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LITERATURE REVIEW

Examination of predisposing risk factors among primiparous women at risk of developing pelvic organ prolapse within a year of childbirth

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Abstract

Pelvic organ prolapse (POP) is a benign gynaecological condition with a multifactorial aetiology that affects 40–50% of adult women. However, the majority of studies focus on middle-aged and older individuals, and only a few have specifically investigated the natural history of POP during and following first pregnancies and deliveries. The dearth of research involving nulliparous women compounds the difficulty associated with the early identification of those at risk of developing POP before the manifestation of its symptoms. In line with the shift from treatment to prevention, the aim of this review is to identify and describe the predisposing and precipitating risk factors associated with developing POP in primiparous women within a year of childbirth in order to recommend early clinical objective assessment. A literature search using the CINAHL and MEDLINE databases was performed, and studies of the natural history of pelvic organ support during pregnancy and up to 1 year postpartum were identified. The papers selected objectively assessed POP using the Pelvic Organ Prolapse Quantification System, and one also included dynamic ultrasound imaging. Six observational cohort studies involving primiparous women were critically appraised in order to identify predisposing risk factors for the condition. This review found that maternal pre-pregnancy pelvic floor anatomical differences, pregnancy and vaginal delivery are associated with the development of POP in first-time mothers. The studies also showed that Caesarean section delivery (CSD) after the onset of active labour does not offer complete protection against the development of POP. Elective CSD offered initial protection for the pelvic organ support structures. No strong association was found between POP, and levator ani muscle injury, race, body mass index, infant birth weight or maternal age at first delivery. The introduction of routine objective assessment of pelvic organ support during pregnancy and up to 1 year postpartum may improve rates of early identification of women who are susceptible to developing POP in later life.

Keywords: childbirth, pelvic organ prolapse, postpartum, primiparous, risk factors.

Introduction

Pelvic organ prolapse (POP) is the symptomatic downward descent of one or more of the anterior vaginal wall, posterior vaginal wall, uterus, or apex of the vagina from the normal anatomical position (Haylen *et al.* 2016). The normal support of female pelvic organs depends on the integrity of the levator ani muscles (LAMs) and endopelvic connective fascia, and an adequate nerve supply arising from the lumbosacral spinal roots. Structural integrity can be compromised when these structures are exposed to trauma or acute physical strains, which leads to the development of POP (Dietz 2006; Ashton-Miller & DeLancey 2007). Approximately 40–50% of adult women suffer from varying degrees of POP, and the estimated lifetime risk of a woman undergoing surgery for POP is 10–20% (Bump & Norton 1998; Sung & Hampton 2009; Smith *et al.* 2010; Wu *et al.* 2014). The risk of

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a reoccurrence following primary surgery and a further operation is estimated to be between 8.5% and 58% (Friedman *et al.* 2018).

The condition has a multifactorial aetiology with identifiable risk factors. These include: pregnancy; childbirth; parity; ageing; menopause; congenital or acquired connective tissue abnormalities; denervation or weakness of the LAMs; smoking; a consistent increase in intra-abdominal pressure; and prior surgery for POP (Schaffer *et al.* 2005; Vergeldt *et al.* 2015). The integrated lifespan model of the predisposing and inciting causal factors for the development of POP (Delancey *et al.* 2008) considered childbirth as the most important inciting factor. Furthermore, various epidemiological studies have suggested that pregnancy and childbirth are the primary reasons for developing POP, with vaginal delivery (VD) predisposing women to a higher level of risk in comparison to Caesarean section delivery (CSD) (Gyhagen *et al.* 2013; Handa *et al.* 2018). Pelvic organ prolapse may be either asymptomatic or symptomatic, with women reporting "bulge" in the vagina, pelvic pressure, low back pain, and sexual, urinary and bowel dysfunction (Haylen *et al.* 2016). The severity of POP symptoms varies between individuals, and can greatly affect activities of daily living and quality of life (Fritel *et al.* 2009). There is often a delay in the manifestation of symptoms: in some cases, several decades can elapse between childbirth and the clinical presentation of POP and the commencement of treatment (Gyhagen *et al.* 2013). Conservative treatments include: lifestyle interventions (e.g. managing constipation, weight reduction and avoiding an excessive increase in intra-abdominal pressure); physical interventions, such as pelvic floor muscle (PFM) training (PFMT) with or without adjunctive therapies (e.g. biofeedback and neuromuscular electrical stimulation); and mechanical devices, such as a vaginal pessary.

