "Public Health Guidance for Cyanobacteria," Public Health Scotland, 2024, https://publichealthscotland.scot/media/27713/public-health-guidance-for-cyanobacteria-june2024.pdf.

74. Royal Society for the Prevention of Accidents, "Weil's Disease (Leptospirosis)," 2008, https://www.rospa.com/leisure-water-safety/water/advice/weils-disease.

75. S. Selvarajah, S. Ran, N. W. Roberts, and M. Nair (2021), "Leptospirosis in Pregnancy: A Systematic Review," *PLoS Neglected Tropical Diseases* 15, no. 9: e0009747, https://doi.org/10.1371/journal.pntd.0009747.

76. Active Pregnancy Foundation, "Find Your Active: Your Guide to Swimming During Pregnancy and Beyond," 2021, https://www.activepregnancyfoundation.org/findyouractive-swimming.

77. Straight Line Swimming, "All You Need To Know About Swimming When Pregnant," 2022, https://straightlineswimming.com/knowledge-base/all-you-need-to-know-about-swimming-when-pregnant/.

78. Active Pregnancy Foundation, "Get Active Questionnaire for Pregnancy (GAQ-P)," 2023, https://www.Activepregnancyfoundation.Org/Getactivequestionnaireforpregnancy.

79. W. R. Keatinge and J. A. Nadel, "Immediate Respiratory Response to Sudden Cooling of the Skin," *Journal of Applied Physiology* 20, no. 1 (1965): 65–69.

80. J. S. Hayward and C. D. French, "Hyperventilation Response to Cold Water Immersion: Reduction by Staged Entry," *Aviation Space and Environmental Medicine* 60 (1989): 1163–1165.

81. M. J. Tipton, "Sudden Cardiac Death During Open Water Swimming," *British Journal of Sports Medicine* 48, no. 15 (2013): 1134–1135.

82. F. Golden and M. J. Tipton, *Essentials of Sea Survival, Human Kinetics* (Champaign II: Human Kinetics, 2002).

83. M. J. Vincent and M. J. Tipton, "The Effects of Cold Immersion and Hand Protection on Grip Strength," *Aviation Space and Environmental Medicine* 59, no. 8 (1988): 738–741.

84. E. M. Lavoie, C. E. Wheelock, J. Schwob, et al., "Gait after Cold Water Immersion and Subsequent High-intensity Exercise: 2749," *Medicine & Science in Sports & Exercise* 55, no. 9S (2023): 931, https://doi.org/10.1249/01.mss.0000988508.24301.23.

85. J. W. Castellani and M. J. Tipton, "Cold Stress Effects on Exposure Tolerance and Exercise Performance," *Comprehensive Physiology* 6, no. 1 (2015): 443–469.

86. M. Tipton, C. Franks, G. Meneilly, and I. Mekjevic, "Substrate Utilisation During Exercise and Shivering," *European Journal of Applied Physiology* 76 (1997): 103–108, https://doi.org/10.1007/s004210050220.

87. S. Barnes and B. Pearson, "Outdoor Swimming Society Swimming for Two>" 2019, https://www.outdoorswimmingsociety.com/swimming-for-two/.

88. Tommys.org.uk, "Swimming in pregnancy," Tommy's The Pregnancy and Baby Charity, 2024, https://www.tommys.org/pregnancy-information/im-pregnant/exercise-in-pregnancy/swimming-pregnancy.

Supporting Information

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

APPENDIX 1: Summary Tables of Included Studies and Reports

Title of publication and date	Author(s)	Country of origin	Aims/objectives	Type of study	Sample characteristics and size	Main findings
Water Immersion to Reduce Peripheral Edema in Pregnancy *Journal of Women's Health Physical Therapy*, Volume 35, issue 2, pp. 46–49, 1 January 2011	Irion, Jean M.; Irion, Glenn L. [49]	USA	To examine the effectiveness of water immersion in reducing peripheral oedema in pregnant woman	Randomised controlled trial	Thirty-two pregnant women at least in the 34th week of pregnancy. Sixteen women randomised to standing in water (29–33°C) immersion up to the Xiphoid process for 20 min. 16 women sat in chairs with both feet elevated for 20 min	Changes in right foot volume were quantified by foot volumetry immediately pre and post-intervention Right foot volume decreased by 38 ± 18 mL (mean ± SD) in the water group and increased by 2 ± 14 mL for the land group $p < 0.001$ between groups Water immersion for 20 min is an effective means of reducing pedal oedema during pregnancy
Swimming and diving by pregnant women *Fetal and Maternal Medicine Review*, Volume 8, issue 3, pp. 165–171, 1 January 1996	Lotgering, F. K.; Spinnewijn, W. E. M.; Wallenburg, H. C. S [56]	The Netherlands	To explore what is known and not known about immersion, swimming and diving in pregnancy	Review	Various	Relatively little is known about the physiological adaptations of pregnant women to exercise in water, especially compared to nonpregnant controls. There is evidence that pregnant women are equally as capable as non-pregnant women of performing rapidly progressive maximal swimming in water close to thermoneutrality Below thermal neutrality, pregnant women need to increase their metabolic rates in order to maintain body temperature Further study is needed to provide insight into such questions as how the pregnant woman and her fetus adapt physiologically to a cold water environment, to strenuous endurance swimming and to breath-holding and scuba diving
Pregnancy, cold water swimming and cortisol: The effect of cold water swimming on obstetric outcomes *Medical Hypotheses* Vol 144. 2020, 109977, https://doi.org/10.1016/j.mehy.2020.109977	Gundle, L and Atkinson A [55]	United Kingdom	Reviewed how winter swimming and stress may interact, and what impact this may have on obstetric outcomes for female outdoor swimmers	Medical hypothesis Review of literature	Various	Overall, whilst winter swimming was shown to increase stress hormones, it is thought that this short-term increase leads to a longer term tolerance of both pain and stress, through less marked increases in subsequent exposures Hypothesis that regular cold water exposure may lead to a dampening of the stress response, namely through a reduction in circulating levels of maternal corticotropin-releasing hormone, which would otherwise be higher in women who do not regularly cold water swim. Authors conclude that pregnancy outcomes may indeed be ameliorated through stress attenuation, as a consequence of long-term cold water swimming

