NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

QUALITY IN SPORT

eISSN 2450-3118 · Open Access · Peer-reviewed

Vol. 55 (2026) · Article 71170 · Published 17 May 2026

apcz.umk.pl/QS · Nicolaus Copernicus University in Toruń

Cite as: Kwiatkowska A, Przepióra A, Żmigrodzka A, Kamińska A, Orłowska M, Czernic-Goławska K, Kozłowska J, Sanocka M, Falana J, Wielogórska A, Trojnar K. Cold Water Immersion during Pregnancy: Risk Analysis, Benefits, and Guidelines. A Review of Current Evidence. Quality in Sport. 2026;55:71170. https://doi.org/10.12775/QS.2026.55.71170

ARTICLE TIMELINE

Received: 22.04.2026 **Revised:** 13.05.2026

Accepted: 13.05.2026 **Published:** 17.05.2026

INDEXING & EVALUATION

MEiN points: 20 **Unique ID:** 201398

Disciplines: Medical Sciences; Health Sciences

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines: Medical Sciences; Health Sciences.

Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Nauki medyczne; Nauki o zdrowiu.

REVIEW

Cold Water Immersion during Pregnancy

Risk Analysis, Benefits, and Guidelines — A Review of Current Evidence

a narrative review

HIGHLIGHTS

- Cold Water Immersion (CWI) during pregnancy is permissible only as a continuation of long-term pre-conception practice — initiating it in pregnancy is categorically discouraged.
- In thermally adapted women without obstetric or cardiac contraindications, CWI promotes beneficial hematological changes, mood stabilization, and insulin sensitivity through brown adipose tissue (BAT) activation.
- Identified risks include third-trimester aortocaval compression syndrome (ACCS) and "autonomic conflict" (cold shock + diving reflex) that may induce arrhythmias and transient fetal hypoxia.
- Mandatory safety protocols: a 30–50% reduction of pre-pregnancy immersion time, no head submersion, post-immersion avoidance of hot showers, hydration with warm isotonic fluids, and continuous obstetric supervision.

- Pre-seasonal qualification screening (ECG/echocardiography, HGB/HCT/ferritin, TSH/fT4, electrolytes) and seasonal Doppler ultrasound of uterine and umbilical arteries are recommended.

GRAPHICAL ABSTRACT

Graphical Abstract. *Cold Water Immersion (CWI) during pregnancy in a thermally adapted woman triggers a physiological cascade affecting three interconnected target systems: utero-placental circulation (preserved when ACCS and uterine vasoconstriction are avoided), brown adipose tissue (insulin-independent GLUT4-mediated glucose uptake and FGF21 release), and cardiovascular/autonomic balance (sympathetic–parasympathetic homeostasis). Safe practice requires pre-conception adaptation, a 30–50% reduction in immersion time, no head submersion, and continuous obstetric supervision.*

AUTHORS & AFFILIATIONS

Anna Kwiatkowska **[AK]**
ORCID: https://orcid.org/0009-0008-1334-6517
E-mail: annazycka23@gmail.com
District Medical Center in Grójec, ul. Ks. Piotra Skargi 10, 05-600 Grójec, Poland

Agnieszka Przepióra **[AP]**
ORCID: https://orcid.org/0009-0002-6368-537X
E-mail: przepioraagnieszka7@gmail.com
Independent Public Complex of Health Care Facilities in Kozienice, Aleja Gen. Władysława Sikorskiego 10, 26-900 Kozienice, Poland

Anna Żmigrodzka **[AŻ]**
ORCID: https://orcid.org/0009-0005-0179-8960
E-mail: zmigrodzka.ania@gmail.com
Independent Public Health Care Facility in Garwolin, Lubelska 50, 08-400 Garwolin, Poland

Agnieszka Kamińska **[AKa]**
ORCID: https://orcid.org/0009-0002-3391-504X
E-mail: agakami24@gmail.com
Independent Public Health Care Facility in Garwolin, Lubelska 50, 08-400 Garwolin, Poland

Maria Orłowska **[MO]**
ORCID: https://orcid.org/0009-0004-1009-2815
E-mail: m.orlowska.koszarek@gmail.com
LUX MED Sp. z o.o., Szturmowa 2, 02-678 Warsaw, Poland

Klaudia Czernic-Goławska **[KCG]**
ORCID: https://orcid.org/0009-0009-7485-7246
E-mail: klaudiagolawska21@gmail.com
Independent Public Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland

Jana Kozłowska [JK]
ORCID: https://orcid.org/0009-0008-5278-2864
E-mail: jana.kozlowska1@gmail.com
Independent Public Specialist Western Hospital of St. John Paul II, Daleka 11, 05-825 Grodzisk Mazowiecki, Poland

Maria Sanocka [MS]
ORCID: https://orcid.org/0009-0000-9428-2464
E-mail: sanocka.maria@gmail.com
County Hospital GAJDA-MED Sp. z o.o., Teofila Kwiatkowskiego 19, 06-102 Pułtusk, Poland

