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The Risks and Benefits of Skiing on Pregnancy

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Abstract

Background: Participating in skiing during pregnancy raises clinical concerns about maternal and fetal safety due to the physiological demands of endurance activity, environmental

exposure, and potential injury risk. While regular physical activity is widely acknowledged to have maternal and fetal health advantages, evidence specific to downhill and cross-country skiing across studies is limited.

Aim: This research paper aims to review the latest literature on the risks and benefits of skiing on pregnancy. Particular attention was paid to endurance training, injuries, cardiovascular adaptations, hypoglycemia, altitude exposure, thermoregulation, and psychological well-being.

Material and methods: The study analyzed published articles on the possible risks and benefits of skiing during pregnancy. The source material was collected from PubMed, Scopus, and Google Scholar using keywords related to skiing and pregnancy. Various guidelines were also analyzed.

Results: Skiing during pregnancy may reduce the risk of gestational diabetes, improve maternal glucose regulation and cardiovascular health, support favorable obstetric outcomes, alleviate low back pain, promote beneficial infant cardiovascular adaptations, and enhance psychological well-being. However, skiing carries risks related to falls and collisions, particularly with high-intensity activity and postpartum. Additional caution is advised regarding cardiovascular strain, hypoglycemia, and high-altitude exposure, especially for pregnant women with pre-existing medical or obstetric conditions.

Conclusions: There is limited data focused specifically on skiing during pregnancy. As a result, recommendations on whether it is safe or not to ski in pregnancy are inconclusive.

Further research on the topic is required to develop knowledgeable and clear guidelines for pregnant skiers, specifically separating results on recreational and athletic pregnant skiers and differentiating between skiing disciplines.

Key words: skiing, pregnancy, physical activity, high altitude, outdoor activity, downhill skiing, cross-country skiing, injury, hypoglycemia, elite athletes, thermoregulation

1. Introduction

Moderate physical activity during pregnancy is widely recognized as extremely beneficial for pregnant women. Pregnant women who engage in moderate physical exercise regularly have a reduced likelihood of developing obesity or becoming overweight. Physical activity helps maintain appropriate muscle tone, decrease pain, and prepare for the strain of childbirth [1]. It shortens the labour [2], reduces the risk of cesarean delivery [3], and even

decreases the symptoms of depression in pregnant women, and may also have a significant role in preventing depression during pregnancy [1]. WHO Guidelines from 2020 recommend undertaking regular, moderate-intensity, aerobic physical activity throughout pregnancy and postpartum [4]. However, involvement in risky or technically challenging activities, like freestyle skiing, is still unclear in the guidelines, with the information for pregnant women to consult a qualified healthcare provider for supervision.

Skiing is a globally popular recreational and competitive sport practiced by millions of individuals each year. Different levels of physical effort, balance, coordination, speed, and exposure to the environment are required. The topic of whether skiing can be continued safely becomes quite important for pregnant people who had been frequent skiers before becoming pregnant. However, due to the risk of falls, collisions, and high-altitude exposure, skiing is often classified as a potentially hazardous activity during pregnancy [5].

The purpose of the literature review is to critically analyze the body of research on how skiing affects pregnancy. This review integrates findings from observational cohort studies, case reports or case studies, guidelines from medical societies, surveys, and retrospective analyses to develop a comprehensive understanding of potential risks and benefits.

2. Methodology

This study examines the current knowledge on the risks and benefits of skiing during pregnancy. Due to the limited availability of skiing-specific pregnancy studies the only inclusion criterion for the article selection was relevance to the topic. Keywords such as "skiing", "pregnancy", "physical activity", "high altitude", "thermoregulation", and related topics were used to collect data from PubMed, Scopus, and Google Scholar. The influence of skiing on maternal and fetal health was evaluated by analyzing the collected materials, which included studies and reviews. WHO, ACOG, Polish Society of Gynecologists and Obstetricians (PTGiP), and Polish Society of Sports Medicine (PTMS) guidelines were incorporated to provide evidence-based recommendations. Related literature on high-impact sports, endurance exercise, winter sports, and outdoor activities during pregnancy provided some additional background information.

