Birthweight and urinary incontinence after childbirth: a systematic review and meta-analysis

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**Abstract**

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Urinary incontinence (UI) is common after childbirth. Many cohort and cross-sectional studies have reported data on birthweight, but results have not been pooled. It is unclear how birthweight affects UI after childbirth. The objective is to review the effect of birthweight on UI after childbirth through meta-analyses.

Searches were performed in Medline, Embase, Svedmed+, ClinicalTrials.gov, Cochrane, and Cinahl in August 2016. Additional reference checking was performed. Included articles evaluated birthweight as a possible risk factor for maternal UI. We included articles that were presented in Norwegian, Danish, Swedish, or English. Two independent reviewers extracted the data and analysed it using Review Manager 5.3 software. Available data from included studies on birthweight (>4000 g and ≥3500 g, respectively) and UI were combined in meta-analyses. PRISMA and MOOSE guidelines were used.

Eighteen studies (N = 30 070) reported data on birthweight >4000 g vs <4000 g. Birthweight>4000 g compared to weight <4000 g was associated with a significantly increased OR of any UI (OR 1.49, 95% CI 1.24 – 1.80). Five studies (N = 15 066) reported data on birthweight >3500 g vs <3500 g. Birthweight>3500 g was also associated with a significantly increased OR of UI (OR 1.26, 95% CI 1.15 – 1.37).

High birthweight appears to increase OR of UI after childbirth. Preventative strategies should be targeted towards women at particular risk.

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**Abbreviations:** UI, urinary incontinence; OR, odds ratio; CI, confidence interval.

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1. Introduction

Urinary incontinence (UI) is a common problem after childbirth. Prevalence estimates vary from 14 – 45% [1]. A systematic review reported pooled prevalence of any UI to be 32-36% three months postpartum [2]. Reviews on epidural [3], episiotomy [4], cesarean section [2] and instrumental childbirth [5] have clarified their association with UI postpartum. There is inconsistency in the literature regarding remaining birth parameters. By identifying significant risk factors for UI among women after childbirth, future research can identify and validate preventive measures that can be targeted towards these women. Many cohort and cross-sectional studies have reported data on birthweight, but results have not been pooled. In studies using electromyography heavier babies have been associated with evidence of pudendal nerve damage in the pelvic floor after vaginal birth [6], with uncertain clinical significance. The objective of this study was to review the literature to identify studies reporting on the association of high birthweight on urinary incontinence after all modes of childbirth, and to perform meta-analyses on the association of high birthweight on UI after childbirth. If birthweight can be isolated as a risk factor for postpartum urinary incontinence, patients at particular risk can be identified.

2. Material and methods

Literature searches were done in Medline, Embase, Svedmed+, and Cinahl. Additional search was done in ClinicalTrials.gov and Cochrane Database of Systematic Reviews. A librarian from the University in Bergen assisted in the search in May 09, 2014 and August 24, 2016. Additional search was done May 03. – 14.2017. The search included the following MESH terms and free text; urinary incontinence, leak, urine, bladder, delivery, obstetric, postpartum, postpartum period, puerperium, birthweight, infant, new-born, large, small, SGA, LGA. Abstracts and articles in Norwegian, Danish, Swedish, or English were considered. Both conference abstracts and full publications were included. Additional literature was added based on authors’ knowledge and after reading references in identified literature. Grey literature was not identified.

In the four-part PICO question for this systematic review, we compared women who gave birth with birthweight >3500 g or >3,500 g to women giving birth with birthweight <4,000 g or <3,500 g. The outcome was any UI, and stress UI after childbirth.

Search was done in headings and abstracts. Birthweight was sometimes one of several risk factors included in sub-analysis in papers, often not presented in the abstract, and thereby not found by the search strategy. Additional articles were added based on the authors’ knowledge of relevant literature, and after reading references. Identified literature was reviewed separately by both authors. Articles evaluating obstetric risk factors for maternal urinary incontinence in title or abstract were reviewed in full by both authors. When discrepancies between the two authors occurred (Seim, Wesnes), the article was discussed with a third researcher (Rortveit, see Acknowledgement). Criteria for inclusion were that the article or conference abstract evaluated birthweight as a possible risk factor for maternal urinary incontinence, with results presented in Norwegian, Danish, Swedish, or English. The process for selecting studies is presented in Table 1. Information about origin, study design, response rate, number of participants, method of data collection, adjusted results, time of UI, mode of childbirth, BMI, weight of new-born, age, parity, and main findings for all included studies were extracted.

No reviews of this topic were identified. For obvious reasons, no randomized controlled studies (RCT) on birthweight and UI have been conducted. A considerable number of cohort studies and cross-sectional studies of high quality have been performed. Even though RCT’s provide the highest level of evidence, a summary of results from cohort studies and cross-sectional studies will be essential in order to evaluate a possible causal association between birthweight and UI.

2.1. Birth weight

Mean birth weight in Europe and USA [7] is approximately 3500 g. Weight cut-off at 3500 g and 4000 g gives information on the association between UI and birthweight beyond mean, as well as extreme birthweight, respectively. Weight cut-off on 3500 g and 4000 g were most common in identified studies, and were therefore chosen for this review.

Birthweight in one study was originally analysed according to the 50th and 90th percentile for birthweight (3,541 g and 4,180 g, respectively). These data have been re-categorized into 3500 g and 4000 g, and data has thereafter been reanalysed and stratified for mode of childbirth. Data were adjusted for BMI and weight loss after childbirth [8]. Birthweight in one study was categorized according to birthweight quartiles [9]; birthweight >3925 g from this study was included in analyses on the association between birthweight >4000 g and UI. Boyles et al used pounds [10]; birthweight of >8 lb (3639 g) from this study was included in analyses on the association between birthweight >3500 g and UI.