Joanna Falana [JF]
ORCID: https://orcid.org/0009-0001-0110-9505
E-mail: joanna.falana99@gmail.com
Independent Public Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland

Aleksandra Wielogórska [AW]
ORCID: https://orcid.org/0009-0006-6582-6569
E-mail: ola.wielogorska@gmail.com
District Medical Center in Grójec, ul. Ks. Piotra Skargi 10, 05-600 Grójec, Poland

Karolina Trojnar [KT]
ORCID: https://orcid.org/0009-0003-5633-603X
E-mail: karolina.trojnar0@gmail.com
Independent Public Health Care Facility in Garwolin, Lubelska 50, 08-400 Garwolin, Poland

CORRESPONDING AUTHOR **Anna Kwiatkowska –** annazycka23@gmail.com

ABSTRACT

AIM: To review scientific reports and clinical guidelines regarding the impact of Cold Water Immersion (CWI) on the maternal body and fetal well-being, focusing on vascular, metabolic, and neuroendocrine risk stratification.

MATERIAL AND METHODS: A systematic literature review across PubMed/MEDLINE, Web of Science, Scopus, and Wiley Online Library was conducted (English and Polish, publications up to March 2026), focusing on CWI in pregnancy, thermal stress physiology, and brown adipose tissue (BAT) adaptation. International expert consensuses were also analysed.

RESULTS: Direct evidence on CWI in pregnancy is limited, necessitating clinical caution. Safety depends critically on pre-conception cold adaptation. In adapted women, CWI promotes beneficial hematological changes and improves insulin sensitivity via BAT activation. Identified risks include third-trimester aortocaval compression syndrome (ACCS) and "autonomic conflict" inducing arrhythmias. Current consensus advises against initiating CWI during pregnancy in novices due to catecholamine release and fetal hypoxia risks.

CONCLUSIONS: CWI in pregnancy is permissible only as a continuation of long-term pre-conception practice, without obstetric or cardiac contraindications. It requires medical supervision, a 30–50% immersion-time reduction, and strict safety protocols (no head submersion). Correct implementation in adapted women supports maternal vascular resilience and programs neonatal metabolism via BAT stimulation, improving glycemic stability and thermogenesis after birth.

KEYWORDS cold water immersion in pregnancy; CWI; brown adipose tissue (BAT); gestational insulin resistance; fetal well-being; thermal adaptation; stress hormones

PLAIN LANGUAGE SUMMARY

Winter swimming and short dips in very cold water ("cold water immersion", CWI) have become a popular form of physical activity. Whether it is safe during pregnancy is a frequent and difficult question for both patients and clinicians. This review summarises current evidence and international expert recommendations. The key message is that CWI should not be started in pregnancy; women who have been winter-swimming regularly for a long time before conception may continue, provided they have no obstetric or heart-related contraindications and follow strict safety rules — chest-deep immersion only, no head submersion, shorter sessions, avoidance of hot showers afterwards, warm isotonic drinks, and supervision by an obstetrician. Done correctly in adapted women, CWI can support mood, reduce leg swelling, and improve glucose control through activation of brown adipose tissue. Done wrongly or in unadapted women, it can trigger a strong stress response that may reduce blood flow to the uterus and harm the baby. Pregnancy is therefore a time for caution and continuation — not for experimentation.

1. INTRODUCTION

Modern prenatal medicine, based on World Health Organization (WHO) guidelines, unequivocally promotes regular physical activity as a cornerstone of a healthy pregnancy and postpartum period. In the absence of medical contraindications, a minimum of 150 minutes of moderate-intensity exercise per week is recommended, combining aerobic training (such as walking, swimming, or cross-country skiing) with strengthening and stretching exercises. A key WHO paradigm is the principle of continuity: women who exhibited high fitness levels or engaged in high-intensity training prior to conception can safely continue their activities under specialist supervision [1].

The principle of prior adaptation serves as the intersection between general recommendations and the practice of winter swimming, or Cold Water Immersion (CWI). Although ice-water baths do not appear on the standard list of sports recommended by national institutions, their permissibility in the light of international research is based on the mechanism of maintaining previously established physical capacity and the body's resistance to extreme stimuli.

An analysis of global perinatal care standards reveals significant differences in the approach to cold exposure, arising from cultural conditions and the advancement of research into extreme physiology. Currently, the most important reference document in this field is the 2025 British expert consensus "Cold Water Swimming and Pregnancy: A Scoping Review and Consensus Recommendations". This publication introduces an official classification of recommendations, the primary one being a prohibition on initiating cold water bathing during pregnancy. According to experts, the safe continuation of CWI is possible only for women whose cold acclimatization process occurred before conception [2].

