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REVIEW

Preoperative predictors of urinary incontinence after holmium laser enucleation of the prostate: A systematic review and meta-analysis

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Summary ***Background: Urinary incontinence following holmium laser enucleation of the prostate (HoLEP) is generally transient; however, it remains among the most concerning complications for patients. The identification of straightforward preoperative predictors may assist clinicians in providing more accurate counseling and in planning earlier continence rehabilitation.***

Methods: This systematic review and meta-analysis adhered to PRISMA 2020 guidelines. Searches were conducted in PubMed, Scopus, ScienceDirect, and Google Scholar from inception through October 2025. Included studies examined urinary incontinence at least 3 months post-HoLEP and provided data on age, body mass index (BMI), or prostate volume. Adjusted study-level odds ratios (ORs) were combined using the generic inverse-variance method. The quality of observational studies was evaluated with the Newcastle-Ottawa Scale, while the randomized trial was assessed with RoB 2.

Results: Eleven studies contributed to the overall analysis. It was observed that older age tends to be linked with increased chances of postoperative urinary incontinence, both when treated as a continuous predictor (OR 1.05, 95% CI 1.00-1.10; p = 0.05; I^2 = 65%) and when older patients were compared to younger patients (OR 2.13, 95% CI 1.33-3.42; p = 0.002; I^2 = 24%). A higher BMI was also connected to urinary incontinence in the continuous analysis (OR 1.85, 95% CI 1.19-2.88; p = 0.006; I^2 = 0%), although categorizing participants as overweight or obese versus those with a lower BMI did not show a significant difference (OR 1.09, 95% CI 0.88-1.36; p = 0.43; I^2 = 90%). Additionally, having a larger prostate volume was linked to a small but statistically significant increase in risk (OR 1.01, 95% CI 1.00-1.01; p = 0.03; I^2 = 0%).

Conclusions: Older age emerged as the most consistent preoperative predictor of urinary incontinence following HoLEP. Elevated body mass index (BMI) and increased prostate volume may also serve as indicators for patients requiring more meticulous counseling and more prompt follow-up; however, the clinical significance of prostate volume was minimal, and the findings related to BMI were contingent upon the manner in which BMI was analyzed.

KEY WORDS: *Holmium laser enucleation of the prostate; Urinary incontinence; Age; Body mass index; Prostate volume.*

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is common in older men and often causes lower urinary tract symptoms such as weak stream, urgency, frequency, nocturia, and incomplete emptying. Its prevalence and clinical impact increase with age, affecting sleep, daily activities, and quality of life (1). When medication is ineffective or complications arise, surgery becomes an important treatment option.

Holmium laser enucleation of the prostate (HoLEP) offers an effective and size-independent surgical solution for bladder outlet obstruction caused by BPH. It provides lasting symptom relief and typically results in less bleeding, shorter catheterization periods, and a lower retreatment rate compared to traditional transurethral resection in suitable patients (2, 3). These advantages have made HoLEP a standard choice, especially for large prostates.

However, *urinary incontinence* (UI) remains a significant concern after HoLEP. Most cases of UI occur early and tend to improve within the first few months, but even temporary leakage can reduce confidence, delay the return to normal activity, and decrease satisfaction despite an overall successful outcome (4, 5). Reported incidence varies widely because studies use differing definitions, types of incontinence studied, and assessment time points (6).

Several predictors have been suggested, including older age, higher BMI, larger prostate volume, preoperative bladder dysfunction, longer operative time, greater tissue removal, apical dissection, and surgeon experience. Findings are inconsistent, and patient-related factors are often difficult to distinguish from technical factors (5-7). This systematic review and meta-analysis primarily examined three simple preoperative variables age, BMI, and prostate volume—and their relationship with UI approximately three months or later after HoLEP.

METHODS

This study was designed as a systematic review and meta-analysis and was reported in line with the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) 2020 guidelines (8). Its main question was whether age, BMI, and prostate volume can predict urinary incontinence after HoLEP in men treated for BPH or benign prostatic obstruction.

