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The association between waterbirth and perineal injury or other adverse outcomes among low-risk women with physiological birth: Results from the Nordic Home Birth Cohort Study

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ABSTRACT

Problem/background: Immersion in water has known benefits, such as reducing pain and shortening the duration of labour. The relationship between waterbirth and perineal injury remains unclear.
Aim: To compare the incidence of perineal injury in waterbirth and birth on land among low-risk women. Secondary outcomes were postpartum haemorrhage and 5-minute Apgar scores <7.
Methods: Prospective cohort study of 2875 low-risk women who planned a home birth in Denmark, Iceland, Norway, and Sweden in 2008–2013 and had a spontaneous vaginal birth without intervention. Descriptive statistics and logistic regression were performed.
Findings: A total of 942 women had a waterbirth, and 1933 gave birth on land. The groups differed in their various background variables. Multiparous women had moderately lower rates of intact perineum (59.3% vs. 63.9%) and primiparous women had lower rates of episiotomies (1.1% vs. 4.8%) in waterbirth than in birth on land. No statistically significant differences were detected in adjusted regression analysis on intact perineum in waterbirth (primiparous women's aOR = 1.03, CI 0.68–1.58; multiparous women's aOR = 0.84, CI 0.67–1.05). The rates of sphincter injuries (0.9% vs. 0.6%) were low in both groups. No significant differences were detected in secondary outcomes.
Discussion: The decreased incidence of intact perineum among multiparous women was modest and inconclusive, and the prevalence of sphincter injury was low.
Conclusion: Low-risk women contemplating waterbirth should be advised to weigh the risks and benefits detected in this study against previously established benefits of waterbirth and should make an informed choice based on their values.

Statement of significance:

Problem/issue:

Waterbirth has many established benefits. Evidence of its effect on perineal outcomes is inconclusive and predominantly based on mixed-risk settings.

What is Already Known:

Systematic reviews on randomised controlled trials show no effect of waterbirth on perineal outcomes. There is a wide discrepancy in the results of observational studies.

What this Paper Adds:

No statistically significant differences in intact perineum rates

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were detected in adjusted regression analysis on waterbirth vs. birth on land, when stratified by parity. Rates of third- and fourth-degree tears are low among low-risk women.

1. Introduction

The first registered waterbirth occurred in France in 1803. A 1983 Lancet article, in which the French physician Michel Odent described observations he had made of 100 waterbirths [1], was the beginning of a modern waterbirth movement that led to the use of waterbirths by hospitals. Waterbirth can facilitate a physiological and woman-centred birth [2]. Birthing tubs are thus widely used in home births and midwife-led birth units where medical pain relief is not available [3,4]. In England, it is recommended that the opportunity to birth in water should be available to all healthy women [5] and many other Western countries have followed suit.

The use of water immersion has been found to have a positive effect on a woman who is in labour. Warm water increases blood flow and temperature in the muscles and joints, increasing muscle relaxation, uterine blood flow in the uterus, and oxytocin secretion, which in turn can lead to more effective contractions [6]. Qualitative studies on the experiences, feelings, and views of women who use water immersion in labour and birth have revealed themes of knowledge, autonomy, and control [7], empowerment, liberation, and transformation [8]. Water immersion facilitates movement and position changes, and women's needs for effective analgesia are frequently met by the calming and comforting effect of water [8]. Women who use water immersion for pain relief in the first stage of labour are less likely to use regional anaesthesia than women who do not use water [2].

Individual studies differ in their results on maternal and neonatal complication rates in land birth and waterbirth, but no decisive overall differences on variables such as postpartum haemorrhage (PPH), neonatal intensive care unit (NICU) admissions, or symptoms of neonatal infection have been found in systematic reviews [2]. A 2018 Cochrane review of randomised controlled trials published in 1993–2015 found no link between waterbirth and perineal injury rates [2]. Little consensus has been found among observational studies on perineal outcomes in waterbirth that have been published in the last decade.

Studies are rarely powered to detect differences in severe perineal injury involving the anal sphincter, i.e., third- and fourth-degree tears, which generally have low incidences. Studies that detect statistically significant differences between waterbirth and birth on land have either detected higher [9] or lower [10,11] rates of third- and fourth-degree tears in waterbirth. When second-degree tears are examined separately, the effect of waterbirth seems to be predominantly positive [12–14]. Rates of a composite variable of first- or second-degree tears have either been found to be significantly higher [15] or lower [16] in waterbirths than in births on land, while significantly higher first-degree tear rates have been detected in waterbirths when examined separately [17]. Many studies have examined the rates of intact perineum and either found them to be significantly higher [15,16,18,19] or lower [17, 20] in waterbirths than in births on land, or found no differences [10,21, 22]. The only consistently positive effect of waterbirth on perineal outcomes in separate studies is a significantly lower episiotomy rate [15, 22].

Adverse perineal outcomes after birth can severely impact a woman's health and wellbeing. Complications such as urine, air, or faecal incontinence can follow, as well as dyspareunia [23,24]. The degree of discomfort after a perineal injury is directly related to the degree of perineal tear [25] and women with a second-degree tear or episiotomy may experience considerable pain postpartum [26]. Perineal pain can lead to reduced mobility and pain when urinating or defecating and can negatively impact the woman's ability to breastfeed or care for the newborn [23]. Possible risk factors for having a perineal tear include being a first-time mother [27,28], having a large baby [27–29], or a prolonged second stage of birth [29]. Operative births, a midline or mediolateral episiotomy [28,30], oxytocin stimulation, and an insufficient overview of the perineum at birth [30] have been associated with sphincter injuries. Additionally, the recurrence risk of a third- or fourth-degree tear in a subsequent birth is high [31].

Implementing preventative measures that protect the integrity of the perineum is a key component of midwifery care in labour. The use of warm compresses has been associated with decreased risk of third- or fourth-degree perineal tears in randomised controlled trials [25]. A midwifery practice of creating a calm atmosphere, perineum-sparing positions, observation of the perineum, a slow crowning, and a predominantly hands-on technique has been found among midwives with confirmed low incidences of perineal tears in their practice [32]. Some observational studies have detected lower rates of severe perineal tears after the implementation of a hands-on technique [30,33,34], while others have found improved perineal outcomes using a hands-poised approach [35] or a combination approach without perineal support [36]. A Cochrane review on randomised controlled trials suggests that a hands-on technique has no benefits over the hands-poised approach [25]. Midwives less frequently have a full view of the perineum or use full manual perineal protection in waterbirths than in births on land [13]. It remains unclear whether waterbirth, which offers a calm atmosphere and easy positioning, and introduces warmth to the perineum, but prevents full hands-on perineal support, has a positive or a negative effect on the rates of perineal tears.

A common element in previous studies on the effect of waterbirth on perineal injury rates is a hospital setting serving a mixed-risk group of women, with a few exceptions [10,12,20]. Further studies on the effects of waterbirth on perineal tear rates among low-risk women planning birth in a low-risk setting may therefore fill a gap in the literature. The database of the Nordic Home Birth Study, which examined the outcome of home births in four Nordic countries, Denmark, Iceland, Norway, and Sweden [37], offers an opportunity to conduct the first study of its kind in the Nordic region.