Data from the research papers were assigned into 7 areas referring to the risks and benefits of skiing for pregnant women. The areas are endurance training, injuries, cardiovascular changes, glycemic changes, altitude exposure, thermoregulation, and psychological effects.

3. Research results

3.1. Effect of endurance high-intensity training on pregnancy and perinatal outcomes

A study on 30 Finnish endurance athletes who had achieved national top-level status in different disciplines, including cross-country skiing [6], shows that the labor metrics of the athletes and controls did not differ significantly, and the athletes' pregnancies and deliveries were not negatively impacted by endurance training. Additionally, meta-analysis of high-intensity training during pregnancy [7] reported a reduction in the incidence of gestational diabetes mellitus and improved 5-minute Apgar scores among neonates, with no significant impact on preterm birth rates, gestational age at delivery, low birthweight, or pregnancy-induced hypertension. However, data on neonatal birth weight in elite athletes varies between the sources [8] - 2 studies express concerns of low birth weight, with no evidence of the infants' health issue [9,10], and one shows an increase in birth weight [11]. Subsequent research [12] reported a decrease in size at birth in pregnant women who continue a high-intensity exercise plan throughout pregnancy, even more prominent in women who increased the intensity of their training, especially in late pregnancy. It is important to note that maternal diet is an impacting factor. On the other hand, a different meta-analysis [13] reported "very low" certainty evidence on increased likelihood of excessive prenatal weight gain in elite athletes compared with controls, highlighting the complexity of metabolic and energy balance responses in this unique population.

Elite athletes who regularly engage in high-intensity or high-volume training before and during pregnancy had lower odds of pregnancy-related low back pain than active or sedentary controls [13]. This suggests that sustained high-intensity physical conditioning may have musculoskeletal benefits. Even though recommendations conclude that pregnancy-related low back or pelvic girdle pain is not less common among elite athletes, health practitioners should consider it when managing pain in pregnant patients [14].

There is one large prospective cohort study specifically focused on perinatal outcomes in participants of the world's largest cross-country ski race - Vasaloppet [15]. Women identified as skiers represent a subset of individuals with high exercise volume and cardiorespiratory fitness and are found to have significantly lower odds of several adverse maternal outcomes compared with non-skiing controls. Specifically, non-skiers exhibited higher odds of gestational diabetes mellitus (GDM), excessive gestational weight gain, psychiatric morbidity, and both any caesarean section and elective caesarean section compared with skiers, after adjustment for socio-demographic, lifestyle, and comorbidity factors. Additionally, non-skiers

had higher odds of delivering large-for-gestational-age infants, whereas skiers had lower odds of inadequate gestational weight gain. Importantly, there were no significant associations between skier status and key fetal or neonatal complications such as preterm birth or small for gestational age infants. Adjustment for early pregnancy body mass index attenuated some associations (e.g., for excessive and inadequate weight gain and large-for-gestational-age outcomes), but the overall pattern remained consistent, indicating that engagement in high-level endurance activity before pregnancy is associated with more favorable maternal metabolic and obstetric outcomes without evidence of increased risk for adverse fetal or neonatal events.

3.2. Risks of injury

Traumatic injuries occur in approximately 8% of pregnancies, half of which are caused by motor vehicle accidents [16]. Compared to that, physical activities are a cause of injuries in around 2% of pregnancies, and the majority of those injuries are bruises or scrapes, not severe injuries. The primary cause of maternal injuries among expectant mothers is falls [17]. This is probably resulting from the musculoskeletal changes that occur in a pregnant woman's body, such as increased joint and ligament laxity brought on by hormonal changes, as well as changes in the body's locus of balance by an increase in body weight and a shift in the center of gravity. Ligament laxity may lead to joint instability and, therefore, increase the risk of injury during high-impact or high-fall-risk sports [18].

