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PAEDIATRICS

# Does being male represent a risk factor for DDH treatment? A systematic review

Maurizio De Pellegrin[1,2], Federico Sinigaglia[3], Lorenzo Marcucci[4], Nicola Guindani[2], Simone Romeni[5] and Laura Mangiavini[6,7]

[1]Pediatric Orthopedic Unit, Piccole Figlie Hospital, Parma, Italy
[2]Department of Orthopedics, ASST Ospedale Papa Giovanni XXIII, Bergamo, Italy
[3]Orthopedic Residency Program, University of Milan, Milan, Italy
[4]Orthopedic Residency Program, University of Verona, Verona, Italy
[5]Modular Implantable Neurotechnologies (MINE) Laboratory, Vita-Salute San Raffaele University & Scuola Superiore Sant'Anna, Milan, Italy
[6]Department of Biomedical Sciences for Health, University of Milan, Milan, Italy
[7]IRCCS Galeazzi-Sant'Ambrogio Hospital, Milan, Italy

Correspondence should be addressed to M De Pellegrin: depellegrin1956@gmail.com

- *Purpose:* Although female sex is a known risk factor for developmental dysplasia of the hip (DDH), limited data exist regarding sex-specific differences in treatment outcomes. This study aimed to analyze whether being male represents a risk factor for unfavorable outcomes in DDH treatment.
- *Methods:* A systematic search was conducted across PubMed, Embase, and Cochrane Library databases to identify studies comparing DDH treatment outcomes between males and females. The review adhered to PRISMA and PROSPERO guidelines, including studies published from 1995 to 2023.
- *Results:* Out of 327 initially identified articles, 23 met the selection criteria, describing 10,307 total DDH cases (5,296 males; 4,700 females). Only six articles clearly reported outcomes stratified by sex. Our analysis focused on establishing whether male sex was a risk factor for Pavlik harness failure and the incidence of avascular necrosis (AVN). For Pavlik harness failure, the meta-analysis included 93 male and 630 female hips, with failure in 32 male (34%) and 148 female (23%) hips. The meta-analysis indicated a significant association between male sex and Pavlik harness failure ($P$ = 0.03). Pooling data from relevant articles for AVN showed that AVN occurred in 32 out of 91 male (35%) and 77 out of 355 female (22%) hips, suggesting a significant association between male sex and AVN ($P$ = 0.008).
- *Conclusions:* Overall, male patients exhibited a higher failure rate in Pavlik harness treatment. The pooled analysis of AVN data further suggests that males may demonstrate a poorer prognosis compared to female patients in DDH treatment.

Keywords: DDH; treatment; male sex; failure rate; Pavlik harness; risk factors; avascular necrosis; AVN

## Introduction

Developmental dysplasia of the hip (DDH) is, with a wide geographical variation and significant variability within ethnic groups, the most frequent abnormality of the musculoskeletal apparatus in newborns (1). Among risk factors such as family history, breech presentation, maternal primiparity (2), coexisting musculoskeletal deformities, oligohydramnios, and mechanical restriction in uterus, female sex with a ratio to male of

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5:1 is also considered a significant risk factor for DDH (3, 4, 5). The higher frequency of dislocations in females supports the genetic theory of this disorder (6). An enormous amount of data is present in the literature regarding treatment outcomes in newborns and children, mostly without distinction between female and male patients (7, 8, 9). A multicenter study conducted by the European Paediatric Orthopaedic Society reported data on 2,636 patients with 3,611 dislocated hips treated using the Pavlik harness; however, outcomes in male patients were not reported separately (10).

Many parameters are analyzed for understanding favorable and unfavorable results. Early diagnosis and early treatment are key for good outcomes, whereas late diagnosis showed a higher percentage of residual acetabulum dysplasia and avascular necrosis of the femoral head (AVN) (11, 12, 13, 14, 15, 16). Closed and open reductions are also compared with a higher percentage of AVN in open reduction (9, 17, 18, 19, 20, 21). The presence of the femoral head nucleus was identified as a positive prognostic factor for improved outcomes (22, 23, 24). Various braces, including the Tübingen and Pavlik harness, have likewise been evaluated (25, 26, 27, 28).

Despite these investigations, sex-specific outcomes, particularly in male patients, are rarely reported. Only limited data are available in the literature regarding treatment results in males with DDH (29, 30). The aim of this systematic review was to analyze if male sex, despite the lower incidence of DDH in comparison with females, represents a risk factor for DDH treatment failure in children.