2.2. Urinary incontinence

Information on UI after childbirth was categorized as questionnaires, objective testing, structured interviews, phone interviews, or reviews of existing medical records. No minimum cut-off for frequency, amount or severity of UI was set to be included in this article. Stress UI is more common after childbirth than urgency UI and mixed UI. The prevalence of pure stress UI is reported to be 2 – 8 times higher than the prevalence of pure urgency UI in pregnancy [1].
The stress/urgency ratio is reduced postpartum as prevalence of stress UI decline. Several studies focus solely on stress UI [11–14], but few studies have data on urgency UI. Data on any UI was used in this meta-analysis. Separate analyses on available data on stress UI were also performed.

2.3. Assessment of quality and bias

Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Initiative has published recommendations on how to report data in cohort and cross-sectional studies [15]. STROBE was used to assess methodological quality. There was a high threshold to exclude studies. Studies with insufficient methodological information on study design, setting, statistical methods, and study participants were excluded from the systematic review and meta-analysis. Selection bias can affect the meta-analytic estimate. Selection bias was therefore considered in studies used in the meta-analyses, based on setting, study population and response rate. Risk of selection bias was considered as low, medium, high, and unclear. Information on studies included in meta-analyses regarding selection bias, adjustment of effect estimates, and reporting of all data (effect estimate, N in exposed and unexposed group, N with UI and continence) were collected. Funnel plot asymmetry based on standard error (log [OR]) was used to explore possible reporting biases.

2.4. Data synthesis

Birthweight was categorized as a dichotomous variable with two categories; <4000 g vs >4000 g, and <3500 g vs >3500 g, respectively. Available original data from included studies on birthweight (≥4000 g and ≥3500 g, respectively) and UI were extracted. Adjusted effect estimates were extracted when available. Unadjusted effect estimates were used when adjusted estimates were not presented; raw data and absolute numbers were then converted to unadjusted OR. Relative risk in one study was treated as OR [16]. To enable comparison across studies, Log [OR] with SE were calculated for each included study. Results were pooled and combined in meta-analyses. Estimates were inserted into Review Manager 5.3 for meta-analyses.

To reduce diversity in study characteristics, separate sub-group meta-analyses were performed according to type of UI, mode of
Table 2
Descriptive data on studies included in the systematic review.