Although large, population-based epidemiological and cross-sectional observational studies have documented the relationship between childbirth and POP, no current literature has analysed the risk factors that predispose primiparous women to developing the condition following childbirth. The aim of the present literature review is to identify the predisposing and inciting risk factors that lead to the development of POP within a year of childbirth in order to recommend early clinical objective assessment. In line with increasing life expectancy, the growing prevalence of POP in the female population, and the National Health Service (NHS) 10-year long-term plan highlighting the importance of early prevention, the present literature review will provide evidence that may influence the implementation of pre-emptive treatment strategies.

Materials and methods

The CINAHL and MEDLINE electronic databases were searched for relevant literatures. A combination of search terms was used, including "pelvic organ prolapse", "childbirth", "delivery", "postpartum" and "risk factors". These were matched with the following Medical Subject Headings:

- pelvic organ prolapse, female pelvic organ prolapse, cystocele, rectal prolapse, rectocele, uterine prolapse, urogenital prolapse and vaginal vault prolapse;
- childbirth, pregnancy, parturition, obstetrics, obstetrics care, delivery and vaginal birth;
- postpartum, postpartum period, postnatal period and puerperium; and
- risk factors and epidemiology.

The inclusion criteria were as follows: publication in English between January 1998 and November 2018; studies of humans; an adult female population, i.e. ≥ 18 years; nulliparous or primigravid women; and prospective longitudinal observational studies. The exclusion criteria were as follows: papers not published in the English language; a male or paediatric population; studies involving middle-aged and menopausal women; studies involving animals; and retrospective studies.

In order to identify the natural history of the development of POP during pregnancy and childbirth, the papers included were limited to prospective observational longitudinal cohort studies of nulliparous women for 1 year postpartum. In addition, non-electronic reference lists of peer-reviewed papers were examined to detect any others that had not been captured by the electronic searches.

Results

After all duplicates were removed, the literature search yielded 131 peer-reviewed papers. Twenty-eight of these met the initial eligibility criteria after their titles were reviewed (Fig. 1). Full-text articles were obtained, and 24 studies were then excluded because: these had a retrospective design; or the cohort studied were not nulliparous women. Papers were also excluded