The aim of this study was to compare the incidence of perineal injury in waterbirth and birth on land, including episiotomies, among low-risk women planning a home birth and having a spontaneous vaginal birth in these four Nordic countries. Secondary outcomes of the study are the rates of postpartum haemorrhage and 5-minute Apgar scores <7. The purpose of the study is to provide knowledge to support women's informed choice in waterbirth.

2. Participants, ethics and methods

This prospective cohort study is based on data from the Nordic Home Birth Study, which has previously been described elsewhere [37]. The study utilised data on women who planned a home birth in Denmark, Iceland, Norway, or Sweden in 2008–2013 and were low-risk at the onset of labour. All home birth midwives were asked to recruit their clients. Women who had chosen and been accepted by home birth services at labour onset were eligible for inclusion [37]. A substantial proportion of planned home births in Norway, Sweden, Denmark, and Iceland were identified in this study, leading to an estimated 70–90% inclusion rate in the study period, depending on the country, when participants' numbers were compared to registered home birth rates [37]. Participants received information on the study in pregnancy or labour, signed a consent form and completed a background information questionnaire. Their home birth midwife registered and submitted a structured item list with information on the birth and immediate postpartum period. Data were predominantly registered prospectively, either on paper or in digital form [37].

In total, data from 3068 women were collected in the Nordic Home Birth Study. This study only includes planned home births where women had spontaneous vaginal births (Fig. 1). Women who had an

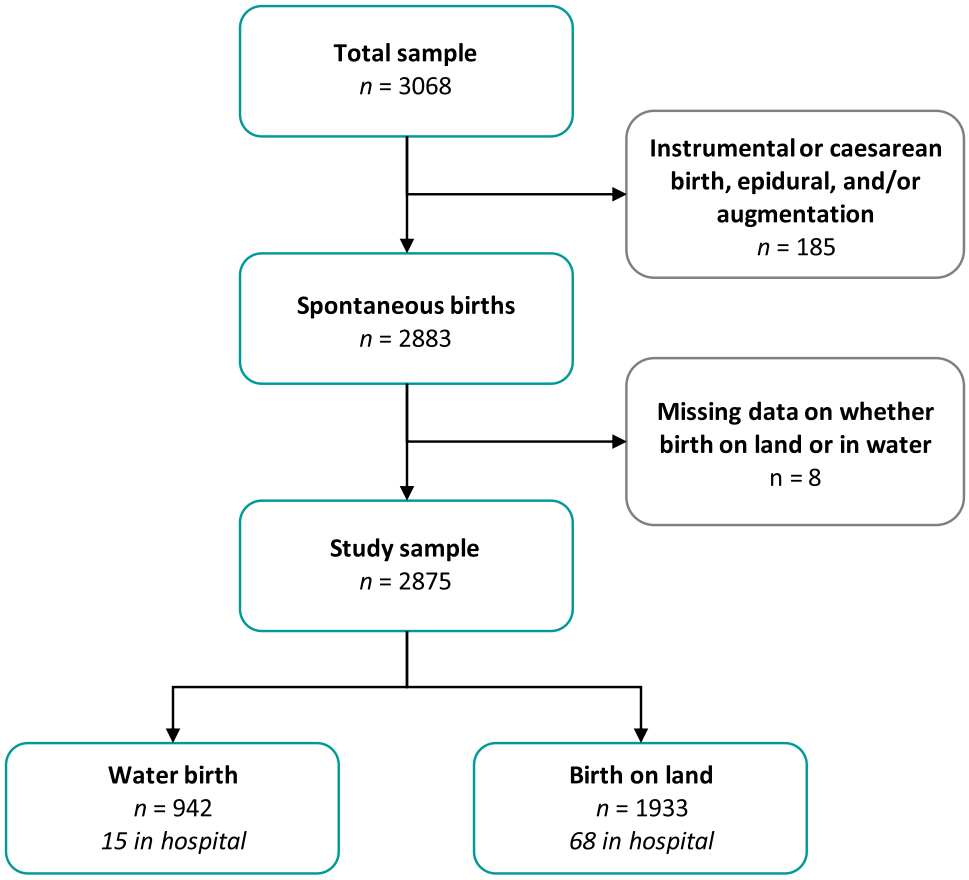

Fig. 1. Spontaneous vaginal planned home births in four Nordic countries in 2008–2013 with data on birth in water vs. on land. Data from the Nordic Home Birth Study.

instrumental or caesarean birth, epidural analgesia, or oxytocin augmentation were excluded (n = 185), as were eight women whose information on whether they had given birth in water or on land was missing, leaving a final sample of 2875 women.

The independent exposure variable of this study was birth in water, defined as any birth where the attending midwife would answer "yes" to the question "Did the woman give birth in water?" This variable defined the two study groups by birth location: Waterbirth (research group), and birth on land (control group).

Background variables that were available in the Nordic Home Birth data collection, and were considered clinically relevant for this study, were: previous caesarean section, previous sphincter injury, previous PPH > 1000 ml, year of birth, country of residence, maternal age, marital status, parity, body mass index (BMI), smoking habits, duration of active second stage of labour, foetal presentation, and birth weight (birth length and head circumference were excluded due to high correlation with birth weight). Duration of active second stage and birth weight were included in regression models for all women. For multiparous women, the perineal outcomes were additionally adjusted for previous third- or fourth-degree tears and PPH outcome for previous PPH ≥ 1000 ml.

The primary dependent outcome variables of the study were perineal injuries, with a main focus on intact perineum. Data on perineal outcomes in the Nordic Home Birth Study were registered and collected as: "Uncomplicated sutured tears" (no / yes), which consists of first- and second-degree tears, including labial and vaginal tears; "Episiotomy" (no / yes); and "Sphincter injury" (no / yes), which consists of third- and fourth-degree tears. Separate variables for first- and second-degree tears, respectively, were not available in the dataset. It is common practice neither to suture the smallest skin abrasions nor to register them as first-degree tears in all four countries under study, and to include labial tears with first-degree tears in most of the countries under study. Previous home birth studies in the Nordic countries have not described labial tear outcomes separately [38–40]. A new combination variable was created: "Intact perineum" (no / yes), excluding first- to fourth-degree tears and episiotomies. Within the variable "Intact perineum" small abrasions that midwives considered not to need suturing could occur. Other primary outcome variables were "first- and second-degree tear," including labial and vaginal tears, "third- and fourth-degree tear," and "Episiotomy."

The secondary outcomes in this study are PPH and Apgar scores. Data on PPH were collected as total bleeding in millilitres during childbirth and up to two hours postpartum, as estimated by the midwife. The variables used in the study were two dichotomous variables: "PPH ≥ 500 ml" (no / yes) and "PPH ≥ 1000 ml" (no / yes). Apgar scores were collected on a 0–10 scale at one, five and ten minutes. The variable used in the study was the dichotomous variable "Apgar score <7 at five minutes" (no / yes).

2.1. Statistical analysis

Complete datasets were available for most women in this study. Of the variables we used in the study, the total proportion of missing values was 3.1%. The variables with the highest proportion of missing values were previous sphincter injury and BMI. The missing data in this study were considered complete at random. A sensitivity analysis using multiple imputations in regression analysis was performed but did not change the statistical significance of the results. Therefore, we present the results from the complete case dataset.