Search strategy

PubMed/MEDLINE, Scopus, ScienceDirect, and Google Scholar were searched from database inception to October 2025. Search terms combined procedure-related terms ("*HoLEP*", "*holmium laser enucleation*", and "*holmium laser enucleation of the prostate*"), disease-related terms ("*benign prostatic hyperplasia*" and "*benign prostatic obstruction*"), outcome terms ("*urinary incontinence*", "*stress urinary incontinence*", and "*transient urinary incontinence*"), and predictor terms ("*predictor*", "*risk factor*", "*determinant*", "*associated*", "*multivariate*", and "*regression*"). Boolean operators and database-specific syntax were used where appropriate. Reference lists of eligible articles and relevant reviews were also checked manually.

Eligibility criteria

Studies were eligible if they: (1) included adult men undergoing HoLEP for BPH or benign prostatic obstruction; (2) used an observational design or randomized trial; (3) assessed urinary incontinence at a minimum follow-up of 3 months; (4) evaluated at least one of the prespecified predictors - age, BMI, or prostate volume; and (5) reported an adjusted effect estimate or enough quantitative data to derive an effect estimate. When several follow-up points were available, the assessment closest to 3 months was prioritized.

Case reports, small descriptive case series, editorials, letters, narrative reviews, animal studies, and studies that combined HoLEP with other enucleation techniques without separate HoLEP data were excluded. Studies were also excluded when the incontinence outcome was not reported clearly or the data could not be extracted for quantitative synthesis.