| Origin     | Design Association | N   | Data gathering | Respons. Time of UI | Birthweight | Parity       | Age | BMI | Delivery | Main finding                                                                 |
|------------|--------------------|-----|----------------|---------------------|-------------|--------------|-----|-----|----------------|-----------------------------------------------------------------------------|
| Altaweel [21] * | Saudi Arabia Cross-sectional Cohort | 2,180 | Quest.: UDI-6, IQ-7 | 30 %                | > 4 kg       | All          | 30 ± 10 | All | SVD and CS | Birthweight of baby > 4 kg OR 1.7 (1.4–2). Not data on type or severity by birthweight. |
| Arya [41] | USA Cohort         | 315 | Telephone interview and questionnaire. IQ-7 | 2 weeks, 3 months, 1 year after delivery | Primiparous | 21-23 | SVD 48% Forceps 29% Vacuum 24% |
| Baracho [42] | Brazil Cross-sectional | 192 | Delivery charts. Interview, ICIQ-SF, physical exam | Yes | >2.988 kg | Primiparous | 23,2 | BMI>25: 39/192 | SVD |
| Boyles [10] * | USA Cross-sectional | 5,599 | Quest. | 3-6 mth pp | > 8 lb. | Primiparous, continent before preg. | 27 | 24 | CS 27%, Forceps/ vacuum 13% | Increasing UI with birthweight > 8 lb., but only among women delivering by vaginal delivery: adjusted OR 1.22, (1.03–1.45). OR 0.84 (0.53–1.35) among women delivering by CS. |
| Brown [22] * | Australia Cross-sectional | 1,336 | Statewide postal survey. | 62 % | >4 kg | All | | | SVD 69%, Forceps 11%, Emergency CS 9%, Elective CS 9%. | Infants weighing ≥ 4000 g associated with higher rates of urinary incontinence (37/196 [18.9%] versus 101/1097 [9.2%], OR 2.29 [95% CI 1.5-3.5]). Associations of assisted vaginal births controlling for duration of labor, birthweight of infant and perineal trauma. Infant birthweight: <3000 g, 3000-3999 g, ≥4000 g: Adjusted OR for UI: 1.90 [1.2-3.1] |
| Burgio [43] | USA Cohort         | 523 | Interview day 2, and 3, week 6 and 3, 6, and 12 mth pp. | Yes | 6 weeks – 12 mth pp. | Mixed, parity 1,0 | 28,6 | | | When only vaginal delivery is analyzed, no statistical association with newborn’s weight was found. |
| Cardo [44] | Spain Cohort       | 272 | Interviewed at term and 4 months pp. ICIQ-SF and KHQ | 4 mth pp | Mixed | 31,8 | | | SVD 62%, Forceps 4%, Vacuum 21%. CS 21%. | |
| Caseym * | USA Cohort         | 3,887 | Interview | 37 % | 5-7 mth pp | > 4 kg | Primiparous | 22,5 | BMI 30 | | |
| Castillo [45] | Spain Cohort       | 243 | Quest; ICIQ-SF | 6 mth pp. | Mixed | 29,9 | BMI 26,2 | | | Univariate analyses: Birthweight >4000 g in 279 women (7%). Among these Urge UI 14% (95%, OR 1.3 (0.7–2.3)). Stress UI 10% (7%, OR 1.0 (0.5–1.9)). Adjusted analyses: association between stress UI and weight >4000 g: OR 1.2: 0.6 – 2.3. No statistically significant differences were found between a worsening on quality of life and birthweight. |
| Chaliha [46] | UK Cohort          | 549 | Interview, examination | 100 % | Mean 3.37 kg ± 0.49 | Primiparous | 29 | | | Fetal weight ass with urge UI: OR 11.3 95% CI 0.4–352.8. Stress UI: OR 2.5 95% CI 1.1–6.1 Vaginal delivery: Birth body weight OR 0.999 (95% CI 0.997– 1.002, p = 0.543) for incident stress UI. When CS: Birth body weight OR 0.997 (95% CI 0.997– 1.002, p = 0.543) for incident stress UI (identical to vaginal delivery) |
| Chou [47] | Taiwan Cross-sectional | 378 | Interview by telephone | Yes | Mean 3.116 kg | Primiparous | 28,1 | BMI 27,0 | SVD 53%, CS 24%, Vaginal 48%, CS 52% | Vaginal delivery: Birth body weight OR 0.999 (95% CI 0.997– 1.002, p = 0.543) for incident stress UI. When CS: Birth body weight OR 0.997 (95% CI 0.997– 1.002, p = 0.543) for incident stress UI (identical to vaginal delivery) |
| Connolly [48] | USA Cross-sectional | 3,205 | Interview, Sandvik SI score >3 | 36 % | > 4 kg | Mixed | 49,2 | | | There was an overall difference in the odds of moderate/ severe UI between the <4,000 g group, the ≥4,000 g group. |
| Study | Country | Cohort Size | Data Collection Method | Postpartum Time | Birthweight (kg) | Parity | BMI | UUI | Results |
|-------|---------|-------------|------------------------|----------------|----------------|------|-----|-----|---------|
| Diez-Itza 2017 | Spain | 376 | Interview | Yes | 6 weeks pp | > 4 kg | Mixed | 32,4 | Vaginal | Urgency only. Birthweight > 4 kg were not associated with UUI 6 weeks postpartum (OR 0.65, 95% CI 0.05 - 3.10). Incident stress UI: No stress UI 2 years postpartum: Mean birthweight 3306. Stress UI 2 years postpartum: Mean birthweight 3281. P = 0.74. Mothers, who gave birth to infants with a birthweight above 3000 g (permanent SUI: 4.7%) had no significantly higher incidence of stress UI 2 years postpartum: Mean birthweight 3306. Stress UI 2 years postpartum: Mean birthweight 3281. P = 0.74. |
| Diez-Itza 2017 | Spain | 272 | Interview | Yes | 2 years pp | 31,2 | BMI 23,4 | Vaginal 86%. CS 14%. |
| Dimoff 2017 | Germany | 350 | Interview | No | 6 and 12 weeks pp. | 3.5 kg | Continent before preg. | Vaginal 83%. CS 17% |
| Dolan 2017 | UK | 1,861 | Cross-sectional | Yes/No | 20 years after delivery | Mean 3.285 kg | Parity 1.6 | 45.7 | 24.8 | Vaginal 86%. CS 13.9 |
| Eason 2017 | Canada | 949 | Questionnaire | 79 % | 3 mth pp | 4 kg | Mixed | 28.6 | CS 18% |
| Eftekhar 2017 | Iran | 702 | Questionnaire | 3 mth pp | 3 kg | Primiparous continent before preg. | Vaginal 51%. CS 49% |
| Emanuela 2017 | Italy | 93 | Questionnaire | 3 and 6 mth pp. | 3.69 kg | CS 25%. SVD 56%. Instrumental 19% |
| Farrell 2017 | Canada | 484 | Questionnaire and hospital charts | 83.50 % | 6 weeks and 6 mth pp | Mean 3.489 kg | Primiparous | 28 |
| Frías 2017 | Spain | 89 | Questionnaire, ICIQ-SF, PISQ-12 | 2 mth | 53.7% primiparous | Eutocic 68%. Forceps 4% CS 28% |