Descriptive statistics were used to describe background and outcome variables. To examine differences between the group of women that had

a waterbirth and the group that gave birth on land, chi-square tests were performed for categorical variables, T-tests for normally distributed continuous variables, and Mann–Whitney U tests for continuous variables that were not normally distributed. The significance level for the p-value was set to 0.05 in all statistical analyses. Results were presented as numbers and percentages (n (%)) for categorical variables and as means and standard deviations (mean ± SD) for continuous variables. Background characteristics of the 2875 women are described in Table 1 and their outcome variables in Table 2, including the rates of missing data.

Logistic regression was used to further investigate whether waterbirth was associated with the likelihood of perineal injuries and postpartum haemorrhage. The outcome variables "Intact perineum," "first- and second-degree tears," and "PPH ≥ 500 ml" were chosen for regression analysis. The low observed numbers of sphincter injury, episiotomies, PPH ≥ 1000 ml and 5-minute Apgar scores <7 were considered likely to increase the risk for type II errors, and therefore were not included in the regression analysis.

The independent variable, waterbirth vs. birth on land, and the confounding variables were analysed simultaneously in a multivariate logistic regression model. Potential cofounders were identified through the Directed Acyclic Graph (DAG) method. Cofounders were chosen for multivariate logistic regression analysis based on clinical relevance and a forward stepwise regression analysis, where variables that did not significantly affect the analysis were excluded (S1: DAGs). All outcome variables were stratified by parity. The results are presented in Table 3 as Odds Ratios (ORs), Adjusted Odds Ratios (aORs), and their 95% Confidence intervals (CIs). IBM SPSS software package 28.0 was used for all analysis.

3. Findings

In this cohort study, 2875 women who planned a home birth and had spontaneous vaginal births were included. Of these women, 2760 (96%) gave birth at home as planned, while 83 (3%) gave birth in hospital. A total of five women gave birth either during transport or under the category "other" and data on place of birth were missing for 27 women (1%). Of the 2875 women, 942 had a waterbirth (33%), thereof 15 gave birth in hospital, and 1933 gave birth on land (67%), thereof 68 in hospital (Fig. 1).

Table 1 presents the women's background characteristics, divided into waterbirth and birth on land. A large majority of women in both groups were multiparous and either married or cohabiting. Compared to overall birth rates, women in Denmark and Iceland were more likely to have chosen waterbirth than were women in Norway and Sweden (Table 1). Women who had a waterbirth were more likely to be primiparous and of younger age, to have a previous history of caesarean birth or third- or fourth-degree tears, to give birth in a position which gives the sacrum flexibility of movement, and to have a baby in an occiput-anterior position than women giving birth on land. No significant differences were found between the groups in BMI, smoking habits, previous PPH ≥ 1000 ml, gestational age, duration of active second stage of labour, and infant's birth weight (Table 1).

Table 2 presents the incidence of perineal injuries, postpartum haemorrhage and 5-minute Apgar scores <7, divided into waterbirth and birth on land, and p-values for chi-square tests. When examining a combination variable that excluded all perineal injuries, a total of 1615 women (57.3%) had an intact perineum after birth. The rate of intact perineum was statistically significantly lower in waterbirth than in births on land (53.9% vs. 59.0%, p = 0.010). Crude analysis found no differences in a subgroup of primiparous women. The proportion of multiparous women with an intact perineum was twice as high as the proportion of first-time mothers (62.4% vs. 33.3%).

The overall rate of first- and second-degree tears was 41.5%. Statistically significantly higher rates were found in waterbirths than in births on land (44.6% vs. 39.9%, p = 0.018), but as with intact perineum, the crude analysis found no differences in a subgroup of primiparous women. The rates of severe perineal injury were low and differences between groups were not significant. A total of 19 women (0.7%) had a third- or fourth-degree tear, with higher rates in waterbirths (0.9% vs. 0.6%), and 20 women (0.7%) had an episiotomy, with lower rates in waterbirths (0.3% vs. 0.9%). Only three of the episiotomies were performed on women who gave birth in water and only one woman had both an episiotomy and a third- or fourth-degree tear. Primiparous women that had a waterbirth were statistically significantly less likely to have an episiotomy than primiparous women giving birth on land, but the absolute numbers in the calculation were very low.

As presented in Tables 2, 8.6% of the study population had a PPH ≥ 500 ml and 1.2% had a PPH ≥ 1000 ml. There was no significant difference in the incidence of PPH ≥ 500 ml and ≥ 1000 ml between women giving birth in water and on land. A total of 16 babies had a 5-minute Apgar score <7. Although the incidence of low Apgar scores was lower in waterbirth (0.3%), compared to birth on land (0.7%), the difference was not statistically significant. None of the babies born to women who were transferred to hospital before giving birth had a 5-minute Apgar score <7.

Table 3 presents logistic regression analysis on three outcome variables: intact perineum, first- and second-degree tears, and PPH ≥ 500 ml. For the total group of women, those who had a waterbirth were less likely to have an intact perineum, both in unadjusted (crude OR 0.80 (95% CIs 0.66–0.96)) and adjusted analysis (aOR 0.79 (95% CIs 0.65–0.95)). Similarly, they were more likely to have first- and second-degree tears, both in unadjusted (crude OR 1.25 (95% Cis 1.04–1.50)) and adjusted analysis (aOR 1.25 (95% Cis 1.03–1.50)). However, when the analysis was stratified for parity, no statistically significant differences were detected. Differences in PPH ≥ 500 were not statistically significant in either unadjusted or adjusted regression analysis.

4. Discussion

No statistical differences were found in perineal tear rates in adjusted regression analysis, when stratified for parity. Rates of third- and fourth-degree tears, PPH, and 5-minute Apgar scores <5 were low. This cohort study examined 2875 low-risk women who planned to give birth at home. The women were carefully selected and had a spontaneous birth without interventions. One third of the women gave birth in water. Higher rates of water birth among primiparous women could, in the absence of deterring regulation, be explained by an increased need for pain relief, compared to multiparous women. Higher rates of waterbirth in Denmark and Iceland may be connected to higher home birth rates in these countries, which in turn may have normalized home birth services and elevated service levels, such as the provision of birthing pools.

Women who gave birth in water had higher rates of spontaneous perineal tears, compared to women giving birth on land, and a reduced probability of an intact perineum. However, these differences were only detected in the total group. No significant differences were detected in perineal tear rates of primiparous women, and their episiotomy rates were statistically significantly lower in waterbirths, although based on low absolute numbers. Marginally significant differences among multiparous women in chi-square tests became marginally non-significant in regression analysis, both crude and adjusted. The results may be different due to the different premises of the tests performed. Additionally, stratified analysis may have lacked statistical power according to post hoc power analysis. The incidence of severe injury in the form of third- or fourth-degree perineal tears was very low, 0.7%, and similar in waterbirths and births on land. No differences were found in PPH or low Apgar scores.

A Cochrane systematic review of randomised controlled trials from 2018 found no overall differences in perineal outcomes in waterbirth and birth on land [2], which is consistent with the heterogeneous results found in observational studies on the subject, as described above. This study adds to the growing evidence base on the associations of waterbirth and perineal outcomes and has the additional benefit of describing

Table 1
Women's background variables in spontaneous vaginal planned home births in four Nordic countries in 2008-2013, by birth location: in water vs. on land. Data from the Nordic Home Birth Study.