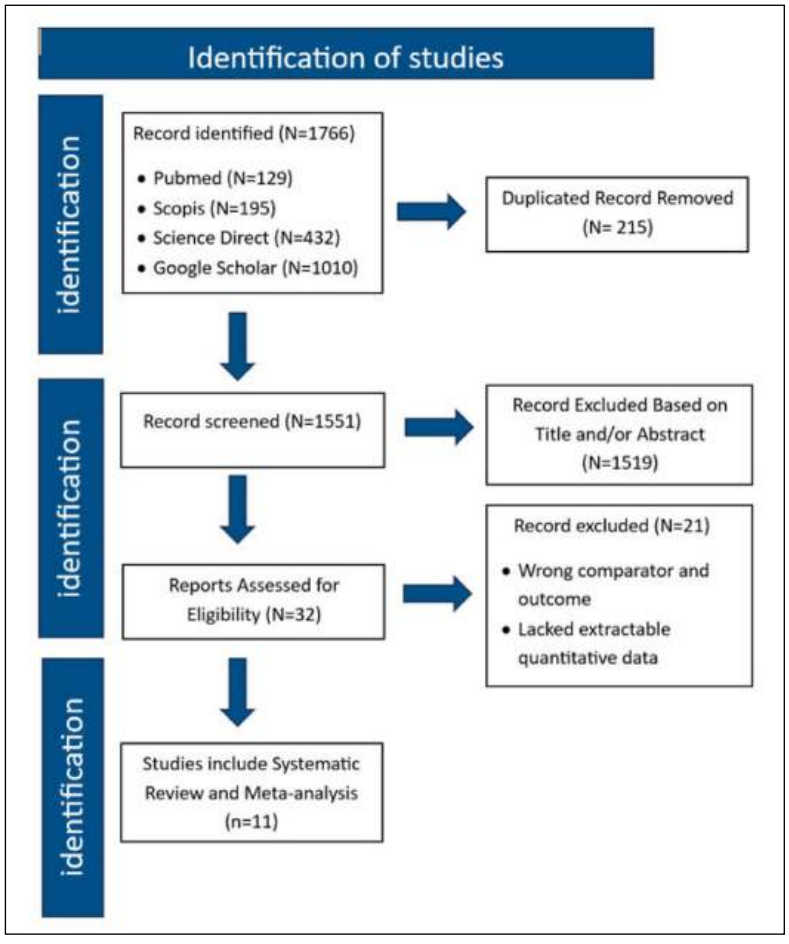
Study selection and data extraction

Search results were combined, and duplicate records were removed. Two reviewers independently screened titles and abstracts, followed by full-text reviews of potentially eligible articles. Disagreements were settled through discussion, with a third reviewer available if needed. Data extraction used a standardized form and included study design, setting, sample size, baseline age and BMI, prostate volume, definitions and timing of UI, operative details where available, adjusted covariates, and effect estimates with 95% CIs. Continuous and categorical versions of the same predictor were analyzed separately. For age, categorical analyses compared an older group with a younger reference group. For BMI, they compared overweight or obese patients to the lower-BMI reference group. Thresholds were kept as reported by the original studies due to variations across studies.

Risk-of-bias assessment

Observational studies were assessed with the Newcastle-Ottawa Scale, which covers participant selection, group comparability, and outcome assessment (9).

The randomized studies were assessed with the Cochrane Risk of Bias 2 tool (10). Assessments were performed independently by two reviewers and resolved by discussion.



RESULTS

Study selection

The search identified 1,766 records: 129 from *PubMed*, 195 from *Scopus*, 432 from *ScienceDirect*, and 1,010 from *Google Scholar*. After 215 duplicates were removed, 1,551 records underwent title and abstract screening. Thirty-two full-text articles were assessed, and 21 were excluded because of an ineligible population or outcome, an unsuitable comparator, or insufficient quantitative data.

Eleven studies were included in the systematic review and quantitative synthesis, comprising 10 observational studies and one randomized controlled trial (Figure 1).

Figure 1.
PRISMA 2020 flow diagram of study identification, screening, eligibility assessment, and inclusion.

No.	Studi	NOS Score	Risk of Bias
1	Cho et al. 2011 (11)	7/9	Low
2	Lerner et al. 2010 (12)	7/9	Low
3	Nam et al. 2015 (4)	7/9	Low
4	Kobayashi et al. 2016 (13)	6/9	Moderate
5	Das et al. 2020 (14)	6/9	Moderate
6	Ueki et al. 2020 (15)	7/9	Low
7	Shigemura et al. 2016 (16)	6/9	Moderate
8	Houssin et al. 2021 (5)	8/9	Low
9	Huang et al. 2024 (17)	7/9	Low
10	Elsaqa et al. 2023 (18)	7/9	Low

Study characteristics and risk of bias

The 11 included studies were published between 2010 and 2024 and comprised 10 observational studies and one randomized controlled trial. Individual study sample sizes ranged from 66 to 2,346 patients. Definitions of UI varied and included any urine leakage, pad use, stress urinary incontinence, and mixed postoperative incontinence. Most observational studies were judged to have a low risk of bias, with scores generally between 7 and 8 on the Newcastle-Ottawa Scale. Three observational studies were judged to have a moderate risk of bias, mainly because of limited control of confounding, the effect of the surgeon learning curve, or non-standardized outcome measurement. The randomized study had some concerns, particularly regarding allocation concealment, blinding, and patient-reported pad use (Figure 2).

Figure 2.
Risk-of-bias assessment for the randomized study using the Cochrane RoB 2 tool.