| Fritel 2017 | France | 307 | Questionnaire | 46% | 4 years | 4 kg | Primiparous | 29,3 |
| Gartland 2017 | Australia | 1,283 | Hospital records, quest and telephone interviews | 28–31% | 3, 6, 9, 12 and 18 mth pp | 4 kg | Primiparous, continent before pregnancy | SVD 31%. CS 21%. Instr 32% |
| Glazener 2017 | Aberdeen; Scotland, Birmingham; England, Dunedin, NZ | 3,405 | Cross-sectional | Yes | 3 mth pp | Mean 3.296 kg. Used quartiles. | Primiparous | 26,7 | SVD 58%, CS 17%, Instr 25% | Incontinence first occurring during pregnancy and still present at 3 months was associated with heavier babies (birthweight in top quartile, OR 1.56, 95% CI 1.12-2.19). Incident UI after delivery: < 3 kg Ref. 3.00-3.35 kg OR 1.26. 3.36–3.69 kg OR 1.42. ≥ 3.70 kg OR 1.33. Persistent UI starting during pregnancy: < 3 kg Ref. 3.00–3.35 kg OR 1.33. 3.36–3.69 kg OR 1.45. ≥ 3.70 OR 1.56. |
| Origin       | Design    | Association | N        | Data gathering | Respons- | Adjust. | Time point of UI | Birth- | Parity | Age | BMI | Delivery | Main finding                                                                                   |
|--------------|-----------|-------------|----------|----------------|-----------|--------|------------------|--------|--------|-----|-----|----------|----------------------------------------------------------------------------------------------|
| Grodstein    | USA       | Cohort (?)  | 83,168   | Nurses' health study | Yes       | Late in life | All               | 60.4  | 20     |     |     |          | For birthweight of the heaviest child, little association with UI. Somewhat lower risks with infant of > 10.5 pounds at birth compared with < 8.5 pounds. Risk for UI: < 3.86 kg OR 1.00, 3.86-4.3 kg OR 1.03, 4.35-4.76 kg OR 1.05, > 4.76 kg OR 0.97. No correlation between birthweight of the first newborn and prevalence of persistent, non-pregnancy-related stress urinary incontinence. Prevalence of persistent, stress UI among grand multiparous women delivering at least one baby >4000 g was 29.4%. Prevalence of persistent stress UI among grand multiparous whose newborns did not weigh more than 4000 g was significantly lower (16.7%, P < 0.05). |
| Groutz [11]  | Israel    | Cross-sectional | 300     | Interview | 100%? | 3 days | 3.5/4 kg nulliparous. 100 primiparous. 100 ≥ para 5 | 20 - 43 | 1.00  |     |     |          | Risk of UI first days PP and 6 mth pp OR 1.0 pr 500 g in adjusted analyses. Adjusted OR for UI first days PP 1.0. OR for UI > 4 weeks PP 1.2 (not sign). Adjusted OR for UI ≥ 12 weeks pp 1.1 (not sign). |
| Gyhagen [35] | Sweden    | Cross-sectional | 5,236   | Questionnaire and birth registry | 65 % | 22 years pp | Primiparous | 50-53 | 26     |     |     |          | Weight > 4 500 g compared to < 4 500 g among CS: OR 0.66 (95% CI 0.33–1.29). Weight > 4 500 g compared to < 4 500 g among VD: OR 1.23 (95% CI 0.87–1.76). The risk of UI after VD vs CS increased with increasing birthweight. |
| Hatem [18]   | Canada    | Cross-sectional | 1,291   | Questionnaire | 52 % | 4 kg | Primiparous | 27,20 | 25,2   |     |     |          | Risk of UI first days PP and 6 mth pp OR 1.0 pr 500 g in adjusted analyses. Adjusted OR for UI first days PP 1.0. OR for UI > 4 weeks PP 1.2 (not sign). Adjusted OR for UI ≥ 12 weeks pp 1.1 (not sign). |
| Hvidman [19] | Denmark   | Cross-sectional | 376     | Questionnaire | 1 % | Yes | Few days pp and 3 mth pp | Mixed | 29     |     |     |          | Risk of UI first days PP and 6 mth pp OR 1.0 pr 500 g in adjusted analyses. Adjusted OR for UI first days PP 1.0. OR for UI > 4 weeks PP 1.2 (not sign). Adjusted OR for UI ≥ 12 weeks pp 1.1 (not sign). |
| Iwanowicz    | Poland    | Cross-sectional | 313     | Women treated for stress UI; medical history and urodynamic test. | 4 kg | Mixed | 50-53 |        |        |     |     |          | The probability of the occurrence of SUI is statistically higher after vaginal delivery of a baby with birthweight of 4000 g or more, 45% of women with UI and 34% of women without UI had babies >4000 g (sign finding). |
| Kashanian    | Iran      | Cohort -      | 1,400   | Questionnaire | 1 year pp |        |        |        |        |     |     |          | There was no significant difference between the women with SUI and without according to neonatal weight. |
| Koveleva [9] | Russian Federation | Cohort ++ for mixed UI | 518     | Interview | 4 mth pp | Mean | All | 30,1 |        |     |     |          | Mean weight of the newborn in group of patients with mixed UI was 3544 + 519 g, in the control group and 3173 + 740 g, (p < 0.01). A relative risk of occurrence mixed UI in group of women with weight of the newborn above 3544 + 519 g was higher (RR = 1.38; 95% CI 1.02 to 1.85; p < 0.05). Birthweight >4000 g vs <4000 g; stress UI 34% vs 31%, urge UI 6% vs 4%, mixed UI 15% vs 11%; p > 0.10. In the group whose infant birthweight was 4000 g or more the prevalence of stress incontinence 6–30 months postpartum was higher than in the <4000 g group (34.0% vs. 36.6% (p > 0.10). |
| Krue [13]    | Denmark   | Cross-sectional | 119     | Questionnaire | 89 % | No | 6-30 mth pp | Mix | >30    |     |     |          | For birthweight of the heaviest child, little association with UI. Somewhat lower risks with infant of > 10.5 pounds at birth compared with < 8.5 pounds. Risk for UI: < 3.86 kg OR 1.00, 3.86-4.3 kg OR 1.03, 4.35-4.76 kg OR 1.05, > 4.76 kg OR 0.97. No correlation between birthweight of the first newborn and prevalence of persistent, non-pregnancy-related stress urinary incontinence. Prevalence of persistent, stress UI among grand multiparous women delivering at least one baby >4000 g was 29.4%. Prevalence of persistent stress UI among grand multiparous whose newborns did not weigh more than 4000 g was significantly lower (16.7%, P < 0.05). |