	All		Water		Land		*p-value*
	n = 2875		n = 942		n = 1933		
Country of residence, n(%)							
Norway	451	(15.7)	107	(11.4)	344	(17.8)	<0.001
Sweden	420	(14.6)	29	(3.1)	391	(20.2)	
Denmark	1738	(60.5)	678	(72.0)	1060	(54.8)	
Iceland	266	(9.3)	128	(13.6)	138	(7.1)	
Missing	0	(0.0)	0	(0.0)	0	(0.0)	
Parity, n(%)							
Primiparous	459	(16.0)	179	(19.0)	280	(14.5)	0.002
Multiparous	2379	(82.7)	752	(79.8)	1627	(84.2)	
Missing	37	(1.3)	11	(1.2)	26	(1.3)	
Age, n(%)							
< 20	10	(0.3)	4	(0.4)	6	(0.3)	<0.001
20-24	175	(6.1)	76	(8.1)	99	(5.1)	
25-29	713	(24.8)	259	(27.5)	454	(23.5)	
30-34	1134	(39.4)	370	(39.3)	764	(39.5)	
35-39	702	(24.4)	196	(20.8)	506	(26.2)	
≥ 40	126	(4.4)	34	(3.6)	92	(4.8)	
Missing	15	(0.5)	3	(0.3)	12	(0.6)	
Marital status, n(%)							
Married	2230	(77.6)	775	(82.3)	1455	(75.3)	<0.001
Cohabiting	576	(20.0)	152	(16.1)	424	(21.9)	
Single	42	(1.5)	14	(1.5)	28	(1.4)	
Other	5	(0.2)	0	(0.0)	5	(0.3)	
Missing	22	(0.8)	1	(0.1)	21	(1.1)	
BMI[d] (kg/m2), mean±SD / n(%)	23,4	±3.9	23,4	±3.7	23,4	±3.9	0.933[a]
< 18,5	97	(3.4)	25	(2.7)	72	(3.7)	0.385
18,5-24,9	1867	(64.9)	635	(67.4)	1232	(63.7)	
25-29,9	505	(17.6)	165	(17.5)	340	(17.6)	
≥ 30	186	(6.5)	61	(6.5)	125	(6.5)	
Missing	220	(7.7)	56	(5.9)	164	(8.5)	
Smoking, n(%)							
No	2632	(91.5)	853	(90.6)	1779	(92.0)	0.335
Yes	187	(6.5)	67	(7.1)	120	(6.2)	
Missing	56	(1.9)	22	(2.3)	34	(1.8)	
Previous caesarean section, n(%)							
No	2736	(95.2)	880	(93.4)	1856	(96.1)	0.002
Yes	138	(4.8)	62	(6.6)	76	(3.9)	
Missing	1	(0.0)	0	(0.0)	1	(0.0)	
Previous third- or fourth-degree tear, n(%)							
No	2257	(78.5)	695	(73.8)	1562	(80.8)	0.003
Yes	47	(1.6)	24	(2.5)	23	(1.2)	
Missing	571	(19.9)	223	(23.6)	348	(18.0)	
Previous PPH > 1000 ml, n(%)							
No	2831	(98.5)	930	(98.7)	1901	(98.3)	0.493
Yes	43	(1.5)	12	(1.3)	31	(1.6)	
Missing	1	(0.0)	0	(0.0)	1	(0.1)	
Gestational age, n(%)							
< 37	8	(0.3)	0	(0.0)	8	(0.4)	0.080
37- 41 $^{+6}$	2723	(94.7)	891	(94.6)	1832	(94.8)	
≥ 42 $^{+0}$	78	(2.7)	30	(3.2)	48	(2.5)	
Missing	66	(2.3)	21	(2.2)	45	(2.3)	
Birth position, n(%)							
Semi-recumbent	657	(22.9)	303	(32.2)	354	(18.3)	<0.001
Supine	219	(7.6)	22	(2.3)	197	(10.2)	
Lateral	398	(13.8)	46	(4.9)	352	(18.2)	
Squatting	217	(7.5)	80	(8.5)	137	(7.1)	
All-fours	317	(11.0)	71	(7.5)	246	(12.7)	
Kneeling	727	(25.3)	346	(36.7)	381	(19.7)	
Standing	212	(7.4)	16	(1.7)	196	(10.1)	
Birth seat	25	(0.9)	1	(0.1)	24	(1.2)	
Other	19	(0.7)	9	(1.0)	10	(0.5)	
Missing	84	(2.9)	48	(5.1)	36	(1.9)	
Duration of second stage, min, mean±SD [b]	18.6	±22.4	17.5	±20.2	19.2	±23.4	0.785[a]
Missing	73	(2.5)	23	(2.4)	50	(2.6)	
Presentation, n(%)							
Occiput-anterior	2734	(95.1)	916	(97.2)	1818	(94.1)	<0.001
Occiput-posterior	63	(2.2)	12	(1.3)	51	(2.6)	
Vertex, other	44	(1.5)	4	(0.4)	40	(2.1)	
Breech	3	(0.1)	0	(0.0)	3	(0.2)	
Other/unknown	6	(0.2)	2	(0.2)	4	(0.2)	
Missing	25	(0.9)	8	(0.8)	17	(0.9)	
Birthweight, mean±SD / n(%)	3684	±456	3689	±450	3682	±459	0.681[c]

(*continued on next page*)

Table 1 (*continued*)

	All		Water		Land		*p-value*
	n = 2875		n = 942		n = 1933		
< 3000 g	128	(4.5)	46	(4.9)	82	(4.2)	0.827
3000-3999 g	1959	(68.1)	636	(67.5)	1323	(68.4)	
4000-4499 g	581	(20.2)	196	(20.8)	385	(19.9)	
≥ 4500 g	135	(4.7)	44	(4.7)	91	(4.7)	
Missing	72	(2.5)	20	(2.1)	52	(2.7)	

BMI: body mass index, PPH: postpartum haemorrhage, SD: standard deviation

[a] Mann–Whitney U test

[b] Duration from onset of pushing until the birth of the baby

[c] T-test

Table 2

Maternal and neonatal birth outcome rates and means in spontaneous vaginal planned home births in four Nordic countries in 2008-2013, by parity and birth location: in water vs. on land. Data from the Nordic Home Birth Study.