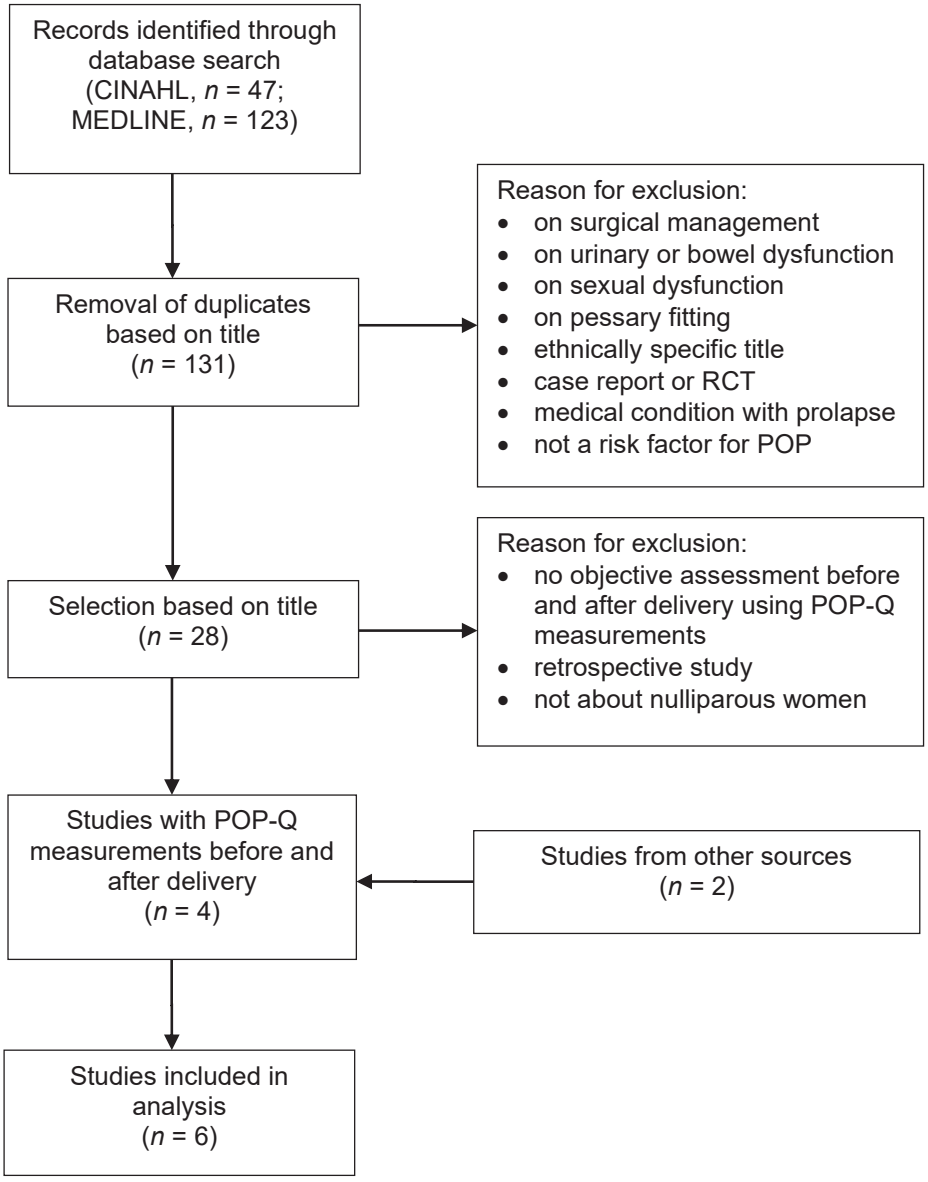

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart demonstrating the literature search strategy (Moher *et al.* 2009; PRISMA 2009): (RCT) randomized controlled trial; (POP) pelvic organ prolapse; and (POP-Q) Pelvic Organ Prolapse Quantification System.

if an objective assessment of POP was not performed using the validated Pelvic Organ Prolapse Quantification System (POP-Q), as described by the International Urogynecological Association and International Continence Society (Haylen *et al.* 2016), during any trimester of pregnancy or the postpartum period. Two papers found in non-electronic peer-reviewed articles were also included in the analysis. Six articles were identified and appraised using the Critical Appraisal Skills Programme Cohort Study Checklist (CASP 2018). These publications are prospective observational cohort studies of 925 nulliparous women with a single gestation and uncomplicated pregnancy recruited from hospital-based antenatal clinics. The research took place in the USA, China, the UK and Norway (Sze *et al.* 2002; O'Boyle *et al.* 2005; Chen *et al.* 2013; Elenskaia *et al.* 2013; Reimers *et al.* 2016, 2019).

The POP-Q quantifies the condition using stages defined by measurements of vaginal points and external genitalia. The stages identified within the selected studies varied from I to ≤II (mild and moderate POP). None of the studies reported stage III or IV (severe POP) in the cohorts observed. All the authors except Sze *et al.* (2002) reported that changes were observed in POP-Q measurements of external genitalia, i.e. the genital hiatus (GH) and perineal body (PB), during pregnancy and the postpartum period. Three studies monitored participants until 6–22 weeks postpartum (Sze *et al.* 2002; O'Boyle *et al.* 2005; Reimers *et al.* 2019), and three until 1 year postpartum (Chen *et al.* 2013; Elenskaia *et al.* 2013;

Reimers *et al.* 2016). Five of the papers under review evaluated the natural history of the development of POP by observing the impact of pregnancy on pelvic organ support, and the association of the mode of delivery with the progress of the condition. One study (Reimers *et al.* 2019) investigated the risk factors for developing POP by using transperineal three-dimensional (3D) dynamic ultrasound imaging to evaluate the morphometry of the PFMs in conjunction with objective assessment with the POP-Q (Table 1).

Discussion

In the year following childbirth, the main risk factors for the development of POP in primiparous women are: maternal pre-pregnancy anatomical differences of the supportive structures of the pelvic floor; pregnancy itself; and vaginal delivery. Women who experienced active labour before an emergency CSD had a higher risk of developing POP compared to those who had an elective Caesarean. Risk factors like injury to the LAMs, a high body mass index (BMI), race, infant birth weight or maternal age at first delivery were not significantly associated with POP during the postpartum period in primiparous women. However, the clinical implications and further considerations relating to the contents of these studies must be discussed.