# Materials and methods

## Database sources and search strategy

To systematically review the relevant literature for this comprehensive analysis, a structured search was formulated using the PICO framework (population, intervention, comparators, and outcomes). The population of interest encompassed systematic reviews, meta-analyses, and randomized, prospective, retrospective, observational clinical studies along with case reports that involved patients affected by DDH. Within this scope, the intervention focused on various conservative or surgical interventions aimed at managing DDH, particularly emphasizing the timing and methods of treatment. No 'comparators' group was necessary. The 'outcomes' under scrutiny encompassed the differences in treatment outcomes between males and females, the principal clinical findings, and any associated complications arising from the interventions applied.

A systematic search was conducted in 2023 across three databases, PubMed, Embase, and Cochrane Library, to identify all published articles pertaining to DDH in males or that were comparing different outcomes in the treatment of DDH between males and females. For this purpose, combinations of the following keywords were used ("congenital dislocation of the hip" OR "developmental dysplasia of the hip" AND "gender differences" OR "sex differences" OR "male disadvantages") AND (congenital dislocation of the hip" OR "developmental dysplasia of the hip" AND "Pavlik harness treatment" OR "avascular necrosis"). The exploded indexing terms and truncation functions were also used. This systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration number: CRD420251147728).

## Article eligibility criteria

Exclusion criteria encompassed articles that were presenting aggregated data of the included patients (males and females) rather than dividing them for gender and articles not written in English. During the initial research, no restrictions were applied based on publication year. Studies published between 1995 and 2023 have been finally included. The reviewer (FS) assessed the relevance of the identified articles by scrutinizing their titles and abstracts. To ensure data accuracy, these selected articles were then organized and curated through a reference management system (RAYYAN) to eradicate any duplicate entries and streamline reference handling.

The author retrieved and reviewed the full-text articles, ensuring thorough scrutiny of the content. Any disparities in assessment were discussed until a consensus was achieved with the senior author (MDP) for resolution.

## Data collection

From each article, patient data were extracted. For each article, the following information (if present) was gathered:

- Authors and publication date
- Study type
- Type of treatment
- Number of patients
- Gender
- Age at the time of treatment
- Treatment failure rate
- Differences among males and females
- AVN cases
- Secondary procedures

Treatment failure was defined as the inability to achieve the expected clinical outcome or the need to escalate to a more invasive intervention. In this context, failure was also considered as the necessity to transition from a less

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invasive to a more invasive treatment. For example, in some cases, failure of Pavlik harness treatment implied the need for closed or open reduction; failure of closed reduction required conversion to open reduction; and failure of open reduction necessitated the use of more advanced surgical techniques, such as pelvic or femoral osteotomy.

### Statistical analysis

A comprehensive descriptive analysis was undertaken, wherein categorical variables were presented in terms of percentage, while continuous variables were expressed as mean values with their corresponding standard deviation. The collection of data was executed utilizing Microsoft Excel (Microsoft Corporation, USA) designed for Windows 10 operating system.

Statistical analyses were performed in R 4.5.2 using RStudio 2025.09.2. Meta-analysis was performed using the metafor package (10.32614/CRAN.package.metafor), and statistical power analysis was performed using the pwr package (10.32614/CRAN.package.pwr). We computed the logarithmic odds ratio (logOR) and its 95% confidence interval (CI), the chi-squared test *P*-value (*P*), and the statistical power of each study. Then, we computed the homogeneity of the studies through the $I^2$ statistics and used meta-analytic techniques to determine the logOR and its CI, the chi-squared test *P*, and the statistical power of the ensemble of the studies. Finally, we computed the same statistics by pooling all available data (including the ones from the same-sex samples) to have an estimate of the effect with the largest statistical power and thus the lowest probability of failing to detect a significant effect.

## Results

### Description of systematic review results

A total of 327 articles were included as relevant studies identified by the search strategy. However, 149 duplicate articles and, after full abstract reading, 148 articles being not relevant or not meeting the selection criteria were excluded. Seven articles were excluded after full article reading for not meeting the selection criteria with results reported without distinction between genders. Finally, a total number of 23 articles met the selection criteria and were included in the final analysis. A PRISMA flowchart of the selection and screening method is provided in Fig. 1.