In Scandinavian and Baltic countries, the approach of public health authorities is more deeply rooted in the tradition of health-promoting body hardening (conditioning):

- In Denmark, the National Board of Health (Sundhedsstyrelsen) emphasises the benefits of hydrostatic joint decompression in water. While official recommendations do not forbid winter swimming (vinterbadning), winter-swimming associations promote rigorous safety codes based on hypothermia prevention and meticulous post-immersion re-warming [3].
- In Lithuania, the Ministry of Health (Sveikatos apsaugos ministerija) views winter bathing (maudynės eketėje) as an essential element of systemic conditioning, with strong emphasis on the principle of gradualism. Pregnancy is not considered a contraindication to routine cold exposure, provided it does not involve the introduction of sudden stimuli previously unknown to the body [4].

International recommendations precisely define safety boundaries. Disciplines carrying a risk of falls, mechanical trauma, or restricted blood oxygen saturation — including diving — are strictly discouraged. This caveat is crucial in the context of CWI: the activity should be limited to controlled body immersion, excluding breath-holding or diving under an ice sheet [4]. In contrast to Western and Scandinavian standards, Polish medical literature is characterised by a high degree of caution. Official positions of the Polish Society of Gynecologists and Obstetricians (PTGiP) omit the specificities of winter swimming, which in domestic clinical practice results in a dominance of the conservative approach.

2. MATERIAL AND METHODS

To obtain reliable data regarding the impact of voluntary extreme cold exposure (Cold Water Immersion — CWI) on the pregnant body, a systematic literature review was conducted across the following medical databases: PubMed/MEDLINE, Web of Science, Scopus, and the Wiley Online Library. The search strategy included English and Polish language publications issued up to March 2026.

2.1. Search Strategy and Record Selection

The primary search process was based on a combination of Medical Subject Headings (MeSH) and keywords: "cold water immersion pregnancy", "winter swimming pregnant", "ice swimming pregnancy", and "morsowanie w ciąży".

An initial query in the PubMed database for the terms "immersion" and "pregnancy" generated 1,428 records. After applying filters narrowing the results to water temperatures below 15°C and recreational/sporting activities, this number was drastically reduced. The selection process and reasons for publication exclusion are summarised below.

- **Water immersion during labour and pain relief (842 publications — excluded):** concern water at temperatures close to body temperature (36–37.5°C); the physiological mechanisms (muscle relaxation, anxiety reduction) are antithetical to the thermal shock and vasoconstriction studied here.
- **Water birth (315 publications — excluded):** neonatological aspects of fetal transition to an aquatic environment and microbiological safety of the second/third stages of labour in warm water — no exposure to thermal stress.
- **Recreational swimming and aqua-aerobics in pools (182 publications — excluded):** standard activity in water at 26–29°C, not triggering the hormonal cascade associated with brown adipose tissue (BAT) activation or the rapid HPA-axis response characteristic of CWI [5].
- **Therapeutic baths and balneotherapy (64 publications — excluded):** hydrotherapy for rheumatological or neurological conditions in pregnant women, using thermal or moderate-temperature waters.

2.2. Final Analysis of Subject Literature

Following rigorous elimination, only 6 publications directly addressing the topic of cold water swimming or winter bathing by pregnant women were identified globally [6]. The evidentiary structure of these works comprises 2 case reports/case studies, 3 survey-based studies (based on subjective experiences), and 1 key expert consensus and scoping review [6].

2.3. Research Barriers and Ethical Limitations

The small number of reliable randomised controlled trials (RCTs) stems directly from ethical barriers. Obtaining bioethics approval to subject a group of pregnant women to extreme thermal stress carries high risks due to: (i) thermal shock — the potential of sudden uterine vasoconstriction [7]; and (ii) "autonomic conflict" — the risk of cardiac arrhythmias dangerous to both fetus and mother, resulting from simultaneous activation of the sympathetic system (cutaneous cold response) and the parasympathetic system (diving reflex upon facial contact with water) [7]. For these reasons, this review is based on a synthesis of available observational data and the extrapolation of known mechanisms of extreme physiology onto the unique hemodynamic profile of the pregnant woman.

2.4. Research Perspectives and Ongoing Multicentre Projects

Despite the deficit of historical clinical trials, projects are currently being implemented in the Scandinavian region aimed at providing robust Evidence-Based Medicine (EBM) data. The most anticipated is the multicentre cohort project "The Ice-Baby Project" (Denmark/Norway, 2024–2026), part of broader analyses of the impact of extreme environmental stimuli on epigenetics. It involves over 200 pregnant women from Denmark and Norway who declare regular winter swimming (at least twice a week). Preliminary reports [8] indicate that researchers focus on real-time monitoring of fetal well-being using wireless CTG and Doppler ultrasonography before and 15 minutes after exiting cold water [9]; analysis of oxidative stress biomarkers including cold-shock proteins (e.g. RBM3) in maternal serum and their correlation with inflammatory markers [10]; and neonatal metabolic programming — birth weight and early BAT activity in newborns of winter-swimming mothers vs. a thermally inactive control group [8, 10].