Rahn *et al.* (2008) described some of the anatomical, physiological and functional changes that occur during pregnancy. Several of these are a result of hormonally induced collagen alterations. The vagina becomes more distensible with reduced stiffness as the pregnancy advances, leading to maximal stress on the pelvic ligaments and muscles at the end of the third trimester. These changes may subsequently affect pelvic organ support in some women. Five of the six studies in the present literature review investigated pelvic organ support during the three trimesters of pregnancy. Although the number of participants in each cohort was small, there were no methodological flaws in terms of: patient recruitment; and the objective assessment of POP to examine the impact of pregnancy on pelvic organ support.

The study of 86 nulliparous women by O'Boyle *et al.* (2005) measured POP-Q points during all three trimesters of pregnancy. These authors observed a decrease in the support of pelvic organs as the pregnancy progressed, and a statistically significant increase in POP staging ($P < 0.001$) in the third trimester in comparison to the first. Similar observations were made by Sze *et al.* (2002) and Chen *et al.* (2013), who both reported a higher prevalence of POP in the third trimester [46% ($n = 94$) and 37% ($n = 108$), respectively]. However, these observations contradict the study by Reimers *et al.* (2016), who reported a low prevalence of anatomical POP in their study participants (0–10%). These authors reported that POP-Q points moved cranially from the second trimester to late pregnancy, indicating better pelvic organ support during this period. Despite reporting this observation, their descriptive data revealed the presence of stage I and II POP in 82 of the 273 participants examined during the third trimester. This dissimilarity in results could be a result of differences in the study populations, or variations in the clinical positioning of participants during POP-Q measurements as reported in these studies.

One of the indicative risk factors associated with developing POP as pregnancy progresses is an increase in the combined measurements of the GH and PB (Reimers *et al.* 2019). These two external measurements of genitalia comprise part of the objective assessment of prolapse with the POP-Q. A combined total of more than 7 cm is associated with abnormal levator hiatal and LAM distensibility on imaging (Khunda *et al.* 2012). In addition, various studies statistically and clinically associated these measurements as markers of deficient pelvic organ support using the POP-Q and ultrasound measurements (DeLancey *et al.* 2007; Volløyhaug *et al.* 2013; Dunivan *et al.* 2016). In parous women, an increase in GH measurement may be a result of PFM weakness or LAM injury, and a deficient PB is thought to contribute to prolapse because of the weakness in level III pelvic organ support (Ashton-Miller & DeLancey 2007). Three studies reported changes in the combined measurements of the GH and PB during pregnancy. O'Boyle *et al.* (2005) and Reimers *et al.* (2016) observed an increase from 6.2 to 7.4 cm and 7.2 to 7.9 cm, respectively, during the third trimester of pregnancy when this was compared with the first. Although these measurements were reported, O'Boyle *et al.* (2005) did not identify this as a risk factor for developing POP in their discussion. On the other hand, Reimers *et al.* (2019) associated an increase in combined measurements during pregnancy as a risk factor for developing POP following childbirth. The study by Chen *et al.* (2013) did not report any significant difference in GH and PB measurements during pregnancy, but reported that POP during the third trimester of pregnancy is a significant predictor of POP

Table 1. Characteristics of the studies included in the literature review: (POS) prospective observational study; (POP) pelvic organ prolapse; (POP-Q) Pelvic Organ Prolapse Quantification System; (3D) three-dimensional; (CSD) Caesarean section delivery; and (N/A) not applicable