In the cohort study [17], the percentage of pregnant women who reported high or very high (vigorous) intensity physical activity or exercise was injured more times than women who engaged in less intense exercises. Furthermore, meta-analysis on postpartum in elite athletes [19] presents “very low” certainty data that they may be more prone to injury, which could be exacerbated by an immediate return to high-intensity activity postpartum. It also shows a more common occurrence of sacral stress fractures in high-impact and endurance training. Sacral fractures in pregnant women might occur due to a reduction in bone mineral density during breastfeeding. The risk of fracture may be increased by returning to an intense training plan in the early postpartum. An elite cross-country skier, who trained intensely during postpartum, experienced two sacral stress fractures [20]. These injuries appeared during a period of increasing training intensity and perhaps corresponded with the athlete's lowest postpartum bone mineral density, suggesting a possible link between the demands of high-level endurance training and skeletal susceptibility during the postpartum period.

Freestyle skiing has been reported to have the highest overall injury incidence among skiing disciplines, whereas cross-country skiing consistently demonstrates the lowest injury

rates, reflecting differences in speed, terrain complexity, and characteristics of each discipline [21]. Across all skiing disciplines, injury patterns are dominated by musculoskeletal trauma, particularly to the lower extremities. Abdominal injuries are comparatively rare, especially when contrasted with upper-body injuries or with the most frequently documented skiing-related trauma, anterior cruciate ligament (ACL) tears, which account for a substantial proportion of serious injuries in skiing [22].

It is worth mentioning that compared to skiers, snowboarders had a considerably greater rate of stomach injuries, despite their age and gender. However, the duration of injuries does not differ. In both skiers and snowboarders, falls remain the predominant mechanism of injury [23].

3.3. Cardiovascular risks and benefits

Pregnancy triggers significant maternal cardiovascular adaptations that begin early in gestation and evolve through the second and third trimesters. Those adaptations include expansion of total blood volume, a substantial increase in cardiac output driven by both elevated stroke volume and heart rate, and a decrease in systemic vascular resistance [24]. These integrated hemodynamic adjustments are physiologically necessary to accommodate the heightened metabolic demands imposed by maternal tissue growth, placental development, and fetal growth, thereby ensuring adequate perfusion of both maternal and fetal compartments.

Women who engage in regular physical activity during pregnancy frequently report improved maternal health outcomes [25], including better regulation of gestational weight gain and enhanced metabolic profiles, both of which are associated with reduced cardiovascular risk. Moreover, maternal exercise may provide long-term cardiovascular benefits for the child's developing autonomic regulation and function. Evidence from randomized controlled trials [26] indicates that prenatal aerobic exercise at recommended moderate intensity levels is linked to beneficial autonomic and cardiovascular adaptations in one-month-old infants. It is reflected by lower resting heart rate and enhanced measures of cardiac function - increased stroke volume and cardiac output.

In contrast to the generally beneficial outcomes of moderate exercise, evidence on high-intensity training, particularly in elite athletes, indicates potential cardiovascular dangers to fetal welfare. A key study of pregnant Olympic-level cross-country skiers and other athletes [27] found that during treadmill exercise at intensities ranging from 60% to 90% of maternal maximal oxygen consumption, uteroplacental blood flow decreased significantly when maternal heart rate exceeded 90% of maximal maternal heart rate. Placental insufficiency

results in measurable reductions in uterine artery perfusion and episodes of fetal bradycardia, a marker of fetal cardiovascular stress. These abnormalities resolved within 10 minutes as exercise was ended, but raised concerns regarding the possibility of reduced fetal oxygenation under excessive maternal cardiovascular effort. Because of these findings, neither the athletes nor the controls continued high-intensity training throughout the second and third trimesters [28].