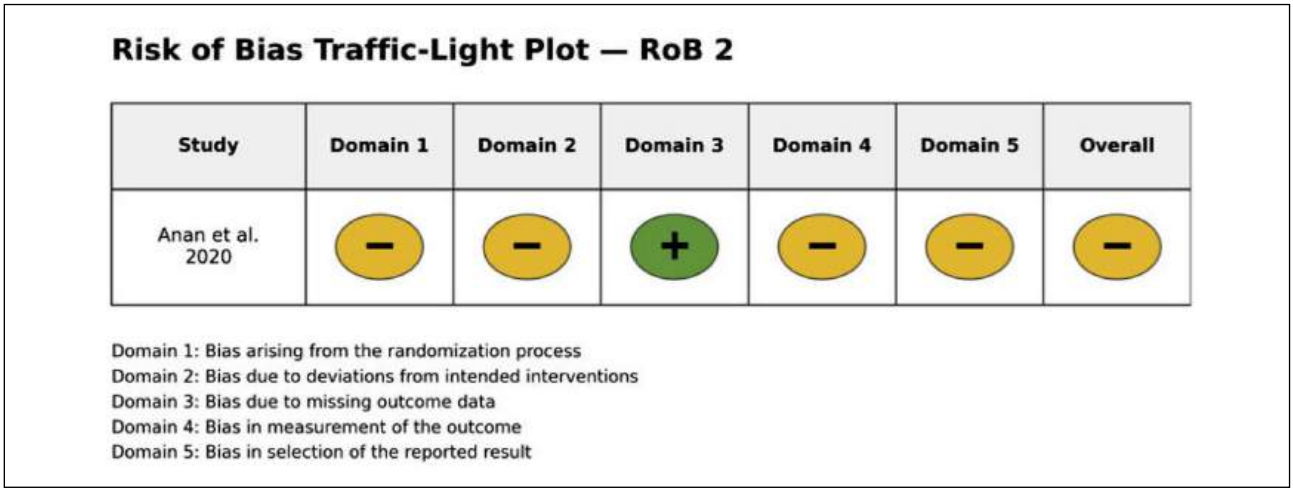
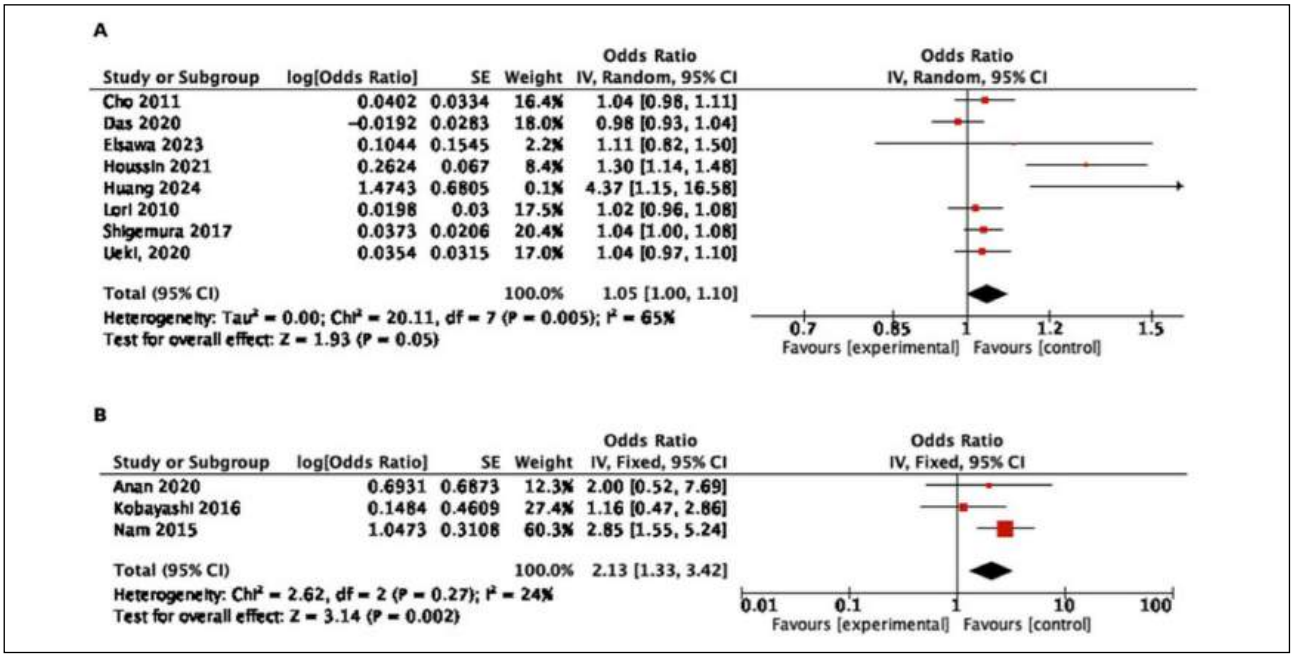


Table 1.
Study characteristics.