	Reference					
Variable	Sze *et al.* (2002)	O'Boyle *et al.* (2005)	Chen *et al.* (2013)	Elenskaia *et al.* (2013)	Reimers *et al.* (2016)	Reimers *et al.* (2019)
Location	USA	USA	China	UK	Norway	Norway
Study type	POS	POS	POS	POS	POS	POS
Number of participants and characteristics	94 nulliparous women Mixed racial cohort Single gestation	135 nulliparous women Mixed racial cohort Single gestation	108 nulliparous women Chinese cohort Single gestation	175 nulliparous women Mixed racial cohort Single gestation	178 nulliparous women Caucasian cohort Single gestation	284 nulliparous women Caucasian cohort Single gestation
Age (years)	22.1 ± 4.6	Mean = 22 (range = 18–38)	27.4 ± 2.9	29.7 ± 5.6	28.7 ± 4.3	28.7 ± 4.3
Objective assessment of POP	POP-Q	POP-Q	POP-Q	POP-Q	POP-Q	POP-Q Transperineal 3D ultrasound
Intervals of POP assessment	Third trimester of pregnancy 6 weeks postpartum	First, second and third trimesters of pregnancy 15–22 weeks postpartum	Second trimester of pregnancy 14 weeks, 1 year and 5 years postpartum	Third trimester of pregnancy 6 weeks, 6 months and 1 year postpartum	Second and third trimesters of pregnancy 6 weeks, 6 months and 1 year postpartum	Second trimester of pregnancy 6 weeks postpartum
Definition of POP	POP-Q stage I or II	POP-Q stage I or II	POP-Q stage II	Changes in measurements of POP-Q variables	POP-Q stage II	POP-Q stage II
Number of POPs in third trimester of pregnancy	Stage I: $n = 19$ Stage II: $n = 24$	Stage I: $n = 45$ Stage II: $n = 29$	Stage II: $n = 39$	No POP-Q measurements performed	Stage I: $n = 81$ Stage II: $n = 2$	No POP-Q measurements performed
Number of vaginal deliveries	Spontaneous: $n = 41$ Operative: $n = 18$	Spontaneous: $n = 22$ Operative: $n = 27$	Spontaneous: $n = 63$ Operative: $n = 2$	Spontaneous: $n = 127$ Operative: not recorded	Spontaneous: $n = 196$ Operative: $n = 47$	Spontaneous: $n = 196$ Operative: $n = 45$
Number of CSDs after active labour	32	Not recorded	14	40	33	22
Number of elective CSDs	3	3	29	9	11	21
Number of POPs 6–22 weeks postpartum	Stage I: $n = 28$ Stage II: $n = 50$	Stage I: $n = 40$ Stage II: $n = 22$	Not recorded	Not recorded	25	25
Number of POPs 6 months postpartum	N/A	N/A	Not recorded	Not recorded	5	N/A
Number of POPs 1 year postpartum	N/A	N/A	Not recorded	Not recorded	4	N/A

following childbirth [OR = 8.2, 95% confidence interval (CI) = 3.07–21.9, $P < 0.0001$].

Apart for the normal physiological changes and hormonally induced collagen alterations during pregnancy causing probable caudal descent of the pelvic organs, there may be other possible explanations for this phenomenon. For example, a first-time pregnancy can reveal the inherent weakness of pelvic organ support in some women, linking prolapse in pregnancy to pre-pregnancy anatomical differences. To examine this possibility, Reimers *et al.* (2019) used 3D ultrasonography to observe variations in LAM morphometry and levator hiatal area (LHA) in 300 pregnant women at 21 weeks gestation and 6 weeks after delivery. These authors observed that some of the pregnant women had a large LHA and a more-distensible LAM when instructed to perform the Valsalva manoeuvre during the second trimester of pregnancy. A previous study on parous women attributed an enlarged LHA to either muscle or nerve injury that might have occurred during childbirth (Shek & Dietz 2009), and this may be a predisposing risk factor for the development of POP in some women (DeLancey & Hurd 1998). This observation indicates that a woman already has reduced pelvic organ support, and this may increase her risk of developing POP irrespective of the mode of delivery.

Another study investigating PFM strength in relation to pelvic organ support in primigravid women reported variations in PFM strength in the third trimester (Diez-Itza *et al.* 2011a). These authors reported that 33% of the 319 women in their cohort had weak PFMs (grade 2 or less on the Oxford Scale) prior to delivery. They concluded that maternal pre-pregnancy pelvic floor strength is a constitutional factor that can contribute to postpartum impairment of PFM function and the development of POP.

A genetic cause linking the manifestation of POP during pregnancy has not been fully identified. However, two systematic reviews of middle-aged and menopausal women revealed that the relative odds of developing POP and its reoccurrence following surgery were high among women who had a family history of prolapse (Lince *et al.* 2012; Friedman *et al.* 2018). As reported in all the studies in this review, the most frequent site of severe POP-Q staging during pregnancy was the anterior compartment, followed by the posterior one. There was minimal descent in the middle compartment.

The mode of delivery is an important risk factor for the onset of POP, and this association was investigated by all six studies in the present literature review. These made a variety of comparisons of the impact of VD, active labour before CSD and elective CSD from 6 to 14 weeks postpartum.