Skiing, especially performed at moderate to high intensity, significantly increases maternal cardiovascular load as a result of elevated metabolic and hemodynamic requirements. Cross-country skiing is especially noteworthy in this regard, as it is characterized by higher aerobic demands, leading to significant increases in oxygen uptake (VO_2) and heart rate compared to downhill skiing and indoor cycling [29]. Evidence indicates that people with higher cardiorespiratory fitness and regular training exposure demonstrate improved exercise tolerance during such activities [30]. They also show lower relative cardiovascular responses, e.g. reduced heart rate and VO_2, for the same absolute workload, suggesting a physiological adaptation to high-intensity training demands. Pregnant elite athletes who have access to more advanced evaluation are advised to avoid training at intensities greater than 90% of their VO2max [14], even though there has not been any research on pregnant athletes whose baseline VO2max is already significantly higher than the general population, which includes cross-country skiers. Clinical guidance on physical activity during pregnancy [31] emphasizes that prolonged or vigorous exercise, if not properly moderated, may increase the risk of negative symptoms, including hypoglycemia, dizziness, and hypotension. This is especially true for untrained or less-conditioned individuals whose cardiovascular adaptations may be insufficient to accommodate sudden or excessive physical stress. To summarize, cross-country skiing can be a safe form of exercise for pregnant individuals if they thoroughly monitor heart rate parameters [32].

3.4. Hypoglycemia risk and maternal glucose tolerance

Pregnancy alters the typical metabolic response to exercise: unlike in non-pregnant women, where exercise can elevate blood glucose at high intensities, pregnancy blunts that response and can even produce a decrease in blood glucose during exercise due to reduced hepatic glucose output and increased glucose oxidation coupled with enhanced glucose uptake [33]. This suggests that prolonged or intense exercise may lower maternal blood glucose levels more than expected, thereby elevating the risk of hypoglycemia during high exertion. Although most pregnant women can safely engage in regular physical activity, the ACOG guidelines [31]

emphasize that prolonged or high-intensity exercise sessions exceeding 45 minutes can increase the risk of exercise-induced hypoglycemia, particularly when caloric intake is inadequate in relation to energy expenditure.

In a randomized controlled trial [34], pregnant women who participated in a structured physical activity program throughout gestation exhibited significantly lower maternal glucose screen values at 24–28 weeks' gestation compared with women in the control group, indicating a meaningful improvement in glucose tolerance among those who exercised. The intervention included a combination of land-based and aquatic activities performed three times per week, with several of the water-based exercises including movements similar to cross-country skiing performed in an aquatic environment, which were chosen to provide safe, moderate-intensity, full-body movement patterns appropriate for pregnancy while minimizing impact stress. The use of these aquatic cross-country skiing movements contributed to the exercise regimen's overall success, implying that such coordinated, rhythmic movements may help improve maternal glucose regulation without negatively impacting maternal weight gain or other measured pregnancy outcomes.

3.5. High altitude exposure

Guidance from national and international authorities indicates general agreement that moderate physical activity during pregnancy is acceptable at altitudes commonly encountered in recreational mountain sports, although the specific altitude thresholds vary slightly between countries [35]. Canadian, United States, Norwegian, and United Kingdom guidelines collectively suggest that exercise at elevations ranging from approximately 1,800 to 2,500 meters is generally safe for healthy pregnant women if no obstetric contraindications are present. Consistent with these recommendations, evidence summarized in the literature indicates no demonstrable adverse fetal effects at altitudes below 1,800 meters (6000 feet) [36], which encompasses most settings used for activities such as hiking and skiing. Polish Society of Gynecologists and Obstetricians (PTGiP) and Polish Society of Sports Medicine (PTMS) [37] emphasize the need for research to provide recommendations for competitive female athletes for altitude training in both natural (mountainous locations) and simulated (normobaric hypoxia) environments.