Title of publication and date	Author(s)	Country of origin	Aims/objectives	Type of study	Sample characteristics and size	Main findings
Thermo-therapy and cryotherapy to decrease the symptoms of restless leg syndrome during the pregnancy: A randomized clinical trial *Complementary Therapies in Medicine*, https://doi.org/10.1016/j.ctim.2020.102409.	Jafarimanesh H, Vakilian K and Mobasseri S [50]	Iran	To compare the effect of leg immersion in cold and warm water on the restless leg syndrome among pregnant women. It was hypothesised that the legs immersion in cold and warm water will relieve the symptoms of restless leg syndrome among pregnant women	Randomised controlled trial before and after	Eighty pregnant women with restless leg syndrome Group 1 warm water for 10 min every night for 2 weeks Group 2 cold water 10 min every night for 2 weeks Severity of restless leg syndrome was measured before and after. Descriptive, and analytical statistics were performed	The intervention with both warm and cold water reduced the restless leg syndrome symptoms among pregnant women The article recommends the cold water for symptom reduction
The effect of pregnancy on metabolic responses during rest, immersion and aerobic exercise in the water. *American Journal of Obstetrics and Gynecology*, Volume 158, issue 3, 1998, pp. 481–486	McMurray, R. G., Katz, V. L., Berry, M. G., Cefalo, R. C., [57]	USA	Examine metabolic responses during and post-partum	Observational single cohort trial	Twelve females were immersed for 20 min in 30°C water statically and then exercised for 20 min at 15, 25 and 35 weeks of pregnancy and then again between 8 and 10 weeks post-partum Resting, immersed and exercising oxygen consumption was measured	Pregnancy alters metabolic responses to cold water immersion when exercising in water It was not clear if this was related to the increase in body mass or the pregnancy itself
Thermoregulation in pregnancy. implications for exercise. *Sports Medicine*, 1990, Volume 10, issue 3, pp. 146–58. https://doi.org/10.2165/00007256-199010030-00002, PMID: 2237032	McMurray R G and Katz V L [58].	USA	To review the literature	Review	Various	Research has indicated that exercise can result in core temperatures above the recommended level Studies have indicated that maternal hyperthermia can be teratogenic, causing primarily CNS abnormalities Other data indicate that if hyperthermia is a potential consideration for the exercising mother, then exercise in the water may be better as it provides for greater heat loss Data concerning exposure to cold, although sketchy, suggest that unless the hypothermia is detrimental to maternal survival, there is minimal risk to the fetus.

Reports included	Report available from
Active Pregnancy Foundation [76]	Find Your Active Swimming Leaflet, https://www.activepregnancyfoundation.org/findyouractive-swimming
Environment Agency UK [71]	Bathing water quality, https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html
Outdoor Swimming Society [87]	Swimming for Two, https://www.outdoorswimmingsociety.com/swimming-for-two/
SafeSwim.nz [72]	Safe Swim, https://www.safeswim.org.nz
Straight Line Swimming [77]	All You Need to Know About Swimming When Pregnant: A Straight Line Swimming Guide, https://straightlineswimming.com/knowledge-base/all-you-need-to-know-about-swimming-when-pregnant/
Tommy's [88]	Swimming in pregnancy, https://www.tommys.org/pregnancy-information/im-pregnant/exercise-in-pregnancy/swimming-pregnancy
UK Health Security Agency [64]	Swim healthy, https://www.gov.uk/government/publications/swim-healthy-leaflet/swim-healthy/
World Health Organisation [69]	Guidelines on recreational water quality. Volume 1 Coastal and fresh waters, https://www.who.int/publications/i/item/9789240031302

APPENDIX 2: Accidental hypothermia case reports

Publication details	Publication type/research design	Participant Characteristics	Cooling	Outcome	Main findings
Usman et al. [51]	Case report	Twenty-five years female 37 weeks pregnant	Accidental/environmental Patient was found unconscious on the floor at home with suspected drug misuse Not clear how long the patient had been unconscious and exposed	Tympanic temperature recorded at 30.3°C at A&E Rewarmed with convective air blanket, warmed IV fluids and warmed vaporised air Within 4 h of arrival in the antenatal suite, she spontaneously delivered	A healthy male infant was delivered. Patient discharged herself 6 h after delivery
Rosenthal Poliquin, Yu [52]	Case report	Female 32 weeks pregnant	Accidental/environmental Hypothermia followed exposure to 'several hours' of air temperatures between −29 and −35°C with wind chill	Rectal temperature 29.8°C on arrival with a reduced level of consciousness, frost-bitten fingers and hypoglycaemia Rewarmed with IV fluids and forced warm air blankets. Within several hours temperature maternal temperature was 36.7°C	Healthy child delivered at 40 + 3 weeks No follow-up information was available.