	Total group				Primiparous women				Multiparous women			
	All n=2875	*Water n=942*	*Land n=1933*	p-value	*All* n=459	*Water n=179*	*Land n=280*	p-value	*All n=2379*	*Water n=752*	*Land n=1627*	p-value
PRIMARY OUTCOMES:												
Intact perineum, n(%)	1615 (57.3)	498 (53.9)	1117 (59.0)	0.010	149 (33.3)	57 (32.8)	92 (33.6)	0.858	1456 (62.4)	438 (59.3)	1018 (63.9)	0.032
Missing	*58 (2.0)*	*18*	*40*		*11 (2.4)*	*5*	*6*		*47 (2.0)*	*13*	*34*	
First- and second-degree tear, n(%)	1178 (41.5)	417 (44.6)	761 (39.9)	0.018	283 (62.6)	111 (62.4)	172 (62.8)	0.929	869 (36.9)	299 (40.1)	570 (35.5)	0.032
Missing	*34 (1.2)*	*7*	*27*		*7 (1.5)*	*1*	*6*		*27 (1.1)*	*6*	*21*	
Third- and fourth-degree tear, n(%)	19 (0.7)	8 (0.9)	11 (0.6)	0.367	11 (2.5)	4 (2.4)	7 (2.5)	1.000[a]	7 (0.3)	3 (0.4)	4 (0.2)	0.519[a]
Missing	*46 (1.6)*	*24*	*22*		*16 (3.5)*	*13*	*3*		*30 (1.3)*	*11*	*19*	
Episiotomy, n(%)	20 (0.7)	3 (0.3)	17 (0.9)	0.088	15 (3.3)	2 (1.1)	13 (4.8)	0.035	5 (0.2)	1 (0.1)	4 (0.2)	1.000[a]
Missing	*31 (1.1)*	*8*	*23*		*8 (1.7)*	*1*	*7*		*23 (1.0)*	*7*	*16*	
SECONDARY OUTCOMES:												
PPH≥500ml, n(%)	232 (8.6)	69 (7.7)	163 (9.0)	0.264	68 (15.9)	22 (13.4)	46 (17.5)	0.263	160 (7.1)	45 (6.3)	115 (7.5)	0.272
Missing	*172 (6.0)*	*49*	*123*		*32 (7.0)*	*15*	*17*		*134 (5.6)*	*33*	*101*	
PPH≥1000ml, n(%)	32 (1.2)	13 (1.5)	19 (1.0)	0.359	9 (2.1)	5 (3.0)	4 (1.5)	0.314[a]	23 (1.0)	8 (1.1)	15 (1.0)	0.776
Missing	*172 (6.0)*	*49*	*123*		*32 (7.0)*	*15*	*17*		*134 (5.6)*	*33*	*101*	
5 minute Apgar <7, n(%)	16 (0.6)	3 (0.3)	13 (0.7)	0.226	2 (0.4)	1 (0.6)	1 (0.4)	1.000[a]	14 (0.6)	2 (0.3)	12 (0.7)	0.249[a]
Missing	*23 (0.8)*	*3*	*20*		*1 (0.2)*	*0*	*1*		*21 (0.9)*	*3*	*18*	

Missing data on parity: n = 37

Percentages may not add up to 100 because of rounding up.

PPH: postpartum haemorrhage

[a] Fisher's exact test. Other significance tests are chi-squared.

Table 3

Odds Ratios for elected outcomes in spontaneous vaginal planned home births in four Nordic countries in 2008-2013, by parity and birth location: in water vs. on land. Data from the Nordic Home Birth Study.[*].

	Land	*Water*											
		Total group (n = 2875)				*Primiparous women (n = 459)*				*Multiparous women (n = 2379)*			
		Crude	*Adjusted*[**]			*Crude*	*Adjusted*[***]			*Crude*	*Adjusted*[****]		
	OR - Ref	*OR*	*95% CI*	*AOR*	*95% CI*	*OR*	*95% CI*	*AOR*	*95% CI*	*OR*	*95% CI*	*AOR*	*95% CI*
Intact perineum	1.00	0.80	[0.66–0.96]	0.79	[0.65–0.95]	0.98	[0.65–1.49]	1.03	[0.68–1.58]	0.84	[0.68–1.04]	0.84	[0.67–1.05]
First- and second-degree tear	1.00	1.25	[1.04–1.50]	1.25	[1.03–1.50]	1.01	[0.67–1.51]	0.95	[0.63–1.43]	1.20	[0.97–1.49]	1.18	[0.95–1.47]
PPH≥500ml	1.00	0.83	[0.62–1.12]	0.86	[0.64–1.17]	0.65	[0.37–1.14]	0.70	[0.39–1.25]	0.84	[0.58–1.19]	0.86	[0.60–1.24]

AOR: Adjusted Odds Ratio, CI: Confidence Interval, OR: Odds Ratio, PPH: postpartum haemorrhage

[*] Adjusted for duration of 2nd stage and birth weight

[**] Intact perineum (n = 2155) and 1st and 2nd degree tear (n = 2176): Additionally adjusted for previous 3rd or 4th degree tear. PPH≥500ml (n = 2596): Additionally adjusted for previous PPH≥1000ml.

[***] Intact perineum (n = 424); 1st and 2nd degree tear (n = 426); PPH≥500ml (n = 407).

[****] Intact perineum (n = 1731) and 1st and 2nd degree tear (n = 1750): Additionally adjusted for previous 3rd or 4th degree tear. PPH≥500ml (n = 2162): Additionally adjusted for previous PPH≥1000ml.

a group of low-risk women planning home birth in a low-risk setting. The stratified regression analysis of this study supports the results of the Cochrane systematic review [2].

The moderately, but statistically significantly, lower rates of an intact perineum in waterbirths in the total group of this study, compared to births on land, have also been detected in some previous studies [17,20], while non-significant results from stratified regression are consistent with others [10,21,22]. The same can be said of the elevated rates of first- and second-degree perineal tears in waterbirths, which are consistent with some of the studies previously performed on perineal outcomes in water [15,17], but not with others [12–14,16]. Rates of intact perineum in previous studies are predominantly related to the rates of the perineal variables with the highest incidence, first- and second-degree tears [16,17], except in studies where high episiotomy rates in birth on land are the dominating factor in perineal outcomes [15].

Inconsistencies in previous study results on first- and second-degree tears and intact perineum, which are high incidence variables and, as such, not susceptible to random inconsistencies, may partially be due to a tendency to use composite variables. The Nordic Home Birth Study data used in this study collected information on first- and second-degree tears as a composite variable. The study therefore cannot determine whether differences detected in crude analysis are due to differences in first-degree tears, second-degree tears, or both.

A previous study that examined first-degree tears separately found higher rates in waterbirths compared to births on land [17], while studies that examined second-degree tears separately found lower rates in waterbirths [12–14]. The potential negative effect of waterbirth may predominantly manifest as increased risk for first-degree tears. If the rates of first- and second-degree tears in this study are similar to those in previous studies, it can be speculated that the higher incidences found in the total group in this study are predominantly driven by higher rates of first-degree tears. This is an important issue, since while first-degree tears seldom lead to long-term morbidity, second-degree tears can inflict considerable perineal pain postpartum [26], which in turn can negatively affect mobility, excretion, and breastfeeding [23].

Previous studies have shown a beneficial effect of a hands-on technique, or at least the option of evaluating the need for it, on perineal outcomes [30,32–34]. Waterbirth can negatively affect midwives' ability to see and support the perineum during the birth of the baby [13]. Home birth midwives in the countries under study tend to sparingly use perineal support in waterbirths, mostly by gentle pressure on the baby's head to slow its progress, if needed. However, if active perineal support were a key factor in protecting the perineum in births on land, this effect should be evident among primiparas in this study, which is not the case. The lower incidence of intact perineum in waterbirths in the total group of this study, and the associated higher incidence of first- and second-degree tears, seems to be predominantly due to 4.6% higher tear rates among multiparous women.