Among the 23 studies analyzed, 8 explicitly suggested, either through data interpretation or author commentary, that being male was associated with a less favorable overall prognosis in the presence of DDH (25, 28, 29, 31, 32, 33, 34, 35) (see Table in the Supplemental material (see section on Supplementary materials given at the end of the article)). In contrast, 12 studies reported no

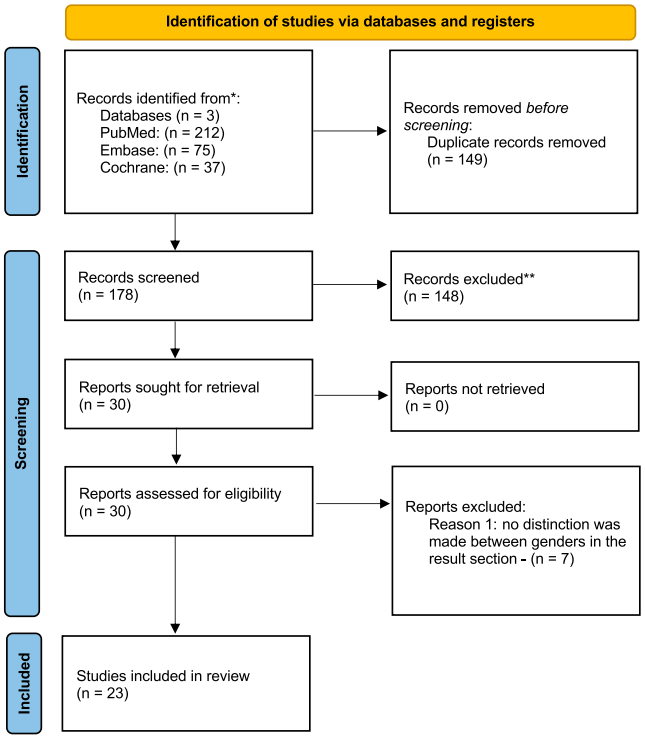


**Figure 1**

Flowchart of the review process by PRISMA.

meaningful sex-based differences (36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47), while 3 studies indicated that female sex might be associated with less favorable characteristics or outcomes (48, 49, 50). Based only on these observations, it may be concluded that most of the evidence points at no statistically significant association between sex and prognosis. In the following, we will show that performing statistical analysis on the available results leads to different conclusions.

Nineteen (25, 28, 31, 32, 33, 34, 35, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50) of the above-mentioned studies analyzed sex-based differences in treatment outcomes based on original data rather than anecdotal evidence, specifying whether any disparity existed between male and female patients and, when present, which sex represented a parameter for favorable or unfavorable treatment results. However, in most of these studies, precise numerical data stratified by sex were not provided. Instead, authors frequently reported only general percentages of failure or used qualitative statements indicating a sex-based difference, without including extractable values. Four studies (25, 29, 35, 46) reported numerical data disaggregated by sex regarding the success or failure of the Pavlik harness treatment (Table 1), and other four studies (29, 31, 35, 47) provided similar data on the incidence of AVN (Table 2), enabling statistical comparison between male and female patients.

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**Table 1** Number of cases and Pavlik harness failures from the literature.

| Study | Total males | Failure males | Total females | Failure females |
|---|---|---|---|---|
| Borges *et al.* (29) | 22 | 20 | NA | NA |
| Kitoh *et al.* (35) | 23 | 7 | 198 | 33 |
| Ömeroğlu *et al.* (25) | 24 | 9 | 106 | 29 |
| Gou *et al.* (46) | 46 | 16 | 326 | 86 |
| Total | 115 | 52 | 630 | 148 |

## Male sex as a risk factor for Pavlik harness failure and AVN

Of the studies reporting data for Pavlik harness failure and AVN, one reported only male cases (29), while the others reported both males and females. We thus performed a meta-analysis of the data from the three remaining articles in each case and subsequently determined which conclusions would have been drawn by observing the full sample described by all the four available articles. The results of the meta-analysis are summarized in Table 3 for Pavlik harness failure and in Table 4 for AVN.

In the case of Pavlik harness failure, the studies were homogeneous ($I^2$ = 0) and systematically reported a logOR larger than zero, namely an average larger risk for male sex. We can see how each single article failed to find statistical significance ($P$ > 0.05), likely because of their low statistical power (pow < 0.4). When we combined their estimates through meta-analytic techniques, even though the power was not very high (pow = 0.56), the association between male sex and higher Pavlik harness failure became significant ($P$ = 0.03). When all available data were pooled (Table 5), this significance was even more marked ($P$ < 0.001) and the statistical power was very high (pow = 0.99).