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| Author          | Country | Type       | Sample Size | Methodology                        | Follow-Up | Gender Distribution | Birthweight | Results                                                                                           |
|-----------------|---------|------------|-------------|-----------------------------------|-----------|---------------------|-------------|---------------------------------------------------------------------------------------------------|
| Mallah [20]     | Iran    | Cohort     | 441         | Examination, medical records      | 3 mth pp. | 4 kg                | Primiparous | The incidence of UI was higher in cases of vaginal delivery and birthweight greater than 4 kg. OR 4.8 (95% CI 3.0 - 7.7). Birthweight was not associated with increased risk of developing stress urinary incontinence. For each additional 16 ounces of infant weight delivered vaginally, the OR for UI increased by 1.13 (1.06-1.20). Birthweight > 4 kg significantly associated with UI 3 months postpartum OR 5.60 (1.21-25.92) |
| Marsh [56]      | UK      | Cross-sectional | 324    | Questionnaire                     | 3 mth pp. | Mean 3.586 kg       | Primiparous | Significant associations between any UI and birthweight > 4000 g (OR 1.1, 95% CI 1.0-1.2); moderate or severe incontinence OR 1.0 (0.9-1.2); > 4000 g also associated with stress UI. There were no significant correlations with birthweights >3925 g. Birthweight >3500 g was associated with stress UI in multiparas (RR 1.4, CI 95% 1.1-1.7). Within the vaginal group: infant birthweight >3500 g (RR 1.3, CI 95% 1.1-1.6). There was no association in multivariate analyses. Some results are adjusted. The weight of the largest baby delivered had the strongest impact on predicting UI symptom severity (UISS) among 12/56 women with baby >4000 g, UI among 140/832 among women with baby <4000 g. Adjusted HR for incident UI postpartum among women with baby >4000 g: 2.8 (0.9-8.4) Weekly UI significantly associated with weighing 4,000 g or more (OR 1.47, 95% CI 1.16-1.86). When analyzed as a continuous variable, greatest birthweight showed evidence of a threshold effect with an increase in the risk of UI associated with increasing birthweight above about 3,200 g. OR 0.928. 95% CI 0.43-2.00 for association with birthweight. Infant birthweight 3,418 vs 3,549 as risk factor for urgency 1 year pp among women delivering by VD: adjusted OR 0.9 (0.98-0.99). No association was found for stress UI or urge UI. Birthweight was increased in infants of mothers who developed stress UI after delivery, but not significantly: p = 0.07 Parity and the largest infant’s weight were additional independent risk factors for UI but did not remain significant in a multivariable logistic regression analyzes. Baby’s birthweight between the 50th - 90th percentile (3541 - 4180 g) and > 90th percentile (> 4180 g) were statistically significant risk factors for incident UI 6 months postpartum (OR 1.4; 95% CI 1.2 - 1.6 and OR 1.6; 95% CI 1.2 - 2.0, respectively) as compared to birthweight below the 50th percentile. Data reanalyzed for 3500 g and 4000 g. |
| McKinnie [57]   | USA     | Cross-sectional | 978               | Questionnaire                      | Yes 6 weeks, 3 mth pp | 80% Multipara, continent before pregn. | SVD 90%      |                                                                                                 |
| Obioah [27]     | Nigeria | Cohort     | 230         | Questionnaire interview            | Yes       | 6 weeks              | Mix          |                                                                                                 |
| Rørtveit [14]   | Norway  | Cross-sectional | 11,397 | Questionnaire and birth registry | 80 %      | Yes                  | 4 kg         |                                                                                                 |
| Samuelsson [28] | Sweden  | Cross-sectional | 487 | Questionnaire, gyno.examin. | 76 %      | Yes                  | Mixed        |                                                                                                 |
| Schytt [16]     | Sweden  | Cohort     | 2,390      | Questionnaire Swedish Birth Register | 53 %      | Yes/no 1 year pp | 3.5-4 kg |                                                                                                 |
| Seshan [58]     | India   | Cross-sectional | 598         | Questionnaire                      | Yes       | Mixed               | 20-60        |                                                                                                 |
| Solans-Domenech [29] | Spain | Cohort     | 1,128      | Questionnaire                      | No 7 weeks pp | > 4 kg | Continent, nulliparous women | CS 20%, VD 80% |                                                                                                 |
| Thom [30]       | USA     | Retrospective cohort | 1,521 | Questionnaire, interview, abstraction of labor and delivery records. | Yes       | > 4 kg | 56 | VD                                                                                           |
| Torkestani [34] | Iran    | Case-control | 250         | Questionnaire gyno.exam. | Yes | 3 and 12 mth pp | Mix |                                                                                                 |
| Van Dommensem [59] | Netherlands | Cohort - - | 344         | Questionnaire | 723 % | Yes | 3,418 vs 3,549 | Nulliparous | Mix | VD 83%. 42% CD 14%                                                                 |
| Viktrup [60]    | Denmark | Cohort     | 305         | Questionnaire                      | 12 mth pp | Parous, mean 2.3 | VD 82%. 42% CD 14% |                                                                                                 |
| Volloyhaug [61] | Norway  | Cross-sectional | 1,641     | Questionnaire                      | Yes Mean 20 years | 2.3 | 47 | 25.8 | VD 42% OD 42% CD 14%                                                                 |
| Wesnes [62]     | Norway  | Cohort     | 5,219      | Questionnaire, birth registry      | 45 %      | Yes | 50/90 percentile. Re-analyzed on 3.5/4 kg | Primiparous | SVD only                                                                                           |
| Table 2 (Continued) | Origin | Design | Association | N | Data gathering | Respons. rate | Adjust. Time point of UI | Birth-weight | Parity | Age | BMI | Delivery | Main finding |
|----------------------|--------|--------|-------------|---|----------------|---------------|--------------------------|-------------|--------|-----|-----|---------|--------------|
| **Williams** [63] UK | Retrospective, cross-sectional | **++**(stress) – (urge) | 482 | Questionnaire | 23 % | 12 mth pp. | Birthweight was associated with incident stress UI (spearman r coefficient r = 0.04) and protective on incident urge UI (r coefficient r = -0.04) |
| **Wu** [64] China | Cross-sectional | + | 2,500 | Interview | | | Fetal weight was associated with stress UI only OR 1.64 (95% CI 1.27–2.13), p < 0.001 for macrosomic infant compared with normal birthweight |
| **Yang** [65] China | Cohort | - | 1,889 | Telephone interview | Yes | 6 mth pp | No association between neonate birthweight and SUI, UUI or MUI. |
| **Yohay** [66] Israel | Cohort | - | 37 | Questionnaire medical records, telephone interview | | 3 mth pp | 3.344 kg | Other obstetrical parameters including episiotomy and birthweight were not found to be significantly associated with any of the PFD items. |
| **Yip** [67] Hong Kong | Cohort | - | 148 | Telephone interview | | 4 years pp | 3.2 kg | The logistic regression analysis showed that birthweight was not significantly associated SUI 4 years after the index pregnancy. |
| **Zanelli** [68] Italy | Cohort | ++ | 452 | Questionnaire | | 3 and 12 mth pp | Nulliparous, continent before preg. | Statistical correlation with incontinence 3 months postpartum was found for high fetal weight |
| **Zhang** [69] China | Cross-sectional | ++ | 4,684 | Questionnaire | 72 % | Yes | | A multiple logistic regression analysis showed fetal weight was common potential risk factors for LUTS (OR 1.40, 1.07–1.85), voiding (OR 1.42, 1.08–1.87) and storage symptoms (OR 1.63, 1.16–2.28). |
| **Zhu** [70] China | Cross-sectional | - | 5,221 | Interview | ? | Yes | Birthweight was not identified as potential risk factors of female SUI. |

