ORIGINAL RESEARCH

Outdoor Activity and High Altitude Exposure During Pregnancy: A Survey of 459 Pregnancies

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Objective.—To evaluate whether women engage in outdoor activities and high altitude travel during pregnancy; the health care advice received regarding high altitude during pregnancy; and the association between high altitude exposure and self-reported pregnancy complications.

Methods.—An online survey of women with at least 1 pregnancy distributed on websites and e-mail lists targeting mothers and/or mountain activities. Outcome measures were outdoor activities during pregnancy, high altitude (>2440 m) exposure during pregnancy, and pregnancy and perinatal complications.

Results.—Hiking, running, and swimming were the most common activities performed during pregnancy. Women traveled to high altitude in over half of the pregnancies (244/459), and most did not receive counseling regarding altitude (355, 77%), although a small proportion (14, 3%) were told not to go above 2440 m. Rates of miscarriage and most other complications were similar between pregnancies with and without travel above 2440 m. Pregnancies with high altitude exposure were more likely to have preterm labor (odds ratio [OR] 2.3; 95% CI 0.97–5.4; $P = .05$). Babies born to women who went to high altitude during pregnancy were more likely to need oxygen at birth (OR 2.34; 95% CI 1.04–5.26; $P < .05$) but had similar rates of neonatal intensive care unit admission ($P =$ not significant).

Conclusions.—Our results suggest pregnant women who are active in outdoor sports and travel to high altitude have a low rate of complications. Given the limitations of our data, further research is necessary on the risks associated with high altitude travel and physical activity and how these apply to the general population.

Key words: pregnancy, exercise, high altitude, intrauterine growth retardation, preterm labor, travel, hypoxia

Introduction

Exercise during pregnancy is considered beneficial to both mother and fetus and is recommended by obstetrical guidelines.^{1,2} These guidelines note that exercise at high altitude may carry risks and specifically discourage certain high altitude activities, although more for concerns of trauma (eg, downhill skiing) than for hypoxic exposure. These and other recommendations for pregnant women traveling and recreating at high altitude are based on expert opinion and a few studies involving long-term high-altitude residents.³ The scant existing studies of nonresidents are limited to a small number of

women traveling to moderate altitudes (1800–2300 m) for only a few hours at a time.^{4,5} Whether these guidelines are thus valid for visits of days to weeks and whether pregnant women and their medical providers comply with these recommendations regarding high altitude activity are unknown.

The overall number of pregnant visitors to high altitude is also unknown, but likely sizable. Honigman et al⁶ documented that 3% of tourists at 1 Colorado high altitude resort area were pregnant during a summer survey, and given that millions of tourists visit these Colorado resorts each year, we can surmise that a very large number of pregnancies are exposed to high altitude. In addition, the physical activities of pregnant women and the incidence of pregnancy-specific complications related to altitude exposure remains undocumented. A retrospective survey of obstetricians and gynecologists in high altitude communities documented an impression of

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increased complications in pregnant visitors.⁷ Respondents identified dehydration and vigorous exercise as perceived risk factors. No medical records review or case studies were performed to confirm these impressions, however. To date, no study has systematically or prospectively studied the occurrence of pregnancy-related complications in women visiting high altitude locales.

Given the logistical and ethical difficulties of prospectively studying pregnant sojourners to high altitude, we sought to gather preliminary data on these questions through an anonymous survey of mothers regarding their exposure to high altitude and exercise during prior pregnancies and their pregnancy outcomes. The specific aims were to 1) identify the types of exercise activities and high altitude exposure women experienced during pregnancy; 2) determine whether women received advice from their health care providers regarding the safety of high altitude activities during pregnancy; and 3) determine if associations exist between high altitude exposure and self-reported pregnancy complications.

Methods

We conducted a cross-sectional survey of women who had been pregnant at least once. The study was considered exempt by the University of Washington and University of Colorado Institutional Review Boards.

SURVEY

We conducted an anonymous online survey via the Catalyst system, a web-based platform run from University of Washington servers with multiple functions including survey creation and administration.