The studies reporting AVN association with sex were much more heterogeneous ($I^2$ = 0.66), with only one study (31) out of the three highlighting a significant association between AVN and sex ($P$ = 0.02). We remark that all studies highlighting no statistical differences, as well as the meta-analytic ensemble, have an extremely low power (pow < 0.10). When we pooled all available data (Table 5), we obtained both a high statistical power (pow = 0.95) and a significant association between sex and AVN ($P$ = 0.008), with male sex related to poorer outcomes (logOR = 0.67; CI = 0.17, 1.17).

**Table 2** Number of cases and AVN from the literature.

| Study | Total males | AVN males | Total females | AVN females |
|---|---|---|---|---|
| Borges *et al.* (29) | 55 | 21 | NA | NA |
| Kitoh *et al.* (35) | 16 | 1 | 165 | 15 |
| Schur *et al.* (31) | 8 | 7 | 62 | 21 |
| Bian *et al.* (47) | 12 | 3 | 128 | 41 |
| Total | 91 | 32 | 355 | 77 |

AVN, avascular necrosis; NA, non-assessed.

**Table 3** Meta-analysis of Pavlik harness failure in males and females. A logOR value higher than zero indicates more frequent Pavlik harness failure in males.

| Study | logOR (95% CI) | *P*-value | Power |
|---|---|---|---|
| Kitoh *et al.* (35) | 0.783 (−0.181, 1.750) | 0.111 | 0.37 |
| Ömeroğlu *et al.* (25) | 0.466 (−0.465, 1.400) | 0.326 | 0.17 |
| Gou *et al.* (46) | 0.398 (−0.257, 1.050) | 0.234 | 0.22 |
| Ensemble | 0.506 (0.034, 0.974) | 0.0342 | 0.56 |

CI, confidence interval; logOR, logarithmic odds ratio.

## Other quantitative results

The mean age at treatment was reported heterogeneously across studies and rarely stratified by sex. For Pavlik harness, the mean age ranged from 7 days to 6 months, for closed reduction from 8 to 10 months, and for open reduction procedures from 13 months to 2.5 years. With the exception of studies that exclusively included male participants, only a limited number of studies (32, 49) provided sex-specific data on patient age at the time of diagnosis or treatment.

Sex-based analysis of secondary procedures was limited. However, several studies indicated that males required additional interventions more frequently following initial treatment failure or complications. Borges *et al.* and Schur *et al.* reported a high frequency of secondary surgeries in males following closed or open reductions (29, 31).

Finally, several studies described ancillary sex-based findings relevant to DDH. Male infants were more likely to lack classic DDH risk factors or be missed by selective ultrasound screening protocols (36). Morphological differences were also noted: males exhibited a higher incidence of femoroacetabular impingement features in adolescence and adulthood (32), while females demonstrated greater femoral anteversion, potentially impacting implant selection and surgical planning (49).

**Table 4** Meta-analysis of AVN in males and females. A logOR value greater than zero indicates more frequent AVN in males.

| Study | logOR (95% CI) | *P*-value | Power |
|---|---|---|---|
| Kitoh *et al.* (35) | −0.399 (−2.491, 1.690) | 0.709 | 0.07 |
| Schur *et al.* (31) | 2.615 (0.455, 4.78) | 0.018 | 0.83 |
| Bian *et al.* (47) | −0.346 (−1.705, 1.010) | 0.617 | 0.08 |
| Ensemble | 0.521 (−1.330, 2.370) | 0.581 | 0.09 |

AVN, avascular necrosis; CI, confidence interval; and logOR, logarithmic odds ratio.

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**Table 5** Results of pooling all available data on Pavlik harness failure and AVN for males and females.

| | logOR (95% CI) | *P*-value | Power |
|---|---|---|---|
| Pavlik harness failure | 0.989 (0.578, 1.4) | <0.001 | 0.99 |
| AVN | 0.672 (0.173, 1.170) | 0.008 | 0.75 |

AVN, avascular necrosis; CI, confidence interval; and logOR, logarithmic odds ratio.