In the study of 182 nulliparous women by Elenskaia *et al.* (2013), POP-Q measurements at a baseline of week 21 of gestation were compared with measurements at week 14 postpartum. These authors found that both the VD ($P < 0.001$) and CSD groups ($P = 0.01$) were associated with a significant increase in POP at week 14 postpartum. One possible explanation for the significant increase in POP in the CSD group may be that this is a result of the analysis of POP-Q measurements of women who had experienced active labour before an emergency CSD alongside the data of those who had undergone an elective one.

A similar observation was made by Sze *et al.* (2002), who reported new cases of stage II POP at week 6 postpartum in 35% of the 26 women who were in active labour before having a CSD. These authors concluded that CSD after active labour does not protect pelvic organ integrity, and speculated that injuries to maternal pelvic organ support might have occurred during the first stage. A possible explanation for this observation could be variation in the duration of the time from active uterine contractions to full cervical dilation: in first-time mothers, a duration of more than 12 h may compress the PFMs or the pudendal nerve, subsequently affecting their function (Zhang *et al.* 2010). In addition, Reimers *et al.* (2016) observed increases in POP-Q measurements in some women who had experienced active labour before CSD, which indicated less pelvic organ support. Although this was mentioned in their discussion, the number of women with poorer POP-Q results was not reported. In contrast, O'Boyle *et al.* (2005) described only one case of stage II POP-Q in 13 women who had undergone CSD, which suggests that CSD prevents damage to the pelvic organ support structures. This observation should be interpreted with caution because these authors did not state whether women had experienced active labour before CSD, or undergone elective CSD.

Vaginal delivery is often cited as one of the main risk factors for POP, and it can be further categorized as spontaneous or operative VD. Two studies reported a significantly higher proportion of stage II POP-Q at week 6 postpartum in women who had had a VD in comparison with those who had undergone a CSD. Chen *et al.* (2013)

investigated the connection between the mode of delivery and the onset of POP by comparing VD with elective CSD in 108 nulliparous women. Elective CSD was reported as being protective of pelvic organ support, and was associated with a 96% lower likelihood of developing POP compared with VD (OR = 0.04, 95% CI = 0.01–0.18). The POP-Q measurements of women who had undergone an emergency CSD following active labour were analysed with the results of women who had had a VD, which could have influenced Chen *et al.* (2013) finding a statistically significant increase in the onset of stage II POP-Q in the VD group. It is also worth noting that 10 of the women who had had an elective CSD experienced stage II POP-Q during the third trimester of their pregnancies. However, no further deterioration had occurred 6 weeks after delivery. Comparative results were published by O'Boyle *et al.* (2005), who reported a significantly higher proportion of stage II POP-Q in women who had had a VD compared with those who had undergone a CSD ($P = 0.02$). These findings are at variance with the results of Reimers *et al.* (2019), who did not find any connection between the mode of delivery and the onset of POP.

The association of an operative VD involving forceps or vacuum extraction with the onset of POP was reported by three of the studies. Sze *et al.* (2002) observed that eight of the 11 women who had undergone a forceps delivery, and five of the seven who had had a vacuum-assisted delivery, had developed stage II POP-Q by the time of their check-up at week 6 postpartum. Although O'Boyle *et al.* (2005) reported a similar association following forceps delivery, this was not statistically significant when compared to women who had had a non-operative VD. The lack of statistical significance may be a result of the small numbers of participants in these studies. Interestingly, Reimers *et al.* (2016) reported that none of the women in their study who had undergone a forceps delivery had developed POP during this period; however, five of the 41 women who had had a vacuum delivery developed a prolapse. This may reflect the low number of women ($n = 4$) who had experienced forceps-assisted deliveries in their cohort of 284 participants. The observations in these studies are similar to the univariate analysis conducted by Diez-Itza *et al.* (2011b). These authors reported an increased risk of developing POP following an operative VD, but there was no statistically significant association when the result was analysed with other obstetric variables. Although most of the studies reported the likelihood of persistent or new-onset POP at week 6 postpartum, spontaneous regression of POP-Q stage in the postnatal period was observed after both VDs and CSDs in six women in the study by Sze *et al.* (2002).

Considering the higher number of women who were reported to have developed POP following a VD in the present literature review, it is important to consider other pathophysiological mechanisms that could account for this association. One potential cause could be an injury to the LAMs. These muscles maintain the integrity of pelvic organ support by keeping the levator hiatus closed during variations in posture and raised intra-abdominal pressures, thereby minimizing the load on connective tissues that attach the organs to the pelvis. When there is damage or an avulsion injury, the function of the LAMs is compromised, and this has been strongly associated with the development of POP in middle-aged parous women (DeLancey *et al.* 2007; Dietz & Simpson 2008). Only a few studies have investigated this association up to 1 year postpartum. Of the six studies reviewed, only one investigated this association (Reimers *et al.* 2019).