Across guidelines and supporting studies, emphasis is placed on maternal symptom awareness rather than strict altitude limits. Recreationally active pregnant women are advised to recognize early signs of altitude illness and to immediately stop exercise, which includes skiing, descend to a lower altitude, and seek medical evaluation if symptoms occur. The

American College of Obstetricians and Gynecologists further highlights the importance of being aware of pregnancy-specific warning signs [32], as these may signal complications caused by altitude exposure and warrant prompt medical attention. Warning signs include vaginal bleeding, dyspnea before exertion, dizziness, or leakage of amniotic fluid, and others that are not common.

In addition to recommendations on safe altitude exposure during pregnancy, clinical guidance highlights that certain maternal risk profiles substantially modify the safety landscape for travel and physical activity at high altitude. Specifically advised against traveling to and engaging in physical activity at high altitudes are women with pre-existing hypertensive disorders of pregnancy - chronic hypertension or a history of preeclampsia, or those with risk factors for fetal growth restriction [38]. This recommendation particularly applies after 20 weeks of pregnancy, because the limited maternal and fetal physiologic reserve may not adequately compensate for the hypoxic stress associated with altitude exposure. Fetal hypoxia might also have a higher occurrence in women who have a history of previous respiratory or cardiac conditions that put them at risk for cyanosis [39].

Pregnancy increases maternal oxygen consumption (VO_2) to meet the metabolic demands of the mother and fetus [24]. As the uterus enlarges with advancing gestation, the diaphragm is elevated, and chest wall mechanics change [40]. This mechanical shift, along with hormonal influences, leads to alterations in lung volumes and ventilatory patterns such as decreased functional residual capacity, increased tidal volume, higher minute ventilation, and alters respiratory mechanics due to diaphragmatic elevation. While most pregnant individuals can efficiently meet increased oxygen demands at rest and during moderate exercise, high-intensity skiing at altitude may challenge respiratory efficiency.

3.6. Thermoregulation

Pregnancy is associated with increased heat production during exercise due to higher metabolic demands, but studies have demonstrated that pregnant women can maintain thermal balance under moderate exercise conditions without developing excessive core temperatures [41]. Thermoregulatory changes during pregnancy increase evaporative and dry heat loss, which is reflected in increased cutaneous blood flow and temperature responses during exercise such as skiing [42]. These modifications aid in maintaining thermal homeostasis despite increased metabolic heat output. Pregnant elite and recreational athletes have a less significant rise in core body temperature and reduced thermal sensations, but increased skin temperature along with greater fluid loss [43].

Skiing presents a unique thermal environment with cold temperatures, wind exposure, and variable intensity, ranging from moderate aerobic cross-country skiing to high-intensity downhill runs. Cold exposure generally reduces the risk of hyperthermia, with the reservation to properly hydrate for the whole duration of exercise, before and after, wear light, loose-fitting clothing, and observe body temperature during high-intensity activities [4,39].

3.7. Psychological benefits

The benefits of outdoor exercise for both physical and mental health are being increasingly studied. According to a systematic review and meta-analysis [44], which synthesized 24 studies, outdoor physical activity, especially in natural environments, may provide substantial psychological benefits when compared to indoor or urban workout conditions. The meta-analysis in the various studies reported statistically significant decreases in anxiety, depression, anger, improved positive affect, increased energy or reduced fatigue, and an increase in tranquillity. A reported decrease in depression was specifically observed in the forest conditions. Another meta-analysis [45] shows natural environments are regarded as more restorative than urban areas.

Although the findings are not specific to pregnancy, participation in skiing is linked to significant psychological benefits. In a single randomized controlled trial involving 399 collegiate students [46], those who participated in practical winter skiing showed significantly lower levels of stress and apprehension than peers who only received lectures on skiing, while also demonstrating higher levels of enjoyment, implying that active participation in skiing not only reduces negative affective states but also promotes positive emotional experiences. Similar results are seen in the studies of the older population - a cohort, cross-sectional research of physically active adults over the age of 55 [47] found that those who practiced alpine skiing had higher levels of intrinsic motivation and physical self-concept (PSC), as well as the physical component of health-related quality of life (HRQoL), when compared to non-skiers.