## Discussion

The objective of this study was to determine whether there may be enough evidence in the existing scientific literature to highlight any sex-related differences in the outcome of DDH treatment, namely to establish whether DDH treatment outcomes in males differ from those of female children. Despite the large body of literature on DDH, after a systematic review, only 23 articles out of 327 could be included as relevant studies identified by search strategy. Baseline DDH severity varied substantially among included studies, encompassing mild acetabular dysplasia (Graf IIb/c and Tönnis I and II) to complete dislocation (Graf III and IV and Tönnis III–IV). Grading of DDH severity, treatment outcome, and AVN at follow-up were never segregated according to gender, thus hindering more in-depth analysis of possible confounding factors affecting a meta-analytic approach. Studies enrolling more severe dislocations tended to report higher rates of Pavlik harness failure and AVN regardless of patient sex.

Of the 23 studies analyzed, eight clearly suggested that male was associated with a less favorable overall prognosis in the presence of DDH (25, 28, 29, 31, 32, 33, 34), whereas a larger amount of studies did not highlight a correlation between gender and treatment failure (28, 29, 30). Here, we focused on the few articles that explicitly reported data of DDH outcome segregated by sex, performing a statistical meta-analysis. Three studies reported less favorable outcomes in female patients. Azzopardi *et al.* (48) found that late-diagnosed DDH was significantly more frequent in females, with an odds ratio of 8.96 ($P < 0.001$), suggesting that delayed diagnosis may contribute to poorer prognosis and a higher risk of surgical intervention. Boughton *et al.* (49) described more severe proximal femoral deformities and increased femoral anteversion in females, potentially influencing long-term joint congruency and mechanical loading. Similarly, Bakti *et al.* (50) observed a slower sonographic and clinical improvement in female infants compared with males, indicating that treatment response may be less favorable in females during early infancy. Although these findings point toward sex-related anatomical or diagnostic differences, none of the studies provided quantitative outcome data directly comparing failure or complication rates between sexes.

When we aggregated through rigorous statistical methods the results of the three available studies providing explicit data on the relationship between Pavlik harness failure and sex, we highlighted an overall significant association between male sex and treatment failure, although each study individually reported no significant association. This is a fundamental result of our analysis: individual DDH studies are often underpowered and, individually, they may fail to detect significant effects. In the case of the association between sex and AVN, this was even more severe, as even after performing rigorous meta-analysis, the power remained extremely low, making the fact that no association was found unsurprising. Indeed, when we pooled all available data in the literature, the statistical power was sufficient to detect a significant association between male sex and AVN insurgence. The fact that AVN and male sex association required further steps of analysis to emerge is readily justifiable observing that the sample sizes at play are in general smaller than in the case of Pavlik harness failure. Moreover, another confounding factor is the different classification used for AVN by the four relevant studies. Borges *et al.* (29) applied the Salter–Thompson classification, Kitoh *et al.* (35) used the Kalamchi–MacEwen system, Schur *et al.* (31) evaluated AVN according to the Salter–Thompson classification, and Bian *et al.* (47) combined the Salter and Kalamchi–MacEwen classifications for severity grading. Across these studies, most AVN cases were classified as mild (types I–II), whereas severe forms (types III–IV) were uncommon, accounting for less than 10–15% of the affected. Follow-up duration ranged from short-term (average 6–12 months) (46, 50) to long-term (average to 10–12 years) (29, 47), with only few studies assessing outcomes beyond skeletal maturity. The heterogeneity of the studies dealing with the risk of AVN is confirmed by the diversity of methods to classify DDH severity and/or treatment outcome (IHDI grade of dislocation in Bian *et al.* (47), Brougham *et al.*'s outcome after treatment scale in Schur *et al.* (31, 51), and roentgenographic and clinical scales in Borges *et al.* (29)); the heterogeneity in the distribution of patients according to Kalamchi & MacEwen (52), with most patients presenting lower AVN grades (I and II) and almost no one for grade IV in Borges *et al.* and Bian *et al.* (29, 47); and an approximately uniform distribution in Kitoh *et al.* (35). The present systematic review highlighted other interesting results that can be found in the literature. Interestingly, according to the Norwegian Arthroplasty Register for primary total hip replacement, DDH accounted 26% for hip replacements with female sex representing 82% of the cases, which correlated with the well-known epidemiological data regarding female/male ratio. However, the median age at the time of the first diagnosis was 4.4 years for females and 22 years for males, suggesting that being male, for whatever reason, negatively influenced the time of diagnosis (33). According to de Salvo *et al.*, a higher percentage of total hip arthroplasty has been performed in female patients having DDH in childhood in comparison with male patients with a percentage for female patients

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between 57.7 and 90.9% reported after a systematic review of seven studies. However, no data are available in this review about complication rates in females and males, which would have been the goal of our study (53).