The survey (see online [Supplementary Material](#)) took approximately 20 minutes and consisted of 24 questions regarding demographics, medical history, current activities, and high altitude exposure, followed by an additional 20 questions specific to each pregnancy including physical activity and high altitude exposure during pregnancy and whether there were any pregnancy complications. For each question, respondents were provided a list of potential activities and complications to which they were asked to respond “yes” or “no” and were given the opportunity to write in additional answers. Definitions were not provided for the terms listed. We considered preterm labor a distinct entity from preterm birth, and ascertained information about preterm births separately by asking about gestational age. Subjects had the opportunity to respond to pregnancy-related questions for up to the first 4 pregnancies, regardless of the time frame in which they occurred. The survey did not include questions about traumatic injuries during high-risk activities.

We defined high altitude as greater than 2440 m (8000 ft). When asked about the specific altitudes to which they traveled, respondents could list either numerical values or place names.

Subjects were asked specifically if they slept at high altitude and for how many nights. If a subject indicated a number of days spent over 2440 m but zero nights sleeping at high altitude, these were considered day trips. We defined high altitude residence during pregnancy as spending greater than 140 days above 2440 m during a given pregnancy. Participants were not required to answer every question; therefore, total answers do not always equal total survey respondents.

SUBJECTS

We recruited women with at least 1 prior pregnancy by posting survey announcements on websites, electronic mailing lists, internet discussion boards, social media platforms, and e-mail lists targeting mothers and/or mountain activities. This included announcements in national and local mountaineering society newsletters, blogs related to motherhood and women’s sports, and discussion boards related to motherhood and parenting in the United States and France. The survey announcement included a uniform resource locator (URL) for the anonymous online survey, which was in English. Respondents who clicked on the URL were directed to a webpage with further information about the study. Those who agreed to participate after reading that information were then directed to the start of the survey.

Women were free to distribute the survey URL at their discretion. Women who had not completed a pregnancy and men were excluded. A history of travel to high altitude either during or before pregnancy was not a requirement for participation.

DATA ANALYSIS

When subjects listed a location rather than a specific altitude in the survey, we performed a Google search on the place name to determine the corresponding altitude. Day trips were distinguished from overnight trips based on the difference between days reported at high altitude and nights slept at high altitude. Some respondents gave information about more than 1 pregnancy. Therefore, demographic data were described at the level of the individual respondent, but altitude exposure, activity, and complications were analyzed by pregnancy.

Descriptive statistics were calculated in Microsoft Excel. Complications were compared between women with and without high altitude exposure using χ^2 or Fisher exact test and odds ratios calculated for

Table 1. Characteristics of survey respondents

Characteristic	Value	% or range*
Number of respondents	298	
Mean age (yrs) of respondents (range)	37	25–65
Mean altitude (m) of residence (range)	871	0–3231
Total number of pregnancies	599	
Deliveries	476	
Miscarriages n (%)	56	19
Mean age (yrs) at delivery (range)	32	18–44
Mean number of pregnancies per respondent (range)	2	1–10
Multiple gestations n (%)	11	4
Used fertility treatment n (%)	21	7
Never smoked n (%)	239	80
Former smoker n (%)	58	20
Current smoker n (%)	1	<1
Smoked during pregnancy n, (%)	4	1
Marijuana during pregnancy n (%)	11	3
Alcohol during pregnancy n (%)	120	26
Other street drugs during pregnancy n (%)	2	<1

* Percentages are calculated from total number of responses to a given questionnaire item, based on number of women, not number of pregnancies.

comparisons between no altitude exposure, high altitude exposure, and high altitude residents.⁸

Results

A total of 298 women from 11 countries and 38 states within the United States responded, providing information on a total of 599 pregnancies. The majority of respondents (241, 81%) were from the United States. Demographic information and medical history are shown in [Tables 1](#) and [2](#). Respondents reported on 294 first pregnancies, 135 second pregnancies, and 29 third pregnancies.