Study	Design	Sample, n	Age, years	BMI, kg/m²	Prostate volume, mL or g	Predictors included in pooled analyses
Lerner et al., 2010	Retrospective cohort	66	67.8	NR	NR	Age
Cho et al., 2011	Retrospective cohort	204	67.9 ± 6.3	24.0 ± 2.7	53.3 (20-162)	Age; BMI
Nam et al., 2015	Retrospective cohort	391	65.9	NR	54.1 ± 25.2/50.7 ± 20.1 (no TUI/TUI)	Age category
Kobayashi et al., 2016	Retrospective cohort	127	72.0 ± 6.0	23.2 ± 2.9	69 ± 33	Age category; BMI
Shigemura et al., 2016	Retrospective cohort	224 enrolled; 203 analysed	71 (34-90)	NR	76.1 ± 41.1	Age; prostate volume
Anan et al., 2020	Randomized controlled trial	70	72 (62-83)	24 (17-31)	56 (35-208)/60 (35-114) (PFME/control)	Age category; BMI
Das et al., 2020	Retrospective cohort	589	70.6	28.8	> 100 g cutoff; 148.7 vs 87.9 (tSUI vs others)	Age; BMI category; prostate volume
Ueki et al., 2020	Retrospective cohort	237	71.9 ± 7.2	NR	NR (continuous variable)	Age; prostate volume
Houssin et al., 2021	Retrospective multicentre cohort	2,346	70.0 ± 8.8	26.2 ± 4.1	NR	Age; BMI category
Elsaqa et al., 2023	Retrospective cohort	666	72 (66-78)	NR	NR	Age; BMI/obesity
Huang et al., 2024	Retrospective cohort	548	72.4	NR	NR	Age

NR: not reported. When a single overall prostate volume was not available, group-specific values or the risk-stratification cutoff from the original study are shown.

Figure 3.
Association between age and urinary incontinence after HoLEP. (A) Age analyzed as a continuous predictor. (B) Older versus younger age category.



Age

Eight studies evaluated age as a continuous predictor. The random-effects model indicated a borderline significant association between higher age and postoperative UI (OR 1.05, 95% CI 1.00-1.10; p = 0.05). Moderate heterogeneity was observed (I^2 = 65%), implying that the strength of this association varied across different populations and analysis methods (Figure 3A).

Three studies compared an older age group to a younger reference group. Older patients had more than double the odds of postoperative UI (OR 2.13, 95% CI 1.33-3.42; p = 0.002), with low heterogeneity (I^2 = 24%) (Figure 3B).

Overall, age was the most consistent patient-related predictor identified in this review.

Body mass index

Four studies evaluated BMI as a continuous predictor. Higher BMI was associated with postoperative UI (OR 1.85, 95% CI 1.19-2.88; p = 0.006), with no significant heterogeneity detected (I^2 = 0%) (see Figure 4A). In contrast, two studies that used categorized BMI did not find a significant link (OR 1.09, 95% CI 0.88-1.36; p = 0.43). These studies showed high heterogeneity (I^2 = 90%), reflecting notable differences in BMI thresholds, patient characteristics, and possibly outcome definitions (see Figure 4B).

Figure 4.
Association between body mass index and urinary incontinence after HoLEP. (A) BMI analyzed as a continuous predictor. (B) Higher versus lower BMI category.