A 3D transperineal ultrasonography assessment performed at 6 weeks postpartum revealed the presence of a LAM injury in 46 of the 241 women (19%) who had had a VD in Reimers *et al.*'s (2019) cohort. Of these 46 participants, six had developed stage II POP-Q. However, there was no statistically significant association between POP and LAM injury during this period. These authors pointed out that this lack of connection may be the result of the measurements being taken during the early postpartum period. Another reason may be because of the lack of statistical power in their study, which was a methodological flaw.

The results of other studies that have investigated this relationship at around the same time postnatally contradict the findings of Reimers *et al.* (2019). Van Delft *et al.* (2014) associated the onset of POP with minor and major LAM injuries at 10–26 weeks postpartum, and Chan *et al.* (2014) reported a correlation at 8 weeks but not at 1 year. It appears that significant effects of LAM injury on pelvic organ support evolve over decades following a transient initial recovery (Dietz & Simpson 2008; van Delft *et al.* 2015; Volløyhaug *et al.* 2016; Handa *et al.* 2019). In addition, a recent meta-analysis by Friedman *et al.* (2019) concluded that operative VD using forceps is associated with LAM injury when

compared with spontaneous VD (OR = 6.94, 95% CI = 4.93–9.78; $P < 0.001$).

Despite the above findings supporting a correlation between POP and mode of delivery, the exact mechanism by which VD or CSD after active labour lead to the failure of pelvic organ support is not completely understood. Long-term epidemiological studies assessing parous women from 5 years or more after their first delivery have all shown a strong association between VD and operative forceps deliveries with the development of POP (Handa *et al.* 2011; Gyhagen *et al.* 2013; Handa *et al.* 2018). These studies are in agreement that there is a latency period between the onset of symptomatic prolapse following childbirth.

Following on from the 6 weeks postpartum period, three studies monitored women until 1 year after childbirth, and one of these measured POP-Q staging 5 years later. A gradual regression of POP-Q stages was reported in women who had had either a VD or CSD until 1 year postpartum by two studies. Chen *et al.* (2013) observed that POP-Q staging declined during the first year, although with less recovery from stage II POP-Q in women who had had a vaginal delivery. Similarly, Reimers *et al.* (2016) observed that POP-Q stages were transient, and any recovery in pelvic organ support had largely taken place by 6 months postpartum. Interestingly, this regression was only observed in women who had undergone a CSD, and not in those who had had a VD in the study by Elenskaia *et al.* (2013). These authors reported persistent worsening and a significant increase in prolapse symptoms at 1 year following VD ($P = 0.001$). All three studies reported that PB measurements in both delivery groups and GH measurements in the CSD group reduced by 1 year after delivery, whereas results for GH measurement in the VD group were divergent. In contrast, Sze *et al.* (2002) reported no changes in POP-Q staging at 4–7 months postpartum in 19 women ($n = 94$) who attended routine postnatal assessment. This result should be interpreted with caution since the modes of delivery were not specified, and the duration of the study design and analysis of the results was for 6 weeks postpartum, not 7 months as reported.

Even though the present literature review is focused on identifying the risk factors in the year following childbirth, it is worth mentioning the POP-Q measurements described by Elenskaia *et al.* (2013) at 5 years postpartum. These authors reported an increase in GH measurements and a shortening of the PB in the CSD group, which indicates worsening pelvic organ support. It is plausible to suggest that CSD is not completely protective of the development of POP with advancing years, and there may be other factors that contribute to the decompensation of pelvic organ support irrespective of the mode of delivery.

Race is another factor that has to be considered with regard to the development of POP. Of the papers reviewed, Sze *et al.* (2002) were the only authors who investigated this association in any detail. They concluded that both the African-American ($n = 54$) and Caucasian ($n = 40$) women in their cohort were equally susceptible to developing POP. This result could be a result of the small sample size and short duration of their study: longitudinal studies with a larger number of participants have reported differences in the correlation of POP with race. The prevalence of symptomatic POP has been reported to be lower in African-American women than their Caucasian, Hispanic and Asian counterparts (Hendrix *et al.* 2002; Whitcomb *et al.* 2009). More studies are needed to confirm this association.