[Table 3](#) shows the physical activities reported by survey respondents. Hiking, running, and swimming were the most common activities performed any time during the first pregnancy. Around 30% of women participated in downhill skiing and a similar proportion participated in cross-country skiing anytime during the first pregnancy. Almost 20% rock climbed and 12% did mountaineering. Hiking, yoga, and swimming were the most common activities participated in throughout pregnancy. Two women reported skydiving, 1 up to 12 weeks and the other up to 24 weeks of pregnancy.

Just over half of respondents travelled to high altitude at some time during one of their pregnancies, while one third slept overnight at high altitude during pregnancy

([Figure 1](#)). Five percent of respondents were high altitude residents ([Table 4](#)). Of the women who were transiently above 2440 m during pregnancy, 139 (63%) reported sleeping at high altitude, suggesting that the other 80 (37%) only made day trips. Day trippers made between 1 and 60 visits above 2440 m during their pregnancies (mean 8 visits; interquartile range 6–11).

[Figure 2](#) summarizes responses regarding medical advice received during pregnancy. The majority of respondents were not specifically counseled regarding high altitude travel, although a small proportion (n = 14, 3%) were told not to go above 2440 m. About a quarter of women were counseled to change or stop sports activities during pregnancy. Activities most commonly cited as recommended to stop were skiing and snowboarding (n = 49, 44%), running (n = 24, 22%), biking (n = 20, 18%), and climbing (n = 12, 11%). Of the women counseled to stop or change activity, the majority followed their medical provider's advice (35/51, 66%). Only 16% (58/354) of respondents did not stop at least 1 of their prepregnancy sports activities. The most commonly stopped activities were skiing or snowboarding (29%), running (29%), biking (23%), and climbing (13%). Almost half the respondents (49%) reported decreasing the intensity of their exercise.

Rates of pregnancy complications were low in our cohort ([Table 5](#)). Excluding high altitude residents, women who had any high altitude exposure during pregnancy were more likely to have preterm labor (odds ratio [OR] 2.3; 95% CI 0.97–5.4; *P* = .05) and less likely to have first trimester bleeding (OR 0.34; 95% CI 0.2–0.77; *P* < .05) than those who did not travel above 2440 m during pregnancy. Babies born to women who went to high altitude during pregnancy were more likely to need oxygen at birth (OR 2.34; 95% CI 1.04–5.26; *P* < .05) but had similar rates of neonatal intensive care unit

Table 2. Underlying medical problems of survey respondents*

Diagnosis	No.	%
Asthma	30	10
Thyroid	18	6
Depression/psychiatric	16	5
Autoimmune	11	4
Hypertension	7	2
Cancer	7	2
Other†	22	7

* Individual women may have had more than 1 medical problem.

† Other includes hypercoagulability (4), “other lung disease” (3), Raynaud's disease (3), celiac disease (2), endometriosis (2), and 1 woman each with diabetes mellitus, multiple sclerosis, ankylosing spondylitis, polycystic ovary syndrome, eczema, epilepsy, pulmonary embolism, and deep vein thrombosis.

Table 3. Outdoor activities currently and during first pregnancy

Activity	Current		Anytime during first pregnancy		First trimester only		First and second trimesters only		All trimesters	
	No.	%	No.	%	No.	%	No.	%	No.	%
Hiking	273	92	250	84	28	9	57	19	148	50
Running	230	77	199	67	70	23	61	20	62	21
Car camping	201	67	140	47	34	11	43	14	40	13
Swimming	199	67	199	67	18	6	31	10	110	37
Yoga	179	60	181	61	11	4	23	8	120	40
Resort skiing/snowboarding	177	59	96	32	50	17	26	9	4	1
Trail running	168	56	118	40	54	18	32	11	23	8
Backpacking	167	56	88	30	36	12	33	11	10	3
Road biking	159	53	112	38	39	13	36	12	27	9
Snowshoeing	136	46	77	26	21	7	17	6	8	3
Cross-country skiing	131	44	86	29	20	7	23	8	11	4
Mountain biking	129	43	71	24	40	13	20	7	5	2
Backcountry skiing/snowboarding	101	34	52	17	22	7	11	4	9	3
Rock climbing	91	31	58	19	20	7	22	7	13	4
Mountaineering	75	25	36	12	21	7	6	2	6	2
Fishing	67	22	29	10	7	2	6	2	7	2
Canoeing	62	21	31	10	13	4	6	2	5	2
Sea kayaking	50	17	21	7	9	3	4	1	1	0
Dance	40	13	39	13	9	3	4	1	21	7
Tennis	37	12	20	7	9	3	7	2	2	1
Team sports (eg, ultimate Frisbee, soccer, basketball)	36	12	19	6	14	5	4	1	1	0
Golf	26	9	14	5	5	2	3	1	4	1
Ice climbing	21	7	12	4	8	3	2	1	0	0
White water kayaking	16	5	10	3	4	1	4	1	0	0
Search and rescue	14	5	10	3	3	1	4	1	1	0
Mountain guiding	7	2	4	1	3	1	0	0	0	0
Surfing	8	3								
Weight/fitness training	9	3					1	<1		
Horseback riding	6	2								
Other*	26	8	9	3	1	<1	7	2	1	<1