Pregnant participants reported higher perceived enjoyment in women who exercised in acute high-intensity interval training sessions compared to moderate-intensity continuous training [48]. One of the possible aspects affecting that result might be that a similar physical effect can be achieved with a shorter time duration. A more positive impact of high-intensity training may contribute to more frequent and regular exercising during pregnancy, crucial to maternal and fetal health.

4. Discussion

This article reviews available evidence on the risks and benefits of skiing during pregnancy by integrating findings from endurance exercise research, skiing-specific observational cohort studies and case studies, pregnancy-specific high-intensity physical activity research, and clinical guidelines from medical societies. According to the findings, skiing combines specific risks associated with trauma, intensity, and environmental exposure with potential metabolic, cardiovascular, and psychological benefits.

Based on the evidence reviewed, skiing during pregnancy, particularly cross-country skiing, can be compatible with healthy pregnancy outcomes in physically active women when performed at moderate intensity and with proper precautions. When done in controlled environments and at a moderate intensity, cross-country skiing may be safer for experienced athletes. However, during high-intensity activity, a maternal maximum heart rate of more than 90% is not suggested because it may decrease uteroplacental perfusion to levels that impact fetal heart rate.

The available data point to potential benefits such as improved metabolic health, reduced risk of gestational diabetes, and lower maternal glucose screen values, lower cardiovascular risk for women, and autonomic and cardiovascular adaptations for infants, lower back pain, positive obstetric outcomes, lower risk of hyperthermia due to cold exposure, and more positive affect, enjoyment, and higher quality of life index. These advantages come with no conclusive evidence of increased prenatal or neonatal risk in recreational or well-monitored moderate-intensity exercises, such as skiing.

Nonetheless, skiing also presents specific risks related to falls, such as sacral fractures and possibly more ligament injuries. Additionally, more injuries are reported during high-intensity exercise, especially during postpartum. Downhill skiing has a higher incidence of injuries due to skier-to-skier collisions. Furthermore, pregnant women should be cautious while skiing due to increased cardiovascular workload, hypoglycemia, and environmental exposure, such as high altitude. Those risks are amplified at higher intensities, in technically demanding skiing disciplines, and among women with underlying medical or obstetric risk factors.

In conclusion, skiing should not be avoided entirely during pregnancy. Rather, it should be viewed as a physically demanding outdoor activity that can be safely performed by qualified individuals under adequate supervision, with careful attention paid to maternal symptoms and physiological limits. The evidence supports individualized decision-making, with a focus on

pre-pregnancy fitness level, skiing discipline, intensity regulation, adequate nutrition, and adherence to established clinical guidelines.

5. Conclusions

At present, evidence on skiing during pregnancy remains limited and largely indirect, mainly based on studies of endurance athletes, cross-country skiers, injury epidemiology, and general guidelines for physical activity in pregnancy. Although these studies indicate both benefits and risks, they are insufficient to draw clear, skiing-specific conclusions. Further research is therefore needed, particularly studies that distinguish between recreational skiers and elite athletes and that account for differences between skiing disciplines, such as cross-country, alpine, and freestyle skiing, due to their different physiological demands, injury profiles, and environmental exposures. This research would assist in clarifying risk profiles and offering more realistic, individualized advice for pregnant women who want to continue skiing throughout pregnancy.

Supplementary materials

Not applicable.

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Not applicable.

Conflicts of Interest

The authors declare no conflict of interest in relation to this study.

Declaration of Generative AI and AI-Assisted Technologies

In preparing this work, the authors used ChatGPT (OpenAI) for the purpose of improving language and readability, text formatting, and grammar correction. After using this tool/service, the authors have reviewed and edited the content as needed and take full responsibility for the content of the publication.

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