Low incidences of sphincter tears have led to statistical power limitations in smaller studies on perineal outcomes. Two previous cohort studies that detected a statistically significantly lower risk of third- and fourth-degree tears in waterbirth, compared to birth on land, were based on large groups. A 2022 study on n = 17 530 waterbirths and n = 17 530 births on land among low-risk women in the United States detected a 0.75% incidence of third- and fourth-degree tears in waterbirths [10]. A 2019 study on n = 1716 waterbirths and n = 21 320 births on land in a mixed-risk group of women in Alberta, Canada found a 0.8% incidence of third- and fourth-degree tears in waterbirths [11]. In comparison, a 2014 study that detected a statistically significantly higher perineal tear risk in waterbirths in the United Kingdom was based on a smaller sample and proportion of waterbirths (n = 298 waterbirths and n = 16 622 births on land) [9].

As was to be expected in a low-risk sample, the incidence of sphincter injury in the study presented here was similar to, or lower than, rates detected in previous Nordic studies that have been done on outcomes after planned home births [38–40]. The study, despite combining data from four Nordic countries, did not detect significant differences in the rates of third- and fourth-degree perineal tears between waterbirths and births on land. This is a common result in studies on perineal outcomes and waterbirth [13,15–22] and may be related to low incidences of third- and fourth-degree tears which, when combined with generally low waterbirth rates, make it difficult to design studies that are powered to detect differences in this variable – setting dyad. This begs the question of whether large waterbirth studies, powered to detect differences in third- and fourth-degree perineal tear rates, will only be feasible in the largest of settings while smaller countries and regions will be unable to fully study the subject.

The largest and most recent studies to detect statistically significant differences in third- and fourth-degree tears found lower rates in waterbirth than in birth on land [10,11]. Even if their results may not be transferrable to all groups of women in all settings, they may indicate that third- and fourth-degree tears among low-risk women in low-risk settings are not a major risk factor when choosing waterbirth. Considering this, and the general lack of feasibility of studies on third- and fourth-degree tears in waterbirth, the focus of prenatal education and informed choice should be on the low absolute risk among low-risk women, such as the 0.7% incidence detected in the study, rather than relative risk.

Low episiotomy rates found in this study, both in water and on land, are consistent with previously detected low episiotomy rates in home births, compared to hospital births [38–40]. The study partially replicates, among primiparous women, previously detected and consistently lower rates of episiotomies in waterbirths, compared to births on land [15,22]. Women who give birth in water are likely to want to avoid intervention, and their midwives want to disturb a waterbirth as little as possible [6], which can be a partial explanation for the low rate of waterbirth episiotomies detected here. Additionally, a lower incidence of episiotomy in waterbirths can be partially explained by the difficulty of performing episiotomy in the water. Women labouring in water may have been asked to leave the water before the birth of the baby if an episiotomy was recommended, introducing bias. These results must therefore be interpreted with caution.

A link has been suggested between the relaxing effect of heat on uterine musculature and less effective postpartum contractions. In this study, no significant difference in PPH $\geq$ 500 and $\geq$1000 ml was found between waterbirths and births on land, which is consistent with the inconclusive results of the most recent Cochrane review on the subject [2]. Previous observational studies on waterbirth and PPH have either shown no significant effect [22] or only within small subgroups of births on land [12]. In the Nordic Home Birth data collection, PPH is estimated within the first two hours after birth, while primary PPH is defined as abnormal haemorrhage up to 24 hours after birth according to international definitions. Thus, some PPH cases could have been lost due to insufficient follow up.

In this study, the overall rates of 5-minute Apgar scores <7 were low, which is to be expected in a group of babies born to low-risk women. No differences were found between babies born in water and babies born on land, which is in line with previous studies on the subject [22]. Because 5-minute Apgar scores < 7 are a rare occurrence, a large study population would have been needed to power a study that was able to detect differences in this variable.

4.1. Strengths and limitations

A significant limitation of the study design, embedded in the data collection, is the combination of first- and second-degree perineal tears, including labial and vaginal tears, into one variable. Not being able to separate first-degree tears from tears that are more likely to impact women's health and wellbeing may negatively impact the clinical significance of the results. Another significant limitation is the age of the data. Changes in midwifery practice since the end of the study period,

especially in the area of perineal tear detection, may limit the generalisability of the study findings. Studies on more recent data would be able to provide more reliable differentiation between tear levels and more robust data, e.g. on second-degree tears.

The inclusion rate in this study was high and no withdrawal from the study has been reported, which strengthens the validity of the study. The data were collected by the midwives who cared for the women in labour and most of the data were collected prospectively. The study followed a standardised study protocol and data were collected in a uniform manner in the four countries. Excluding births with interventions and adjusting for the effects of confounding variables in logistic regression may have counteracted potential confounder bias. Minimal differences between crude and adjusted analysis argues against possible over-adjustment having occurred by using both DAG's and regression. The rate of missing data was low for most variables, which increases the external validity of the study and the generalizability of its results to a group of low-risk women choosing a low-risk birth setting.

Missing data may nevertheless have led to less statistical power in logistic regression analysis. Sensitivity analysis using multiple imputations did not significantly change the results. Self-selection bias may have occurred in this cohort study. The Nordic Home Birth study had a wide aim and a Hawthorne effect on home birth midwives' perineal care is therefore unlikely. However, midwives' recommendation to leave the water before the birth of the baby due to increased risk may have introduced a bias affecting variables such as Apgar scores and episiotomies.

5. Conclusion

No statistical differences were found in perineal tear rates in adjusted regression analysis, when stratified for parity. Rates of third- and fourth-degree tears, PPH, and 5-minute Apgar scores <5 were low. Midwives should advise women to weigh the risks and benefits detected in this study against the previously established benefits of waterbirth [2,6–8] and make an informed choice based on their own values and preferences. Waterbirth may be particularly beneficial for primiparous women, whose positive first birth experiences may positively impact subsequent births.

This study adds to the growing evidence base of the association of waterbirth and perineal birth outcomes. Studies on larger groups are still called for, since few studies have been powered to detect differences in the variable leading to the most severe morbidity, third- and fourth-degree tears. Furthermore, studies on midwifery practices in waterbirth and possible ways to prevent perineal tears in water would represent a valuable tool in developing quality midwifery care for low-risk women.

Ethical considerations/statement

The submitted manuscript involved research using data from the Nordic Home Birth Study. Participants received written information on the study in pregnancy or labour, gave their written informed consent to participate, and completed a background information questionnaire. Their home birth midwife registered and submitted information on the birth and immediate postpartum period.

The study was approved in each of the participating countries, by the Regional Committee for Medical and Health Research Ethics (REK) (200704605–5) in Norway, by the Regional Ethical Committee at Karolinska Institutet (2009 / 147–31) in Sweden, by the Scientific Committee for the Capital Region (H-3–2014-FSP71) in Denmark, and by the National Bioethics Committee (No. 11–031) in Iceland.

Author contributions/publication

The authors confirm that the article is their original work, that this manuscript has not been published elsewhere, and that it is not under consideration for publication by another journal. All those entitled to authorship are listed as authors. All authors meet the criteria for authorship, have seen and approved the manuscript being submitted, and agree with its submission to *Women and Birth*. The authors abide by the copyright terms and conditions of Elsevier and The Australian College of Midwives.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.wombi.2024.101625.