* Other includes rafting, gardening, paddle board, inline skating, roller derby, BASE jumping, skydiving, rowing, SCUBA, volleyball, snowmobiling, martial arts, badminton, parkour, jump roping, caving.

Figure 1. Maximum altitude attained by survey respondents during pregnancy. At each step, the number of women whose maximum elevation attained during pregnancy falls within the specified altitude range is listed. Excludes 2 women who did skydiving during pregnancy and reached altitudes of >6000 m by plane.

(NICU) admission (P = not significant) (Table 6). When preterm births were excluded, there was no difference in need for oxygen (P = not significant).

Babies born to women who resided at high altitude during pregnancy were more likely to have intrauterine growth retardation (IUGR), need oxygen at birth, and be admitted to the NICU than lowland residents with or without altitude travel during pregnancy (Tables 5 and 6).

Discussion

The results of this survey, the largest to date examining physical activity and high altitude during pregnancy, found that a select population of women are active

outdoors during pregnancy. A large number of these travel to and are active at high altitude, engaging in a wide range of physical activities, with low rates of pregnancy and neonatal complications.

Despite the fact that published guidelines refer to risks of high altitude travel, only a small percentage of women in our study reported receiving counseling from their medical providers regarding high altitude activities. The low fraction of women who reported receiving counseling is consistent with results published in prior studies about the rates of counseling about exercise during pregnancy.⁹ One possibility is that providers may not offer advice about high altitude activity due to the lack of evidence regarding the safety of short-term visits, or that advice was offered, but not recalled.¹⁰ In addition, published guidelines may not be readily accessible to all providers. Finally, women may not have received counseling because they did not seek specific advice from their provider or did not tell their provider of their plans to travel to high altitude.

Even though the reported rates counseling were low, the majority of women changed their participation in some activities and almost half changed their exercise intensity during pregnancy. Only hiking, running, swimming, and yoga were commonly continued throughout pregnancy. Many outdoor activities may become physically difficult or uncomfortable due to the pregnant body habitus prompting women to stop or modify their activity. The fact that they changed their activities despite not receiving medical provider advice may also reflect the fact that women receive advice from sources other than their clinicians, such as friends, websites, and blogs run by nonmedical providers.

Table 4. Altitude visits during pregnancy

Total number of pregnancies*	459
Number (%) of high altitude residents (>140 days above 2500 m during pregnancy)	25 (5%)
Travel to high altitude during pregnancy (number, %)	219 (48%)
During first pregnancy	172 (58%)
During second pregnancy	61 (45%)
During third pregnancy	11 (38%)
Mean altitude for those travelling above 2440 m (range)	3277 m (2440 m–7100 m)
Number (%) of women who slept above 2440 m during any pregnancy	139 (32%)
Mean number of days (range) above 2440 m during any pregnancy	13 (1–100)

* Includes only those with responses to altitude travel questions and excludes high altitude residents (>140 days above 2440 m during pregnancy).

Figure 2. Proportion of women receiving counseling about exercise and high altitude during pregnancy.