Preg = pregnancy. PP = postpartum. Quest = questionnaire. SVD = spontaneous vaginal delivery. CS = cesarean section. VD = vaginal delivery. Instr = instrumental delivery. OD = operative delivery. Adj. = adjusted analyses. OR = odds ratio. RR = relative risk. Mth = months. UI = urinary incontinence. SUI = stress urinary incontinence. UUI = urgency urinary incontinence. MUI = mixed urinary incontinence. OR = odds ratio. ++ = significant positive association between birthweight and UI. + = non-significant positive association between birthweight and UI. - = non-significant negative association between birthweight and UI. − = significant negative association between birthweight and UI. * = studies used in meta-analysis.
delivery, primiparous women, and UI 3 – 18 months postpartum. Mode of delivery was categorized as any vaginal delivery or any CS. Main findings on the association between birthweight and UI are presented as odds ratio, and in Forest plot figures. Both adjusted data and unadjusted data are presented in Forest plot figures.

Heterogeneity among studies was assessed by I². An I² of 0% to 40% represents minimal heterogeneity, while 75% to 100% represents considerable heterogeneity. Adjusted data and unadjusted data had in general moderate to substantial heterogeneity in effect estimates. Random effect estimates were therefore used.

The review was registered in PROSPERO (73021); NHS International prospective register of systematic reviews. The review adheres to the PRISMA guidelines and MOOSE guidelines for meta-analyses and systematic reviews of observational studies.

### 3. Results

A total of 477 articles were identified. Fifteen external articles were added based on the authors’ knowledge of relevant literature, and after reading references. A total of 385 articles remained after removing duplicates (Table 1). Fifty-seven articles (N = 164,600) were included in this systematic review. Descriptive data can be included in the meta-analyses. Descriptive data are presented in Table 3.

Selection bias was considered in studies used in the meta-analyses. Risk of selection bias was considered as high in 2/22 studies [13,17], moderate in 2/22 studies [18,19], unclear in 2/22 studies [12,20], and low in 16/22 studies (Table 3). Unadjusted association between birthweight and UI was reported in 9/22 studies. Funnel plot did not reveal publication bias, as it spread evenly on both sides of the average, creating a roughly funnel-shaped distribution.

There was a significant positive association between high birthweight and UI after childbirth in 35% (20/57) of the studies. There was a non-significant positive association in 19% (11/57) of the studies. There was no association in 46% (26/57) of the studies. A significant protective association between high birthweight and urgency UI was also found in one of the above studies.

### 3.1. Birthweight >4000g

Eighty studies [8,11–14]–[18–30], reported data on 30,070 women for review on birthweight >4000 g and UI. Birthweight >4000 g compared to weight <4000 g was associated with a significantly increased risk of any UI in meta-analyses (OR 1.49, 95% CI 1.24 – 1.80) (Fig. 1). Meta-analyses revealed higher OR of UI in adjusted data than unadjusted data (OR 1.73 and OR 1.28, respectively). Funnel plot did not reveal publication bias, as it spread evenly on both sides of the average, creating a roughly funnel-shaped distribution.

#### 3.1.1. Birthweight >4000 g and stress UI

Data from four European [11–14] and one American [23] study were available for meta-analyses. Time of recording UI varied from 3 days postpartum [11] to several decades after childbirth [14]. Weight >4000 g was associated with a significant increased risk of stress UI (OR 1.52, 95% CI 1.03 – 2.25) when analysing available data from these five studies with a total of 15,806 women.

#### 3.1.2. Birthweight >4000 g and UI 3 – 18 months postpartum

Nine studies; six cohort studies [8,20,23,25–27] and three cross-sectional studies [18,19,22] gave data on 13,603 women for meta-analyses. The studies were conducted in Europe [8,19], Africa [27], Asia [20], Australia [22,26], and America [18,23,25]. Age was 22 – 31 years in the cohorts; two cross-sectional studies reported age 27 – 29 years. Five studies included primiparous only [8,18,20,23,26]. Birthweight >4000 g lead to a significantly increased OR 1.54 (95% CI 1.08 – 2.19) for UI 3 – 18 months postpartum compared to women delivering infants with birthweight <4000 g (Fig. 2).

#### 3.1.3. Birthweight >4000 g and UI after vaginal birth

Seven studies gave data for meta-analyses on 19,907 women on the association between UI and birth weight >4000 g among women delivering by any vaginal birth; three cohort studies [8,24,30] and four cross-sectional studies [11–14] were identified. Three large studies with adjusted data were included; Rortveit et al. [14] enrolled 11,397 women; Wesnes et al. [8] enrolled 5,219 women, and Thom et al. enrolled 1,521 women. However, mean

### Table 3

Descriptive data on studies included in meta-analyses.

| Study          | Data on 4000 g | Data on 3500 g | Data on stress UI | Data 3-18 months postpartum | Data on vaginal delivery | Data on primiparous | Risk of selection bias | Adjusted effect estimates |
|----------------|---------------|---------------|-------------------|-----------------------------|--------------------------|----------------------|------------------------|--------------------------|
| Altwawel [21]  | X             | X             |                   | X                           | X                        | X                    | Low                    | X                        |
| Boyles [10]    |               |               |                   |                             |                          |                      | Low                    | X                        |
| Brown [22]     | X             | X             |                   |                             |                          |                      | Low                    | X                        |
| Casey [23]     | X             |               | X                 | X                           | X                        | X                    | Low                    | Low For stress UI        |
| Diez-Ratta [24]| X             | X             |                   |                             | X                        |                      | High                   | X                        |
| Dimpfl [31]    |               | X             | X                 |                             | X                        |                      | Low                    | Partly                   |
| Dolan [32]     | X             |               |                   |                             |                          |                      | Low                    |                         |
| Eason [25]     |               |               |                   |                             |                          |                      | Low                    |                         |
| Garrland [26]  | X             |               |                   |                             |                          |                      | Low                    |                         |
| Greutz [11]    | X             |               |                   |                             |                          |                      | Low                    |                         |
| Hatem [18]     | X             | X             |                   |                             |                          | X                    | Moderate                | X                        |
| Hvidman [19]   | X             |               |                   |                             |                          |                      | Moderate                |                         |
| Iwanowicz [12] | X             |               |                   |                             |                          | X                    | Moderate                | X                        |
| Krue [13]      | X             |               |                   |                             |                          | X                    | Moderate                |                         |
| Malik [20]     | X             |               |                   |                             | X                        | X                    | Unclear                 | X                        |
| Ohioah [27]    |               |               |                   |                             |                          |                      | Unclear                 | X                        |
| Rortveit [14]  | X             | X             | X                 |                             | X                        | X                    | Low                    | X                        |
| Samuelsson [28]| X             |               |                   |                             |                          |                      | Low                    | X                        |
| Schynt [16]    |               | X             |                   |                             |                          |                      | Low                    |                         |
| Solans-Domenech [29] | X           |               |                   |                             |                          |                      | Low                    |                         |
| Thom [30]      | X             |               |                   |                             | X                        | X                    | Low                    | X                        |
| Wesnes [62]    | X             | X             | X                 |                             | X                        | X                    | Low                    | X                        |

UI = urinary incontinence.
age, parity and time of UI varied in these studies. Weight >4000 g was associated with a significantly increased risk of UI after vaginal birth (OR 1.41, 95% CI 1.14 – 1.75) (Fig. 3).

