

Pregnancy under Pressure

A systematic literature review on the effects of pressure on pregnancy

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High-Altitude
visit

Commercial
flight

HBOT

SCUBA

Introduction

Background: Pregnancy involves cardiopulmonary adaptations that alter responses to pressure environments. Evidence is limited in both pressure directions. Current recommendations are inconsistent: commercial flying is generally allowed up to 36 weeks, while altitude travel is often discouraged. SCUBA is universally contraindicated, yet hyperbaric oxygen (HBOT) is considered safe and indicated for specific treatments during pregnancy. Clear adverse outcomes such as fetal growth restriction and hypertensive disorders are mainly documented in chronic high-altitude residents, not occasional visitors. For SCUBA, direct human pregnancy evidence is sparse; recommendations rely heavily on theoretical mechanisms, animal evidence and risk-benefit reasoning.

Objective: To critically review the literature concerning the safety and clinical outcomes for both the mother and the fetus in hypobaric and hyperbaric environments, and to evaluate whether current recommendations are proportionate to the available human evidence.

Methods

Design: Systematic literature search in PubMed and Cochrane for publications from 2000 onward.

MeSH terms: Pregnancy AND Atmospheric pressure / Aircraft / Hyperbaric oxygen / Altitude / Altitude sickness / Decompression Sickness / Diving / Decompression / Diving and Hyperbaric Medicine / Mountaineering

Screening: Records were screened in Rayyan.

Exclusion criteria: Chronic hypoxia or high-altitude residence, animal and in-vitro studies, non-relevant studies, foreign language articles.

Study selection: Initial yield of 3,322 references. After removing 795 duplicates, 2,527 abstracts were screened based on abstract. 50 articles underwent full-text review, after which 28 articles were excluded (12 foreign language, 12 not relevant, 1 CME activity, 1 duplicate, 1 withdrawn and 1 unavailable). 22 articles were included.



Results: Flying & Altitude

A. Commercial Flight

Exposure: Commercial cabins approximate 1,524-2,438 m (6,000-8,000 ft), with maternal SpO₂ commonly around 90-95% in healthy passengers (Savona-Ventura, 2022).

- Freeman et al. (2004), n=222: No significant differences in gestational age, birthweight, stillbirth, pre-eclampsia, preterm delivery or Apgar score outcomes. No relationship between gestational age delivery and gestational age at first air travel or total hours spent airborne.
- Chibber et al. (2006), n=992: Among primigravidae, air flight during pregnancy was associated with an increased risk of preterm births (34-37 weeks of gestation) and lower birthweight. Regression analysis showed a definite relationship between gestational age at delivery and gestational age at first air travel ($r = 0.002$, $P = 0.01$) and total hours airborne ($r = 0.012$, $P = 0.01$). No differences in vaginal bleeding, pre-eclampsia, Caesarean birth or birth asphyxia/neonatal death.
- Petrkovsky et al. (2018), n=112: Transatlantic flights at 34-37 weeks produced some transient changes in fetal movement and fetal heart rate, without demonstrated lasting fetal harm.

Interpretation: Occasional flight in uncomplicated pregnancy is broadly reassuring, but evidence is observational and confounded by sociodemographics.

B. Short-term High-Altitude Visits

Risks established for altitude residents (IUGR, preeclampsia) cannot be extrapolated to short-term visitors.

- Keyes et al. (2016), n=459 pregnancies: 244 involved travel above 2,440 m. Miscarriage and most complications were similar between exposed and unexposed pregnancies. Altitude exposure was associated with more self-reported preterm labour (OR 2.3; 95% CI 0.97-5.4) and neonatal oxygen use (OR 2.34; 95% CI 1.04-5.26), but not more NICU admission.
- Niermeyer (2000): In fully acclimatized pregnant women above 4000 m, arterial oxygen tension is higher and pCO₂ lower than in acclimatized nonpregnant women at the same altitudes. The decrease in fetal pO₂ is less than would be expected from the relative maternal hypoxemia at high altitude. Maternal pO₂ decreases from 91 mmHg at 150 m to 61 mmHg at 4200 m, while fetal scalp pO₂ drops from 22 mmHg to 19 mmHg.

Overall confidence	Recommendation
LOW Mixed observational evidence	Flight generally allowed Altitude often cautioned

Confidence categories are a narrative appraisal, not a formal GRADE assessment.

Results: HBOT & SCUBA

A. Hyperbaric Oxygen Therapy (HBOT)

- Ozogok-Kangal (2021), n = 28 pregnancies: One fetal death preceded treatment, while three adverse outcomes had plausible alternative causes. The remaining 24 pregnancies resulted in healthy term infants with normal development. No definite fetal morbidity or mortality was attributed to HBOT.
- Wattel et al. (2013), n = 406 women: After HBOT no significant differences were found in psychomotor or height/weight ($p > 0.05$ for both) between the exposed and unexposed children. No malformations were reported.
- Arslan et al. (2021), n = 32 women: During follow-up after HBOT for CO poisoning, no problems and no teratogenic effects were reported.

A. SCUBA Diving

- Biological concern:** fetal circulation bypasses pulmonary filtration through the foramen ovale, maternal decompression illness (DCI) could therefore reach fetal organs. Animal studies suggest potential fetal harm, but human applicability is uncertain (Reid and Lorenzo, 2018).
- Damron (2016), n = 2,239 women: 466 dived while pregnant. No difference in miscarriage or prematurity, but congenital malformations were reported in 6 offspring of women who dived while pregnant versus 0 among non-pregnant divers ($p<0.01$). All occurred after first-trimester exposure and within population norms. The association is vulnerable to self-report, selection bias, confounding and incomplete exposure data, so causality cannot be inferred.
- St Leger Dowse et al. (2008), n = 157 pregnancies: No significant correlation between diving and fetal abnormalities could be established, nor could safe depth or exposure limits be defined.

Overall confidence	Recommendation
VERY LOW Small, retrospective human evidence	HBOT presumably safe when indicated, SCUBA avoided.

Confidence categories are a narrative appraisal, not a formal GRADE assessment.

SCUBA avoidance remains appropriate because the exposure is elective and potential fetal harm could be severe, based on theoretical principles. Inadvertent early exposure is not, by itself, an indication for pregnancy termination.

Overall confidence	Recommendation
LOW Mixed observational evidence	Flight generally allowed Altitude often cautioned

Confidence categories are a narrative appraisal, not a formal GRADE assessment.

Summary of Evidence

Exposure	Current practice	Evidence
Commercial flight	Generally permitted	Mostly reassuring for occasional travel, one study signals preterm delivery and lower birthweight in frequent/long flights.
Short-term High-Altitude Visits	Cautioned	Low absolute complication rates in healthy active visitors and presumably safe. Possible preterm labour and neonatal oxygen need. Allow time for acclimatisation. Avoid if cardiopulmonary or placental pathology exists.
Hyperbaric Oxygen Therapy	Presumably safe when indicated	Small series are reassuring with no teratogenic effects or psychomotor delay. Untreated CO poisoning presents a clearer fetal hazard than HBOT.
SCUBA Diving	To be avoided during pregnancy	No evidence-based safe threshold exists. Human studies provide weak and conflicting evidence regarding congenital malformations, while animal studies support a theoretical fetal risk.

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