In published guidelines regarding high altitude travel, it is recommended that pregnant women rest or limit their activity during the first several days at high altitude.^{2,11} In our survey, however, slightly more than 40% of women made only single-day trips to high altitude, suggesting that a significant number of women are active immediately following exposure, rather than providing more time for acclimatization and physiologic adaptation. It is likely that

day trips are more common among those who live near high altitude regions, as this proximity facilitates rapid ascent and descent. Our survey did not allow us to verify this possibility. In addition, we cannot comment on whether women who made multiday trips took time to acclimatize, but given the low number of women who received advice regarding high altitude activity, we suspect that many women did not.

Table 5. Pregnancy complications*

Complication	All pregnancies [†] (n = 459)		No high altitude exposure (n = 215)		High altitude exposure [‡] (n = 219)		High altitude residents (n = 25)	
	No.	%	No.	%	No.	%	No.	%
Caesarean section	94	21	41	19	45	21	8	32
Miscarriage	9	2	6	3	3	1	0	0
Hypertension	38	8	14	7	22	10	2	8
Preeclampsia	17	4	8	4	8	4	1	4
Eclampsia	2	0	1	0	1	0	0	0
Gestational diabetes mellitus	9	2	3	1	5	2	1	4
Intrauterine growth retardation	6	1	0	0	3	1	2	8
Preterm labor	31	7	8	4	18	8 [§]	3	13
Bed rest	29	6	11	5	15	7	3	13
First trimester bleeding	47	10	29	14 [¶]	13	6	1	4
Second trimester bleeding	10	2	4	2	5	2	0	0
Third trimester bleeding	6	1	4	2	1	0	0	0
Induced delivery	83	17	39	19	35	16	8	32
Ectopic	1	0	1	0	0	0	0	0
Placenta previa	7	2	5	2	1	0	1	4
Abruption	1	0	0	0	1	0	0	0

* Percentages are based on number of responses to specific yes/no questions about each complication and not total number of pregnancies. Not all respondents answered every question.

[†] All pregnancies for which we received survey answers regarding complications and high altitude exposure.

[‡] Excluding women who lived at high altitude.

[§] $P = .05$ vs no high altitude exposure.

^{||} $P < .05$ compared with non-high altitude residents with and without HA exposure.

[¶] $P < .05$ vs. women with HA exposure (nonresidents and residents).

Table 6. Perinatal complications*

Complication	All pregnancies		No high altitude exposure		High altitude exposure [†]		High altitude residents	
	No.	%	No.	%	No.	%	No.	%
Birth defects	7	2	4	2	2	1	1	4
Need for oxygen	38	8	9	4	20	9 [‡]	9	36 [§]
NICU admissions	26	6	7	3	15	7	4	17 [§]
Born at <30 weeks	3	1	0	0	3	1	0	0
Born at <36 weeks	13	3	5	2	8	4	0	0
Born at <40 weeks	170	38	75	35	86	40	9	38
Born at >42 weeks	27	6	11	5	15	7	1	4
Stillbirth	4	1	2	1	2	1	0	0

* Percentages are based on number of responses to specific yes/no questions about each complication and not total number of pregnancies. Not all respondents answered every question.

[†] Excluding women who lived at high altitude.

[‡] $P < .05$ vs no high altitude exposure.

[§] $P < .05$ compared with nonhigh altitude residents with and without high altitude exposure.

Our data suggest that most healthy, active women with uncomplicated pregnancies can safely travel to and exercise at high altitude, as the complication rates reported by our respondents were comparable to those of the general population. For example, currently about 33% of deliveries are by cesarean section in the United States, but only 21% had cesarean sections in our sample.¹² Given the age of some of our survey respondents, some of the pregnancies for which data were provided in our survey may have occurred up to 25 years earlier when cesarean section rates were near 21%.¹³ The frequency of birth defects in the United States overall is 3%, whereas 1% of respondents reported this complication.¹⁴ These results need to be interpreted with caution, however, as our data is based on the individual's recall of their pregnancy outcomes rather than a review of medical records. In addition, all of the women in our sample were physically active, and regular exercise during pregnancy has been associated with improved pregnancy outcomes.^{15,16}

The data regarding bleeding in pregnancy is another area where caution is warranted in interpreting the results. Due to the limitations in our survey, we were unable to determine when high altitude travel occurred relative to the bleeding event and as a result are not able to establish a causal relationship. For example, a woman may have had first trimester bleeding and then traveled to high altitude in the third trimester, in which case the 2 events would be unrelated to each other. Another explanation is that women who had this complication in the first trimester were more cautious and did not travel to high altitude because of a perceived risk.