Only one study had additional data on birthweight >4000 g and birth by CS [8]. OR for UI after birth by any CS of child >4000 g compared to <4000 g was 1.38 (95% CI 0.84 – 2.28).

3.1.4. Birthweight >4000 g and UI among primiparous women

Five cohort studies [8,20,23,26,29] and one cross-sectional study [18] had data on 11,643 women for meta-analyses on birthweight >4000 g among primiparous women. All studies had data on UI 2 – 18 months postpartum. Three studies included only women who were continent before pregnancy [8,26,29]. Weight >4000 g was associated with a non-significantly increased risk of UI among primiparous women (OR 1.46, 95% CI 0.95 – 2.26). Only two studies gave adjusted effect estimates [8,20], leading to an OR of 2.48 (95% CI 0.70 – 8.71) for UI among primiparous women delivering babies >4000 g compared to <4000 g. However, due to heterogeneity in effect estimates, I² was 96%. Unadjusted analyses gave OR of 1.15 (95% CI 0.88 – 1.50).
3.2. Birthweight >3500 g

Only four studies from Europe [8,16,31,32] and one from America [10] gave data on birthweight >3500 g and risk of any UI, including 15,066 women for meta-analyses. Two studies reported data on primiparous women [8,10]; three studies included women who were continent before pregnancy [8,10,31]. Weight >3500 g was associated with a significantly increased risk of UI (OR 1.26, 95% CI 1.15 – 1.37) (Fig. 4).

3.2.1. Birthweight >3500 g stress UI

Two studies had unadjusted data on the association between birthweight >3500 g and stress UI [16,31]. Data was collected 6 weeks – 1 year after childbirth. None of these studies reached statistical significance on the association between birthweight >3500 g and stress UI. Birthweight >3500 g was associated with a non-significantly increased risk of stress UI in meta-analyses of 2525 women (OR 1.33, 95% CI 0.97 – 1.82).

3.2.2. Birthweight >3500 g and UI 3 – 12 months postpartum

Four studies reported data on birth weight >3500 g and UI 3 – 12 months after childbirth [8,10,16,31]. Included studies were rather similar regarding study population; three studies reported data on primiparous [8,10,16], and three studies reported data on women who were continent before pregnancy [8,10,31]. Meta-analyses on 14,181 women found a significantly increased risk of UI 3 – 12 months postpartum (OR 1.26, 95% CI 1.15 – 1.39) (Fig. 5).

3.2.3. Birthweight >3500 g and UI after vaginal childbirth

Three large studies with 5599 [10], 2390 [16], and 5219 [8] participants had data on the association between birthweight >3500 g and UI after vaginal childbirth. All studies presented adjusted data on UI 3 – 12 months postpartum with OR 1.22, 1.30 and 1.25, respectively. In meta-analyses, weight >3500 g was associated with a significantly increased risk of UI after vaginal childbirth (OR 1.26, 95% CI 1.15 – 1.37). I2 was 0%.

Boyles [10] and Wesnes [8] reported stratified data for CS: there was no association between birthweight >3500 g and UI after CS (OR 1.04, 95% CI 0.67 – 1.63).

3.2.4. Birthweight >3500 g and UI among primiparous women

Four large questionnaire-based studies investigated the association of birthweight >3500 g on UI [8,10,16,32] in women 3 – 12 months after childbirth. Three studies reported adjusted results. Two studies found a significant positive association [8,10] between birthweight >3500 g and UI among primiparous women, two
studies found a non-significant positive association [16,32]. Meta-analyses from these studies gave an OR of 1.23 (95% CI 1.11 – 1.35) for UI among primiparous women delivering infants with birthweight >3500 g compared to <3500 g. Schytt et al [16] reported stratified data on primiparous and multiparous women. Results indicated that birthweight >3500 g lead to higher RR for UI postpartum among multiparous compared to primiparous women (RR 1.5 (95% CI 1.2–1.9) and RR 1.1 (95% CI 0.8–1.4), respectively).

4. Discussion

This is the first systematic review on the association between birthweight and UI after childbirth. UI postpartum is a common condition, affecting 32 – 36% of women [2]. Many risk factors have been brought forth in studies, most are not well documented. Reviews on epidural [3], episiotomy [4], cesarean section [2] and instrumental childbirth [5] have made their association with UI postpartum clear. Some birth variables are more commonly extracted from birth registries (birthweight, head circumference, rupture) and often included in analyses. There has been need to summarize knowledge on these potential risk factors.

4.1. Main findings

Birthweight >4000 g and >3500 g were associated with significantly increased risk of UI (OR 1.49 and 1.26, respectively). Separate analyses on stress UI, UI 3 – 18 months postpartum, UI after vaginal birth and UI among primiparous women also revealed significantly increased risk of UI.

4.2. Strengths and limitations

Prevalence of UI after childbirth varies with time of information gathering, type of UI, mode of childbirth, and characteristics of the study population [1]. Diversity in studies included in meta-analyses needs to be addressed. To control for some of these parameters, separate meta-analyses were performed for time of UI, stress UI, vaginal birth, and parity. Subgroup meta-analyses on the reported variables showed significantly increased OR in the range 1.41 – 1.54 for UI and birth weight >4000 g. Corresponding analyses on UI and birth weight >3500 g gave significantly increased OR in the range 1.23 – 1.33. This indicates that the overall risk estimates are robust. Studies have shown that selection bias affects prevalence estimates, but data are still valid for risk estimates [33]. High birthweight is also associated with high BMI in the mother, prolonged birth, CS, rupture, episiotomy, birth by forceps and vacuum. We cannot rule out confounding.