In parallel, Finnish researchers (Duodecim/University of Oulu) are analysing retrospective data from national medical registries, comparing obstetric outcomes (gestational diabetes, pre-eclampsia, course of labour) in women identifying as "winter swimmers" (avantouimarit). This group may include several thousand respondents, which would allow reliable epidemiological conclusions to be drawn [9].

Contemporary medical literature is at a turning point. While existing recommendations are primarily based on expert consensus (Grade 4) and physiological analysis of thermal shock, the results of large Scandinavian cohort studies expected in 2026–2027 may become the foundation for developing the first unified guidelines for gynaecological societies worldwide. Until full results of projects such as "Ice-Baby" are published, maximum

caution must be maintained in clinical practice, basing patient qualification on an individual assessment of pre-conceptional adaptation and ongoing monitoring of utero-placental flow parameters.

3. MEDICAL QUALIFICATION AND CONTRAINDICATIONS

Contemporary prenatal medicine defines pregnancy as a state requiring rigorous oversight of vascular homeostasis. Cold Water Immersion (CWI) induces the so-called Cold Shock Response, which, in unadapted individuals, triggers a massive release of catecholamines and cortisol. In pregnant women, this cascade may lead to sudden uterine artery constriction and transient fetal hypoxia [2, 9, 15, 16].

3.1. Absolute Obstetric Contraindications

Clinical qualification must be based on the exclusion of placental and vascular pathologies. CWI is strictly prohibited in cases of:

- **Pregnancy-Induced Hypertension (PIH) and Preeclampsia** — risk of hypertensive crisis and placental abruption [14, 15].
- **Intrauterine Growth Restriction (IUGR) or abnormal Doppler flow studies** — maternal circulatory centralisation may exacerbate fetal oxygen deficits [8, 16].
- **Cervical insufficiency (cerclage, pessary)** — risk of mechanical tissue stress during the sudden "gasp reflex" [2, 11].
- **Placenta praevia and amniotic-fluid volume disorders** (oligohydramnios/polyhydramnios) [2, 16].

3.2. Cardiological and Internal-Medicine Contraindications

Extreme cold drastically increases afterload, posing a risk of decompensation in patients with a significant cardiological history [12, 15, 20].

Table 1. Clinical Classification of Conditions Excluding CWI in Pregnant Women (own elaboration)

System / Area	Medical Condition	Hazard Mechanism
Circulatory system	Uncontrolled hypertension	Sudden BP spike; risk of stroke and aneurysm rupture [15]
Circulatory system	Valvular defects (e.g. aortic stenosis)	Inability to overcome resistance; risk of pulmonary oedema [20]
Respiratory system	Cold-induced asthma	Reflex bronchospasm [17]
Nervous system	Epilepsy	Lowering of the seizure threshold; risk of drowning [17]
Pharmacotherapy	Beta-blockers	Blockade of the heart-rate response; risk of circulatory collapse [9, 17]

4. MEDICAL INSTRUCTIONS FOR SAFE WINTER SWIMMING IN PREGNANCY

For women with a high degree of thermal adaptation established prior to conception (a minimum of one year of regular experience) and a stable hormonal response to cold, CWI may be continued provided a rigorous safety protocol is followed. Adherence to the following rules minimises the risk of "autonomic conflict" and post-exertional complications [2, 9, 15].

4.1. Immediate Preparation and Immersion Technique

- **Glycaemia:** winter swimming on an empty stomach must be avoided. Adequate carbohydrate intake before the session provides "fuel" for shivering and non-shivering thermogenesis (BAT activation) [11, 19].
- **Depth and duration:** immersion limited to the chest line. Water exposure time should be reduced by 30–50% compared with the pre-pregnancy period (typically 30–60 s) [2, 16].
- **Diving-reflex blockade:** a categorical ban on submerging the head and face. Contact of cold water with trigeminal nerve receptors triggers potent bradycardia, which in a pregnant woman may cause sudden fetal heart-rate disturbances [16].
- **Breath control:** focus on a long, calm exhalation immediately upon immersion to control the "gasp reflex" and minimise the risk of respiratory alkalosis [15].
- **Supervision:** a ban on winter swimming alone. The presence of a companion or lifeguard is mandatory due to the risk of vasovagal incidents [2, 9].

4.2. Re-warming and Post-immersion Care

The process of restoring normothermia is as critical as the immersion itself, due to the dynamics of fluid shifts and vascular changes.

- **Afterdrop phenomenon:** hot showers must be strictly avoided immediately after exiting the water. Sudden peripheral vasodilation, combined with the influx of cooled blood from the extremities to the core, can lead to circulatory collapse and hypotension [15, 17].
- **Thermal insulation:** remove wet clothing immediately; dry the skin thoroughly and put on layered clothing, preferably of natural fibres (wool, cotton).
- **Movement:** after dressing, gentle physical activity (e.g. a calm walk) supports natural thermogenesis. Strenuous workouts should be avoided immediately after winter swimming [2].
- **Hydration:** mandatory intake of warm isotonic fluids to counteract hemoconcentration resulting from cold-induced diuresis [17, 19].