One complication for which lowland residents traveling to high altitude were at higher risk in our survey was

preterm labor, where the frequency was nearly twice as high as in those without high altitude exposure during pregnancy. The reason for this preliminary finding is not clear. One explanation may relate to the timing of ascent and physical activity relative to the stage of gestation. It is possible that third trimester exposure to high altitude hypoxia may increase the risk of preterm labor. We were unable to determine during which trimester high altitude exposure occurred in our survey participants. We also cannot account for other confounding variables that may influence preterm labor. Because the lower limits of the 95% confidence intervals approach the value of 1, it is possible that no clinically important clinical difference exists. Of note, the current US population rate of preterm births is 11.5%, and in our sample even the women who traveled to high altitude during pregnancy had a frequency that fell below this population average.¹²

Although we saw a statistical increase in the need for oxygen at birth in babies born to women who had high altitude exposure, there was no difference in admission to NICU, suggesting this finding is of minimal clinical importance. In addition, this difference may be accounted for by the increase in preterm labor, as the difference in need for oxygen at births was no longer statistically significant when preterm births were excluded.

Among the small number of high altitude residents, we found an increased risk of IUGR and need for fetal NICU admission and oxygen administration following delivery. These results are similar those previously documented in the literature.^{17,18} In contrast to prior studies, however, we did not see increased rates of pregnancy-related hypertension, preeclampsia, preterm labor, or stillbirths among the high altitude residents.¹⁷⁻¹⁹ This may be due to differences in altitude of residence

among our survey respondents compared with prior studies, or due to the fact that our survey process selected for a population of healthy, active women that is not necessarily reflective of the general population residing at high altitude.

LIMITATIONS

As an anonymous, online survey, this study has several important limitations. All the responses regarding complications are self-reported and not confirmed by medical record review, which could lead to over- or under-estimation of the true complication rate in our population. Some of the terms such as IUGR have specific medical definitions that respondents may not have understood. Furthermore, the survey results are susceptible to the risk of recall bias, especially given the time that had lapsed since some of the reported pregnancies occurred.

Due to the forums in which we advertised our survey, we attracted survey responses from active, healthy women who were likely to participate in mountain activities or live in communities with high altitude access. Our results may not be applicable to the general population and, in particular, to sedentary women, those with underlying medical problems or complicated pregnancies, and those from other geographical areas far away from the mountains. The generalizability of the survey results is also limited by the fact that the total number of participants was small relative to the total number of pregnant women each year as well as the fact that the majority of our respondents came from a single country, the United States, where clinical practice, counseling, and other aspects of obstetric care may differ from other countries.

Our survey may have also been underpowered to detect differences in complications with low prevalence and we did not make statistical adjustments for multiple comparisons.

Given the multiple limitations of this approach to gathering information, our findings should be viewed as preliminary and are presented for the purpose of generating hypotheses for future studies on these questions. They should not be used as a basis for advising for or against high altitude travel in pregnant women. Instead, providers should rely on existing guidelines and a careful case-by-case assessment of each pregnant patient to determine the suitability of planned activities at low and high altitude.

Conclusions

Our data demonstrate that a select population of women is active in mountain sports and travel to high altitude during

pregnancy with low rates of self-reported pregnancy and neonatal complications. Given the limitations of the current survey, further research and, in particular, prospective data is warranted to clarify whether there are risks associated with high altitude travel and physical activity and how these risks apply to the larger, general population.

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Supplemental Materials

The survey is available online at: <http://dx.doi.org/10.1016/j.wem.2016.02.010>.

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