References

[1] M. Odent, Birth under water, Dec 24-31, Lancet 2 (8365-66) (1983) 1476–1477, https://doi.org/10.1016/s0140-6736(83)90816-4. PMID: 6140561..
[2] E.R. Cluett, E. Burns, A. Cuthbert, Immersion in water during labour and birth, Cochrane Database Syst. Rev. 5 (5) (2018) CD000111, https://doi.org/10.1002/14651858.CD000111.pub4. PMID: 29768662; PMCID: PMC6494420.
[3] Birthplace in England Collaborative Group, P. Brocklehurst, P. Hardy, J. Hollowell, L. Linsell, A. Macfarlane, C. McCourt, N. Marlow, A. Miller, M. Newburn, S. Petrou, D. Puddicombe, M. Redshaw, R. Rowe, J. Sandall, L. Silverton, M. Stewart, Perinatal and maternal outcomes by planned place of birth for healthy women with low risk pregnancies: the Birthplace in England national prospective cohort study, BMJ 343 (2011) d7400, doi: 10.1136/bmj.d7400. PMID: 22117057; PMCID: PMC3223531.
[4] E.E. Burns, M.G. Boulton, E. Cluett, V.R. Cornelius, L.A. Smith, Characteristics, interventions, and outcomes of women who used a birthing pool: a prospective observational study, Birth 39 (3) (2012) 192–202, https://doi.org/10.1111/j.1523-536X.2012.00548.x. Epub 2012 Jul 3. PMID: 23281901.
[5] National Institute for Health and Care Excellence. Intrapartum care for healthy women and babies. London: National Institute for Health and Care Excellence; 2014. p. 36.
[6] D. Garland, Revisiting Waterbirth: An Attitude to Care. 2nd ed, Palgrave Macmillan, London, 2017.
[7] C. Clews, S. Church, M. Ekberg, Women and waterbirth: a systematic meta-synthesis of qualitative studies, Women Birth 33 (6) (2020) 566–573, https://doi.org/10.1016/j.wombi.2019.11.007. Epub 2019 Dec 26. PMID: 31883699.
[8] C. Feeley, M. Cooper, E. Burns, A systematic meta-thematic synthesis to examine the views and experiences of women following water immersion during labour and waterbirth, J. Adv. Nurs. 77 (7) (2021) 2942–2956, https://doi.org/10.1111/jan.14720. Epub 2021 Jan 19. PMID: 33464640.
[9] K.C. McPherson, A.D. Beggs, A.H. Sultan, R. Thakar, Can the risk of obstetric anal sphincter injuries (OASIs) be predicted using a risk-scoring system? BMC Res Notes 7 (2014 Jul 24) 471, https://doi.org/10.1186/1756-0500-7-471. PMID: 25056485; PMCID: PMC4119183.
[10] M.L. Bovbjerg, M. Cheyney, A.B. Caughey, Maternal and neonatal outcomes following waterbirth: a cohort study of 17 530 waterbirths and 17 530 propensity score-matched land births, BJOG 129 (6) (2022) 950–958, https://doi.org/10.1111/1471-0528.17009. Epub 2021 Dec 1. PMID: 34773367; PMCID: PMC9035022.
[11] S. Jacoby, G. Becker, S. Crawford, R.D. Wilson, Water birth maternal and neonatal outcomes among midwifery clients in Alberta, Canada, from 2014 to 2017: a retrospective study, J. Obstet. Gynaecol. Can. 41 (6) (2019) 805–812, https://doi.org/10.1016/j.jogc.2018.12.014. Epub 2019 Mar 21. PMID: 30904342.
[12] H.G. Dahlen, H. Dowling, M. Tracy, V. Schmied, S. Tracy, Maternal and perinatal outcomes amongst low risk women giving birth in water compared to six birth positions on land. A descriptive cross sectional study in a birth centre over 12 years, Midwifery 29 (7) (2013) 759–764, https://doi.org/10.1016/j.midw.2012.07.002. Epub 2012 Aug 11. PMID: 22884894.
[13] H. Ulfsdottir, S. Saltvedt, M. Edqvist, S. Georgsson, Management of the active second stage of labor in waterbirths compared with conventional births - a