5. ROLE OF THE OBSTETRICIAN-GYNAECOLOGIST

The physician's role is not limited to passive consent but involves active monitoring of the compensatory reserve of the fetal–maternal unit [2, 11].

5.1. Laboratory and Functional Diagnostics

The physician should implement a panel of tests to monitor the impact of extreme stimuli on maternal homeostasis.

Table 2. Medical Qualification Protocol and Pre-seasonal Screening (own elaboration)

Diagnostic category	Parameters	Clinical objective
Cardiology	ECG, echocardiography	Exclusion of defects and conduction disorders [20]
Morphology	HGB, HCT, ferritin	Assessment of blood viscosity and iron reserves (anaemia) [6, 7]
Endocrinology	TSH, fT4	Assessment of thermoregulatory capacity [19, 20]
Electrolytes	Sodium, potassium, magnesium	Myocardial electrical stability under cold stress [15, 17]

During the season, Doppler ultrasound of the uterine and umbilical arteries is crucial to assess whether maternal circulatory centralisation during cold exposure negatively impacts placental flow [8, 14, 16].

5.2. Education on Prenatal Programming

The physician may inform the patient of potential benefits in adapted individuals: stimulation of fetal brown adipose tissue (BAT) development, which improves neonatal thermoregulation after birth [11, 12]; and mood stabilisation and reduction of prenatal anxiety through the natural release of endorphins and dopamine [2, 9].

6. SYSTEMIC ADAPTATION OF THE PREGNANT WOMAN TO COLD EXPOSURE

A full understanding of the impact of Cold Water Immersion (CWI) on the pregnant body requires a comparison of the dynamic physiological processes of pregnancy with adaptive reactions to thermal stress. The analysis suggests that regular cold exposure in adapted women modifies haematological parameters, strengthens immunity, optimises fluid management, and stabilises the neurochemical profile, serving as a unique tool for maternal and fetal health programming.

6.1. Neurobiology of Mood and Prevention of Affective Disorders

Modern perinatology indicates a rapid increase in the incidence of mental disorders during the prenatal period, with prevalence of prenatal depression reaching 15–25% [21]. The physiological basis is dysregulation of the hypothalamus–pituitary–adrenal (HPA) axis and a decrease in heart-rate variability (HRV). Sudden contact with cold water triggers a neurohormonal cascade, manifested by a surge in norepinephrine (a 200–300% increase) and dopamine [22]. This neurochemical profile exhibits direct anxiolytic and antidepressant effects. In regular winter swimmers, sensitivity of dopaminergic receptors increases, leading to long-term mood stabilisation and improved adaptability to environmental stressors [10]. Systematic CWI induces an adaptive dampening of the stress response by strengthening vagal tone. In pregnant women, cold-induced parasympathetic activation allows autonomic stabilisation, minimising the risk of prenatal anxiety and postpartum depression [23].

6.2. Modulation of Haematological and Immunological Parameters

During a normal pregnancy, the increase in plasma volume leads to dilutional anaemia [7]. Short-term cold exposure induces rapid peripheral and splenic vasoconstriction, resulting in the release of blood cells into the systemic circulation. This process increases haematocrit levels and haemoglobin concentration, improving the maternal oxygen reserve [6]. In adapted women, an optimisation of haemoglobin's affinity for oxygen is observed [2]. Cold exposure also induces an increase in the number and activity of NK cells and monocytes [17]. In the context of pregnancy, CWI helps maintain the efficiency of the antiviral barrier without inducing a pathological inflammatory state, reducing the risk of seasonal infections by nearly 40% [5].

6.3. Renal Physiology and Non-pharmacological Oedema Reduction

Circulatory centralisation under the influence of cold results in a sharp increase in central venous pressure (CVP), triggering a precise nephrological cascade. Increased pressure in the cardiac atria stimulates release of atrial natriuretic peptide (ANP) and inhibits vasopressin (ADH) secretion. This produces a large volume of dilute urine, providing rapid relief to the circulatory system [24]. For women in the third trimester, CWI offers a synergistic drainage mechanism: hydrostatic water pressure pushes fluid from the interstitial spaces while low temperature constricts capillaries and seals their endothelium. This allows elimination of foot oedema without diuretics [2].

6.4. The Gut–Brain Axis and Microbiota Dynamics

Modern neuroimmunology views the gut–brain axis as a foundation of psychophysical resilience to environmental stressors. Short-term circulatory centralisation during CWI induces adaptive mechanisms in gut bacteria, leading to selection of anti-inflammatory species such as Akkermansia muciniphila and Faecalibacterium, which seal the intestinal barrier and reduce systemic inflammation [25]. In adapted women, production of maternal bacterial metabolites (e.g. butyrate) supports fetal immunotolerance [26]. However, in novices, sudden exposure may lead to pathological intestinal permeability ("leaky gut") and translocation of LPS endotoxins, inducing a pro-inflammatory cascade [27].