Although an elevated BMI, maternal age, height and infant birth weight at first delivery were identified as confounding factors in some of the studies reviewed, their association with the development POP were not investigated by any of the authors. Retrospective and systematic reviews of these factors in parous women have shown statistical associations with POP (Gyhagen *et al.* 2013; Giri *et al.* 2017; Martinho *et al.* 2019).

Limitations

The critical analysis of the studies has a few limitations. It was conducted solely by the present author, and hence, the evaluation of each longitudinal study may have an element of bias. The internal and external validity of the conclusions may be subject to debate by other experts. In addition, the literature search was limited to nulliparous women with a single, uncomplicated pregnancy. The effect of a twin or multiple-gestation pregnancy on pelvic organ support in nulliparous women was not examined. Most of the studies involved a small number of cases, which limits external validity. However, all had been peer-reviewed and published. While further evidence from well-conducted longitudinal studies is required to enhance our current understanding of this topic, its inherent nature imposes ethical constraints on any methodology.

Implications for physiotherapy and clinical practice

The findings from the present literature review suggest that carrying out routine risk assessments and objective measures of pelvic organ support before and after delivery may help to identify first-time mothers who are at risk of developing POP. This would allow treatment to begin at an early stage, when intervention is simpler. Furthermore, the increasing life expectancy of women in the UK and worldwide means that the prevalence of POP in the female population is likely to increase, especially as more women now have children later in their reproductive years. The early identification of women who are at risk is important for directing prevention strategies, and also reducing the costs of expensive surgical interventions. Currently, in the present author's clinical practice within the NHS, pregnant women are not routinely screened using a validated risk assessment tool for POP, and when prolapse symptoms are reported, women are not normally assessed using validated POP-Q measurements. In light of this review, she plans to discuss her findings with maternity staff in order to influence a change in practice. The UR-CHOICE risk assessment scoring tool (https://riskcalc.org/UR_CHOICE/) has recently been developed and validated on the basis of two large, independent international cohort studies, and is available to facilitate the above change in practice. This tool provides an individual prediction of the risk of developing pelvic floor dysfunction (PFD) up to 12 and 20 years after delivery using maternal and obstetric variables that are available before childbirth (Wilson *et al.* 2014; Jelovsek *et al.* 2018; Milsom & Gyhagen 2019). Since UR-CHOICE uses a scoring system, midwives and physiotherapists can complete it during routine antenatal clinics, regardless of whether women have symptomatic PFD.

Another proposal would be to identify at-risk women by introducing routine pelvic floor morphometry assessments with a routine anomaly scan offered to women at the week 21 pregnancy check in the UK. However, there is a substantial learning curve in carrying out and interpreting images and measurements. While this may be time-consuming and laborious, the initial cost implications could be offset against future savings.

When at-risk women are identified antenatally, it would be appropriate for them to be referred to a physiotherapist to ensure that they are correctly taught how to perform PFM exercises. Although there is evidence to support the role of PFMT in the prevention of urinary incontinence in first-time mothers, no study to date has evaluated the effect of this form of exercise as a primary preventive strategy for POP (Woodley *et al.* 2017). Furthermore, very few studies have investigated the efficacy of postpartum PFMT in the improvement of POP symptoms. A recent systemic review and meta-analysis of postpartum PFMT concluded that there is no clear evidence that it improves POP symptoms in the immediate postpartum period because of the very low methodological quality of the available studies (Wu *et al.* 2018). However, there is evidence to support PFMT for the prevention and treatment of POP in middle-aged parous women (Li *et al.* 2016).

Conclusion

To date, the evidence for the risk factors that predispose primiparous women to the development of POP during pregnancy and within the 12 months following delivery has been sparse. The present literature review highlights possible risk factors in nulliparous women with an uncomplicated pregnancy identified in longitudinal studies published between 1998 and 2018. It appears that maternal antepartum anatomical pelvic floor differences, pregnancy and vaginal delivery are risk factors that predispose primiparous women to POP in the year after childbirth. More observational studies involving larger numbers of participants that investigate other confounding factors are needed before stronger causal associations for POP in nulliparous women can be inferred. Individuals may have different combinations of risk factors that could have more or less impact at varying times during pregnancy and the postpartum period. There is no evidence for PFMT as a primary preventive strategy for POP in at-risk women. However, these findings should be interpreted cautiously in view of the exclusion criteria imposed, and the number of studies in the present literature review.

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