In 1995, Borges *et al.* specifically analyzed outcomes of congenital hip dislocation treatment focusing on 55 male patients with 78 congenitally dislocated hips (29). The overall rate of success for different treatment types was much lower than expected for the same age-group and in comparison with female patients with a much higher prevalence of avascular necrosis (45% of the hips treated with closed reduction).

Age at the start of treatment is known to influence DDH prognosis. However, in this review, no statistically significant difference in treatment initiation age was found between males and females. Thus, it was not possible to correlate the timing of treatment to failure rates by sex, although the timing of intervention may represent a potential confounding factor explaining outcome disparities between males and females.

This is largely attributable to the fact that most studies reported age stratified by treatment type rather than by sex, limiting the ability to assess age as a potential confounding factor in the observed sex-based differences in treatment failure rates. Notably, Engesæter *et al.* reported a striking difference in age at diagnosis (4.4 years for females versus 22 years for males with a gap of 17.6 years), suggesting that delayed diagnosis in males may contribute to a higher frequency of total hip replacement later in adult life (33).

Borges *et al.* hypothesized that the high rate of dislocation may have been secondary to intrinsic deficiency of acetabulum development and laxity in boys compared with girls.

Intrinsic factors, such as increased muscle tonus, can be hypothesized. Females have a higher percentage of body fat than their male equivalents (54). Moreover, body composition revealed that girls had a significantly greater percentage of body fat and less fat-free mass than did boys in the first 3–6 months of life (55). Having a different body composition and a reduced muscle tonus could be a justification for the well-known higher incidence of DDH in females. Having an increased muscle tonus like males have in the first months of life could be an unfavorable factor for DDH treatment negatively influencing the reduction maneuvers and increasing the pressure on the displaced femoral head justifying the higher failure rate during Pavlik treatment and the higher AVN percentage in males.

The limitations of this review must be acknowledged. Only a limited number of studies in the literature reported outcome data separately for male and female patients. As a result, the extracted data concerning outcomes of DDH treatment in males, already a population with a lower overall incidence of the condition, were relatively limited compared to data available for females. Nevertheless, a total of 93 male patients for Pavlik failure rate and 91 male patients for AVN rate were analyzed, and statistically significant findings could still be identified through appropriate statistical evaluation.

This limitation prevented us from conducting statistical analyses to compare treatment outcomes or failure rates by sex across different interventions such as closed and open reduction.

Future research will benefit from a more comprehensive detail of the employed data and the use of more standardized methods of grading, at the same time enabling multi-cohort meta-analyses to produce more robust clinical insight.

Moreover, further research involving larger male patient cohorts is warranted to validate and expand upon these findings. Future studies should systematically report sex-specific outcomes in DDH treatment to enable more accurate and meaningful comparisons.

## Conclusion

Overall, our systematic review highlighted that even though a large corpus of scientific literature on DDH has been published, some fundamental associations of clinical interest remain challenging to be studied, mainly because of the overwhelming number of articles not explicitly reporting numerical data that may be used for rigorous meta-analysis. Here, we studied the association between sex and DDH prognosis, specifically relative to the frequency of Pavlik harness failure and AVN insurgence, claiming through pooling of the available literature through rigorous statistical tools that male sex is in general a relevant risk factor in both cases. Based upon the limited data and by pooling the available studies, a higher failure rate for males in Pavlik harness may have been uncovered. Confounders exist on baseline DDH severity and AVN severity, for which the meta-analysis does not have a detailed breakdown against sex in order to fully account for these. The main limitation of our work remains linked to the important heterogeneity of the existing literature, an observation that should push clinical centers invested in studying and treating DDH to perform investigations with larger sample sizes and to publicly share anonymized data to benefit the whole scientific and clinical communities.

**Supplementary materials**

This is linked to the online version of the paper at https://doi.org/10.1530/EOR-2025-0176.

**ICMJE Statement of Interest**

Each author certifies that they have no commercial associations (e.g. consultancies, stock ownership, equity interest, and patent/licensing arrangements) that might pose a conflict of interest in connection with the work reported here.

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**Author contribution statement**
MDP is a main contributor to study design, performing analysis, and manuscript preparation, FS and LM performed data collection and analysis, NG prepared the manuscript, LM revised the manuscript, and SR performed statistical analysis. All authors have read and agreed to the published version of the manuscript.

**Data availability**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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