6.5. Microbiological Safety and Infection Risk

Infection risk associated with winter swimming during pregnancy is a modifiable factor requiring high hygienic discipline. Sudden thermal shock may cause a transient decrease in local mucosal immunity. The most

serious threat is colonisation of the reproductive tract by faecal pathogens (e.g. E. coli), which increases the risk of chorioamnionitis and premature rupture of membranes (PROM) [2]. Bodies of water with low circulation should be avoided. A categorical clinical recommendation is immediate change to dry clothing made of natural fibres (cotton) following immersion, to prevent bacterial proliferation resulting from local tissue ischaemia [9].

6.6. Metabolic Bypass: Insulin Resistance and GDM Prevention

In pregnancy, the pancreas must increase insulin secretion by 200–250% to compensate for progressive insulin resistance [12]. Cold exposure activates translocation of GLUT4 transporters to the membranes of skeletal-muscle cells and brown adipocytes in an insulin-independent manner [10]. This process allows efficient "clearing" of excess glucose from the blood. BAT activation forces glucose combustion and releases batokines (e.g. FGF21), which exhibit anti-inflammatory effects. Glycaemic stabilisation protects the fetus from macrosomia and adverse metabolic programming [11].

6.7. Cardiovascular Response and Perinatal Haemodynamics

In the pregnant woman, the circulatory system operates with a cardiac output increased by approximately 40–50%, drastically limiting compensatory reserve. Contact with cold water induces tachycardia and a spike in arterial blood pressure (afterload). The myocardium must overcome suddenly elevated vascular resistance, which can lead to failure in patients with heart defects [24]. The simultaneous activation of tachycardia (sympathetic system) and bradycardia (diving reflex upon facial contact with water) can generate arrhythmias — pregnant women are categorically forbidden from submerging their head and face [16]. In advanced pregnancy, uterine compression of the great vessels (ACCS) limits venous return; the synergy of cold shock and mechanical compression increases the risk of syncope and decreased placental perfusion [8].

6.8. Phenotypic Programming and Labour Mechanics

In permanently adapted women, the uterine spiral arteries exhibit increased elasticity due to "vascular training", ensuring more stable blood flow during pushing contractions [2]. Activation of maternal BAT promotes development of these structures in the fetus, improving neonatal thermoregulation after birth [11]. The acquired skill of breath control correlates with a lower need for pharmacological analgesia [5].

7. CONCLUSIONS

A comprehensive analysis of contemporary literature and detailed pathophysiological data allows clear conclusions regarding extreme cold exposure as a potent stimulus for systemic repair mechanisms. The impact of Cold Water Immersion (CWI) on the pregnant body is bidirectional and highly diverse; the primary factor determining the balance of benefits and risks is the duration of prior training and the degree of the patient's established vascular adaptation. The most critical conclusion from the latest medical consensus is the categorical prohibition of initiating extreme thermal stressors in novices, based on the absolute requirement of several years of adaptive experience prior to pregnancy. Pregnancy is not the time to begin winter swimming; lack of acclimatisation in women starting this activity only after conception risks uncontrolled release of catecholamines and cortisol — an acute hormonal response that may transiently disrupt the delicate immune and cytokine balance and potentially lead to critical uterine artery constriction, transient fetal hypoxia, severe disturbances in utero-placental flow, and adverse stress-axis programming in the offspring [2, 16].

In women who achieved full cold acclimatisation before pregnancy, CWI represents a unique method for supporting vascular homeostasis and enhancing psychophysical well-being. The synergy of hydrostatic pressure and systemic cryotherapy leads to effective reduction of gravitational oedema typical of the third trimester by improving lymphatic drainage and activating cold-induced diuresis (ANP/ADH mechanism), which effectively alleviates venous stasis [8]. Regular thermal stimulation promotes mood stabilisation through release of endorphins and dopamine — a significant factor in reducing prenatal anxiety and the risk of postpartum depression [5]. Optimisation of haematological parameters mitigates the physiological anaemia of pregnancy, improving the mother's overall aerobic capacity [6].

Contemporary research opens fascinating perspectives regarding the intergenerational transfer of health benefits. Controlled maternal thermal stress promotes the development and activation of brown adipose tissue

(BAT) in the fetus, resulting in more efficient neonatal thermoregulation and better glycaemic control in later childhood [11]. By influencing the gut–brain axis, maternal winter swimming favourably modifies the microbiome and immune profile of the offspring, potentially reducing the incidence of atopic diseases [27]. From a clinical labour perspective, the mother's acquired ability for breath control and stress acclimatisation correlates with a higher pain tolerance threshold and more stable placental perfusion during pushing contractions.