prospective cohort study, Midwifery 107 (2022) 103283, https://doi.org/10.1016/j.midw.2022.103283. Epub 2022 Feb 8. PMID: 35172265.
[14] H. Ulfsdottir, S. Saltvedt, S. Georgsson, Waterbirth in Sweden - a comparative study, Acta Obstet. Gynecol. Scand. 97 (3) (2018) 341–348, https://doi.org/10.1111/aogs.13286. Epub 2018 Jan 17. PMID: 29288489.
[15] K.M. Lim, P.S. Tong, Y.S. Chong, A comparative study between the pioneer cohort of waterbirths and conventional vaginal deliveries in an obstetrician-led unit in Singapore, Taiwan J. Obstet. Gynecol. 55 (3) (2016) 363–367, https://doi.org/10.1016/j.tjog.2016.04.012. PMID: 27343316.
[16] J.M. Bailey, R.E. Zielinski, C.L. Emeis, L. Kane Low, A retrospective comparison of waterbirth outcomes in two United States hospital settings, Birth 47 (1) (2020) 98–104, https://doi.org/10.1111/birt.12473. Epub 2019 Dec 9. PMID: 31820494.
[17] D. Papoutsis, A. Antonakou, A. Gornall, C. Tzavara, The incidence of and predictors for severe perineal trauma and intact perineum in women having a waterbirth in England: a hospital-based study, J. Women's. Health 30 (5) (2021 May) 681–688, https://doi.org/10.1089/jwh.2019.8244. Epub 2020 Sep 9. PMID: 32907460.
[18] A.C. Sidebottom, M. Vacquier, K. Simon, W. Wunderlich, P. Fontaine, D. Dahlgren-Roemmich, S. Steinbring, B. Hyer, L. Saul, Maternal and neonatal outcomes in hospital-based deliveries with water immersion, Obstet. Gynecol. 136 (4) (2020 Oct) 707–715, https://doi.org/10.1097/AOG.0000000000003956. PMID: 32925614; PMCID: PMC7505143.
[19] L. Lewis, Y.L. Hauck, J. Butt, J. Hornbuckle, Obstetric and neonatal outcomes for women intending to use immersion in water for labour and birth in Western Australia (2015-2016): a retrospective audit of clinical outcomes, Aust. N. Z. J. Obstet. Gynaecol. 58 (5) (2018 Oct) 539–547, https://doi.org/10.1111/ajo.12758. Epub 2018 Jan 17. PMID: 29344940.
[20] M.L. Bovbjerg, M. Cheyney, C. Everson, Maternal and newborn outcomes following waterbirth: the midwives alliance of North America statistics project, 2004 to 2009 cohort, J. Midwifery Women's. Health 61 (1) (2016) 11–20, https://doi.org/10.1111/jmwh.12394. Epub 2016 Jan 20. PMID: 26789485.
[21] P.L. Barry, L.E. McMahon, R.A. Banks, A.M. Fergus, D.J. Murphy, Prospective cohort study of water immersion for labour and birth compared with standard care in an Irish maternity setting, BMJ Open 10 (12) (2020) e038080, https://doi.org/10.1136/bmjopen-2020-038080. PMID: 33277276; PMCID: PMC7722381.
[22] U. Menakaya, S. Albayati, E. Vella, J. Fenwick, D. Angstetra, A retrospective comparison of water birth and conventional vaginal birth among women deemed to be low risk in a secondary level hospital in Australia, Women Birth 26 (2) (2013) 114–118, https://doi.org/10.1016/j.wombi.2012.10.002. Epub 2012 Oct 31. PMID: 23122911.
[23] C.E. East, M. Sherburn, C. Nagle, J. Said, D. Forster, Perineal pain following childbirth: prevalence, effects on postnatal recovery and analgesia usage, Midwifery 28 (1) (2012) 93–97, https://doi.org/10.1016/j.midw.2010.11.009. Epub 2011 Jan 13. PMID: 21236531.
[24] G. Hilde, J. Stær-Jensen, F. Siafarikas, M.E. Engh, I.H. Brækken, K. Bø, Impact of childbirth and mode of delivery on vaginal resting pressure and on pelvic floor muscle strength and endurance, Am. J. Obstet. Gynecol. 208 (1) (2013) 50.e1–50.e7, https://doi.org/10.1016/j.ajog.2012.10.878. Epub 2012 Oct 24. PMID: 23103345.
[25] V. Aasheim, A.B.V. Nilsen, L.M. Reinar, M. Lukasse, Perineal techniques during the second stage of labour for reducing perineal trauma, Cochrane Database Syst. Rev. 6 (6) (2017) CD006672, https://doi.org/10.1002/14651858.CD006672.pub3. PMID: 28608597; PMCID: PMC6481402.
[26] V. Andrews, R. Thakar, A.H. Sultan, P.W. Jones, Evaluation of postpartum perineal pain and dyspareunia–a prospective study. Eur. J. Obstet. Gynecol. Reprod. Biol. 137 (2) (2008) 152–156, https://doi.org/10.1016/j.ejogrb.2007.06.005. Epub 2007 Aug 2. PMID: 17681663.
[27] E. Burns, L. Price, J. Carpenter, L. Smith, Predictors of obstetric anal sphincter injury during waterbirth: a secondary analysis of a prospective observational study, Int Urogynecol J. 31 (3) (2020) 651–656, https://doi.org/10.1007/s00192-019-04167-6. Epub 2019 Dec 7. PMID: 31813039.
[28] M. Stedenfeldt, P. Øian, M. Gissler, E. Blix, J. Pirhonen, Risk factors for obstetric anal sphincter injury after a successful multicentre interventional programme, BJOG 121 (1) (2014) 83–91, https://doi.org/10.1111/1471-0528.12274. Epub 2013 May 20. PMID: 23682573.
[29] J.W. de Leeuw, P.C. Struijk, M.E. Vierhout, H.C. Wallenburg, Risk factors for third degree perineal ruptures during delivery, BJOG 108 (4) (2001) 383–387, https://doi.org/10.1111/j.1471-0528.2001.00090.x. PMID: 11305545.
[30] K. Laine, W. Rotvold, A.C. Staff, Are obstetric anal sphincter ruptures preventable?– large and consistent rupture rate variations between the Nordic countries and between delivery units in Norway, Acta Obstet. Gynecol. Scand. 92 (1) (2013) 94–100, https://doi.org/10.1111/aogs.12024. Epub 2012 Dec 5. PMID: 23034015.
[31] E. Baghestan, L.M. Irgens, P.E. Børdahl, S. Rasmussen, Risk of recurrence and subsequent delivery after obstetric anal sphincter injuries, BJOG 119 (1) (2012) 62–69, https://doi.org/10.1111/j.1471-0528.2011.03150.x. Epub 2011 Oct 10. PMID: 21985470.
[32] C. Begley, K. Guilliland, L. Dixon, M. Reilly, C. Keegan, C. McCann, V. Smith, A qualitative exploration of techniques used by expert midwives to preserve the perineum intact, Women Birth 32 (1) (2019) 87–97, https://doi.org/10.1016/j.wombi.2018.04.015. Epub 2018 May 3. PMID: 29730096.
[33] E. Hals, P. Øian, T. Pirhonen, M. Gissler, S. Hjelle, E.B. Nilsen, A.M. Severinsen, C. Solsletten, T. Hartgill, J. Pirhonen, A multicenter interventional program to reduce the incidence of anal sphincter tears, Obstet. Gynecol. 116 (4) (2010) 901–908, https://doi.org/10.1097/AOG.0b013e3181eda77a. PMID: 20859154.
[34] E. Sveinsdottir, H. Gottfredsdottir, A.S. Vernhardsdottir, G.B. Tryggvadottir, R. T. Geirsson, Effects of an intervention program for reducing severe perineal trauma during the second stage of labor, Birth 46 (2) (2019) 371–378, https://doi.org/10.1111/birt.12409. Epub 2018 Nov 16. PMID: 30444289.
[35] N. Lee, M. Firmin, Y. Gao, S. Kildea, Perineal injury associated with hands on/hands poised and directed/undirected pushing: a retrospective cross-sectional study of non-operative vaginal births, 2011-2016, Int J. Nurs. Stud. 83 (2018) 11–17, https://doi.org/10.1016/j.ijnurstu.2018.04.002. Epub 2018 Apr 5. PMID: 29684830.
[36] M. Basu, D. Smith, R. Edwards, STOMP project team, Can the incidence of obstetric anal sphincter injury be reduced? The STOMP experience, Eur. J. Obstet. Gynecol. Reprod. Biol. 202 (2016) 55–59, https://doi.org/10.1016/j.ejogrb.2016.04.033. Epub 2016 Apr 30. PMID: 27164486.
[37] E. Blix, M.H. Kumle, K. Ingversen, A.S. Huitfeldt, H.K. Hegaard, Ó.Á. Ólafsdóttir, P. Øian, H. Lindgren, Transfers to hospital in planned home birth in four Nordic countries - a prospective cohort study, Acta Obstet. Gynecol. Scand. 95 (4) (2016) 420-8, doi: 10.1111/aogs.12858. Epub 2016 Feb 29. PMID: 26830511.
[38] E. Blix, A.S. Huitfeldt, P. Øian, B. Straume, M. Kumle, Outcomes of planned home births and planned hospital births in low-risk women in Norway between 1990 and 2007: a retrospective cohort study, Sex. Reprod. Health 3 (4) (2012) 147–153, https://doi.org/10.1016/j.srhc.2012.10.001. Epub 2012 Oct 26. PMID: 23182447.
[39] B. Halfdansdottir, A.K. Smarason, O.A. Olafsdottir, I. Hildingsson, H. Sveinsdottir, Outcome of planned home and hospital births among low-risk women in Iceland in 2005-2009: a retrospective cohort study, Birth 42 (1) (2015) 16–26, https://doi.org/10.1111/birt.12150. Epub 2015 Jan 23. PMID: 25613161.
[40] H.E. Lindgren, I.J. Rådestad, K. Christensson, I.M. Hildingsson, Outcome of planned home births compared to hospital births in Sweden between 1992 and 2004. A population-based register study, Acta Obstet. Gynecol. Scand. 87 (7) (2008) 751–759, https://doi.org/10.1080/00016340802199903. PMID: 18607818.