A total of 33/57 studies report on the association between birthweight and UI as secondary finding, without authors reporting values, percentages or risks. Information from these articles was applicable for this review, but not for the meta-analysis.

The literature search also needs to be addressed. Birthweight and UI was the main objective in few articles. Literature search retrieved information from headings and abstracts, therefore it did not retrieve articles where relevant information was solely in the main text. 476 articles were identified by literature search. Author’s knwoledges of literature, and full reference reading identified 15 external articles (Table 1). A total of 27 articles were not evaluated for inclusion due to foreign language or lack of access. We must therefore accept that the sensitivity of the search was high, but not complete. Publication bias may be a problem, as significant data are more likely to be published, and presented in abstracts.

Categorizing of weight groups and reference groups can affect the results. Birthweight >3500 g and >4000 g led to OR 1.26 and 1.49, respectively. The reference groups were birthweight <3500 g and <4000 g, respectively. One study with 5,219 women used lower reference value [8]. OR of UI was 1.6 (95% CI 1.2 – 2.0) after birthweight >4,180 g (90 percentile) compared to birthweight 3,540 g (50 percentile) [8]. Another study compared birthweight >3,925 to <3,199, finding OR of 1.4 [28]. Risk estimates in studies might have been higher if reference groups consisted of lower birthweights.

Few studies use weight groups >4500 g [16,34,35]. Few study participants in the exposure group makes it difficult to do meta-analyses. One study reported adjusted OR 1.23 (95% CI 0.87 – 1.76) for UI among women delivering babies with birthweight >4,500 g compared to < 4,500 g [35].

Vaginal birth is associated with higher risk of UI than CS in most studies [2]. Weight >4000 g was associated with UI after vaginal birth and CS (OR 1.41 95% CI 1.14 – 1.75 and OR 1.38, 95% CI 0.84 – 2.28, respectively). Weight >3500 g was also associated with UI after vaginal birth and CS (OR 1.26, 95% CI 1.15 – 1.37, and OR 1.04 95% CI 0.67 – 1.63, respectively). These meta-analyses on birthweight and UI are in line with what is previous shown regarding birth mode and UI [2]; lower risk of UI after CS, than after vaginal birth. Studies including women delivering by vaginal birth and CS indicate that birthweight is a significant risk factor for UI only in association with vaginal birth [8,35]. Mode of birth is a confounder
that is likely to affect the association between birthweight and UI in the remaining sub-analysis. There were, however, no data available for further stratified sub-analysis on CS and vaginal birth.

It is unclear how high birthweight lead to UI. Trauma to the pelvic floor when delivering large babies is a plausible contributing factor. Heavier babies have been associated with EMG evidence of pudendal nerve damage in the pelvic floor after vaginal birth [6,36].

The majority of studies report grams, others report pounds [10]. Several studies analysed on mean birthweight [37], some use percentiles [8] or quartiles [38]. Birthweight was often categorized arbitrary without authors reporting reason for cut-off, most studies use 500-gram groups (3500 g, 4000 g, and 4500 g). Varying reporting and different weight categorizing makes it difficult to summarize published results. Weight cut-off on 3500 g and 4000 g were most common, and were therefore chosen for this review. As 3500 g generally represents mean birth weight, these weight cut-offs gives important information on the association between UI and birthweight beyond mean, as well as extreme birthweight >4000 g.

4.3. Interpretation

Birthweight appears to be a risk factor for UI after childbirth. Data in this meta-analysis are gathered from epidemiological cohort and cross-sectional studies. When planning future epidemiological studies, data on birthweight ought to be gathered when possible. Birthweight is likely to effect risk estimates on UI after deliver, and adjustment should be considered in future research.

The Hill Criteria are useful when considering a possible causal relationship between exposure and outcome. Birthweight satisfies several of the Hill Criteria for causation; it is biologically plausible, exposure precedes outcome, and there is consistency in the majority of studies. There is a dose–response association, as birthweight >4000 g gave higher OR for UI than >3500 g.

To predict future risk of UI after childbirth, the UR-CHOICE risk calculator intend to include eight variables, of which birthweight is the only fetal factor [39]. Birthweight is included in the risk calculator due to the high likelihood of causation.

Even though results appear biological plausible, results in the meta-analysis are based on epidemiological research and can thereby not automatically be applied into a clinical setting. As high birthweight is associated with UI postpartum, clinical preventive strategies ought to be identified. Strategies might be targeted on identifying mothers at risk of having babies with high birthweight (for instance by identifying high maternal BMI, identifying previous deliveries of babies with high birthweight), avoiding high birthweight (for instance by avoiding high maternal weight gain during pregnancy, detecting gestational diabetes), detecting high birthweight (for instance by growth charts, ultrasound, symphysis-fundus height measurements), reducing risk of incident UI postpartum (for instance by aiming at normal weight before pregnancy, and at regaining pre-pregnancy weight postpartum, considering CS, performing PFMT), or by treating UI postpartum, for instance by PFMT. Future research will need to find ways to identify which women are likely to give birth to babies >3500 g, and look into the best preventive strategies.

Pelvic floor muscle training is generally recommended in pregnancy and postpartum. It has been unclear which women benefit the most from this training. Women delivering babies with birthweight > 3500 g are women at risk of developing UI. No preventive strategy is validated in this study, but pelvic floor muscle training has documented effect on preventing UI among women delivering heavy babies [40].

5. Conclusion

We conclude that birthweight appears to be a risk factor for UI after childbirth. A causal relationship between birthweight and UI is biologically plausible. Strategies towards preventing UI postpartum should be targeted towards women at higher risk, like women giving birth to babies with high birthweight.

Author contribution to the manuscript

Wesnes: Project development, data collection, manuscript writing, statistical analysis.
Seim: Data collection, manuscript writing.

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Declaration of Competing Interest

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