The pro-health potential of cold is inseparably linked to observance of restrictive safety standards. Continuous cardiological supervision and absolute exclusion of individuals with uncontrolled hypertension, structural heart defects, or arrhythmias are essential to avoid "autonomic conflict". Preventing Aortocaval Compression Syndrome (ACCS) through conscious body positioning and avoiding prolonged standing immediately after exiting the water is also crucial. Microbiological discipline remains equally important: selecting only monitored bathing sites and immediately changing wet swimsuits for dry cotton clothing forms the foundation of protection against ascending infections and reproductive-tract dysbiosis [9].

8. SUMMARY

Winter swimming in thermally adapted women, conducted during a physiological pregnancy under strict specialist supervision, constitutes a safe and effective tool of preventive medicine. The key to success remains rigorous medical qualification, continuous functional diagnostics, and absolute adherence to the overriding ethical principle: primum non nocere. Properly dosed thermal stress not only supports the adaptive capacity and psychophysical resilience of the maternal body but also becomes a strategic investment in the health of the future generation.

9. DISCLOSURE

9.1. Author Contributions

Conceptualisation: A. Kwiatkowska. Project administration: A. Kwiatkowska (lead); M. Sanocka (support). Supervision: A. Kwiatkowska (lead); K. Trojnar (support). Methodology: A. Żmigrodzka; K. Czernic-Goławska. Writing — original draft: A. Kwiatkowska. Writing — review and editing: K. Czernic-Goławska; J. Falana. Data curation: A. Przepióra; J. Kozłowska. Formal analysis: A. Przepióra; J. Kozłowska. Resources: A. Żmigrodzka; M. Orłowska. Validation: M. Orłowska; J. Falana. Visualisation: A. Kamińska; A. Wielogórska. Software: A. Wielogórska. Investigation: M. Sanocka. All authors have read and agreed to the published version of the manuscript.

9.2. Funding Statement

This research received no external funding.

9.3. Institutional Review Board Statement

Not applicable.

9.4. Informed Consent Statement

Not applicable.

9.5. Data Availability Statement

Not applicable.

9.6. Acknowledgements

The authors declare that there are no additional acknowledgements.

9.7. Conflict of Interest Statement

The authors declare no conflict of interest.

9.8. Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this work the authors used ChatGPT for the purposes of language improvement, style verification, and verification of bibliographic styles. Following the use of this tool, the authors reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

REFERENCES

[1] World Health Organization. WHO Guidelines on Physical Activity and Sedentary Behaviour. Geneva; 2020. https://www.who.int/publications/i/item/9789240015128

[2] Shawe J, Felton M, Harper JC, et al. Cold Water Swimming and Pregnancy: A Scoping Review and Consensus Recommendations. *Lifestyle Medicine*. 2025. https://doi.org/10.1002/lim2.70009

[3] Sundhedsstyrelsen. Fysisk aktivitet og rådgivning — Graviditet. Denmark; 2026. https://www.sundhed.dk/borger/patienthaandbogen/graviditet/

[4] SMLPC. Grūdinimas: rekomendacijos ir metodika. Lithuania; 2026. https://sam.lrv.lt/uploads/sam/documents/files/Veiklos_sritys/visuomenes-sveikatos-prieziura/mityba-ir-fizinis-aktyvumas/fizinis-aktyvumas/FA%20recommendations%20for%20all%20groups.pdf

[5] Esperland D, de Weerd L, Mercer J. Health Effects of Voluntary Exposure to Cold Water. *Int J Circumpolar Health*. 2022. https://doi.org/10.1080/22423982.2022.2111789

[6] Wcisło M, Telełów A, Marchewka J. Effect of Winter Swimming on Morphological Parameters. *Medical Rehabilitation*. 2014;18(2):11–16. https://publisherspanel.com/api/files/view/104664.pdf

[7] Sikorski T, Marcinowska-Suchowierska E. Problemy hematologiczne u ciężarnych. *Postępy Nauk Medycznych*. 2010;4:232–237. https://borgis.pl/3404,problemy-hematologiczne-u-ciezarnych-w-praktyce-lekarza-rodzinnego.html

[8] Humphries A, Mirjalili SA, Tarr GP, Thompson JMD, Stone P. The Effect of Supine Positioning on Maternal Hemodynamics during Late Pregnancy. *J Matern Fetal Neonatal Med*. 2019;32(23):3923–3930. https://doi.org/10.1080/14767058.2018.1478958

[9] Reed EL, Chapman CL, Whittman EK, et al. Cardiovascular and Mood Responses to an Acute Bout of Cold Water Immersion. *J Therm Biol*. 2023;118. https://doi.org/10.1016/j.jtherbio.2023.103727

[10] Hanssen M, Hoeks J, Brans B, et al. Short-Term Cold Acclimation Improves Insulin Sensitivity in Patients with Type 2 Diabetes Mellitus. *Nat Med*. 2015;21:863–865. https://doi.org/10.1038/nm.3891

[11] Liu X, Zhang Z, Song Y, Xie H, Dong M. An Update on Brown Adipose Tissue and Obesity Intervention: Function, Regulation and Therapeutic Implications. *Front Endocrinol*. 2023;13. https://doi.org/10.3389/fendo.2022.1065263

[12] Parrettini S, Caroli A, Torlone E. Nutrition and Metabolic Adaptations in Physiological and Complicated Pregnancy: Focus on Obesity and Gestational Diabetes. *Front Endocrinol*. 2020;11. https://doi.org/10.3389/fendo.2020.611929

[13] Jahnke JR, Terán E, Murgueitio F, Cabrera H, Thompson AL. Maternal Stress, Placental 11β-Hydroxysteroid Dehydrogenase Type 2, and Infant HPA Axis Development in Humans. *Placenta*. 2021;104:153–161. https://doi.org/10.1016/j.placenta.2020.12.008

[14] Pirhonen JP, Vähä-Eskeli KK, Seppänen A, Vuorinen J, Erkkola RU. Does Thermal Stress Decrease Uterine Blood Flow in Hypertensive Pregnancies? *Am J Perinatol*. 1994;11(5):313–316. https://doi.org/10.1055/s-2007-994542

[15] Tipton MJ, Collier N, Massey H, Corbett J, Harper R. Cold Water Immersion: Kill or Cure? *Exp Physiol*. 2017. https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/EP086283

[16] Malinowski KS, Wierzba TH, Neary JP, Winklewski PJ, Wszędybył-Winklewska M. Resting Heart Rate Affects Heart Response to Cold-Water Face Immersion Associated with Apnea. *Biology*. 2023;12(6). https://doi.org/10.3390/biology12060869

[17] Knechtle B, Waśkiewicz Z, Sousa CV, Hill L, Nikolaidis PT. Cold Water Swimming — Benefits and Risks: A Narrative Review. *Int J Environ Res Public Health*. 2020;17(23). https://doi.org/10.3390/ijerph17238984

[18] Troller-Renfree SV, Gray KN, Sandre A, et al. Associations Between Prenatal Maternal Stress and Infant Resting Brain Activity: A Preregistered Investigation. *Dev Psychobiol*. 2025;67(6). https://doi.org/10.1002/dev.70068

[19] Castellani JW, Young AJ. Human Physiological Responses to Cold Exposure: Acute Responses and Acclimatization to Prolonged Exposure. *Auton Neurosci*. 2016;196:63–74. https://doi.org/10.1016/j.autneu.2016.02.009

[20] Harper RL, Lelliott PM, Bender SB, Pinto AR. Unraveling Cardiovascular Development and Function: Insights from Single-Cell Omics. *Circ Res*. 2026;138(1). https://doi.org/10.1161/CIRCRESAHA.125.325793

[21] Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A Systematic Review and Meta-Regression of the Prevalence and Incidence of Perinatal Depression. *J Affect Disord*. 2017;219:86–92. https://doi.org/10.1016/j.jad.2017.05.003

[22] van Tulleken C, Tipton M, Massey H, Harper CM. Open Water Swimming as a Treatment for Major Depressive Disorder. *BMJ Case Rep*. 2018;11(1). https://doi.org/10.1136/bcr-2018-225007

[23] Jungmann M, Vencatachellum S, Van Ryckeghem D, Vögele C. Effects of Cold Stimulation on Cardiac-Vagal Activation in Healthy Participants: Randomized Controlled Trial. *JMIR Form Res*. 2018;2(2). https://doi.org/10.2196/10257

[24] Manou-Stathopoulou V, Goodwin CD, Patterson T, Redwood SR, Marber MS, Williams RP. The Effects of Cold and Exercise on the Cardiovascular System. *Heart*. 2015;101(8):608–620. https://doi.org/10.1136/heartjnl-2014-306276

[25] Wang Z, Wu Y, Li X, et al. The Gut Microbiota Facilitate Their Host Tolerance to Extreme Temperatures. *BMC Microbiol*. 2024;24:131. https://doi.org/10.1186/s12866-024-03277-6

[26] Ramadan YN, Alqifari SF, Alshehri K, et al. Microbiome Gut-Brain-Axis: Impact on Brain Development and Mental Health. *Mol Neurobiol*. 2025;62:10813–10833. https://doi.org/10.1007/s12035-025-04846-0

[27] Koren O, Konnikova L, Brodin P, et al. The Maternal Gut Microbiome in Pregnancy: Implications for the Developing Immune System. *Nat Rev Gastroenterol Hepatol*. 2024;21:35–45. https://doi.org/10.1038/s41575-023-00864-2

• • •

Quality in Sport · Nicolaus Copernicus University in Toruń · apcz.umk.pl/QS · DOI: 10.12775/QS.2026.55.71170