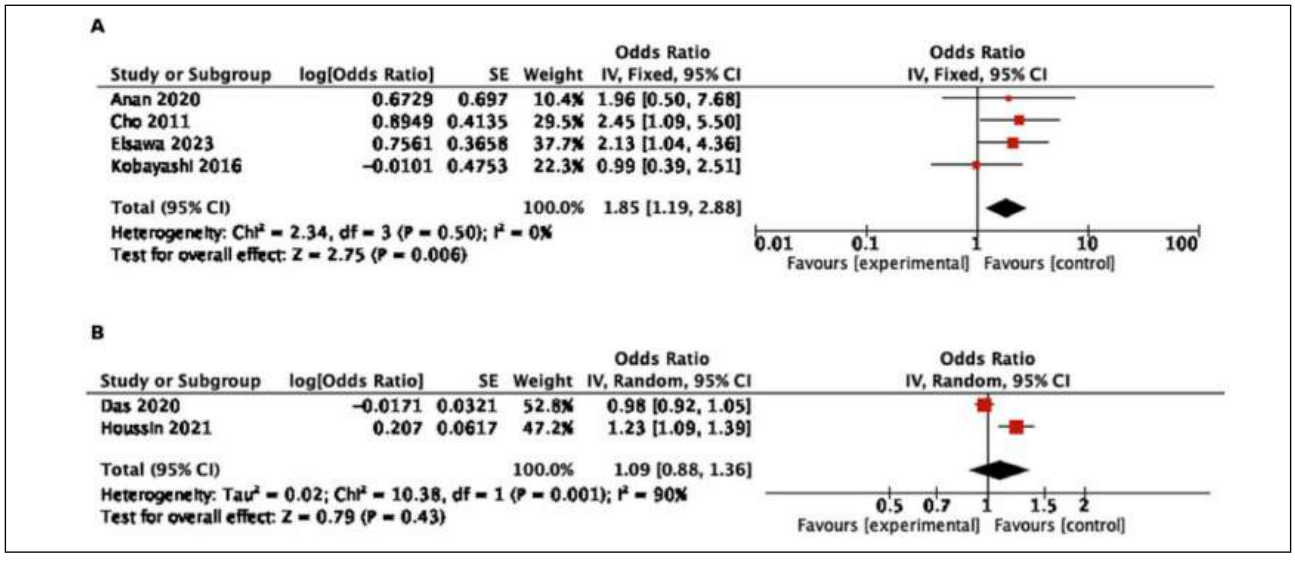
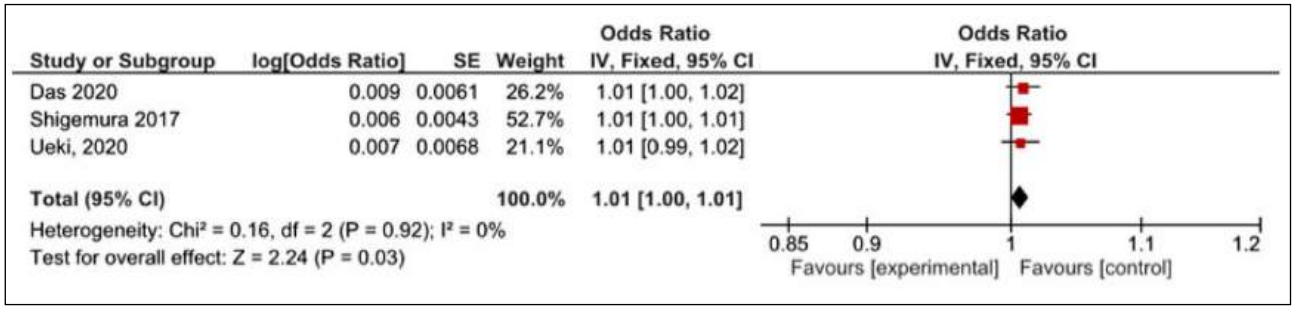


Figure 5.
Association between continuous prostate volume and urinary incontinence after HoLEP.



Prostate volume
Three studies evaluated prostate volume as a continuous predictor. Larger prostate volume was associated with higher odds of postoperative UI (OR 1.01, 95% CI 1.00-1.01; p = 0.03), with no detected heterogeneity (I^2 = 0%) (Figure 5). The effect was statistically significant but small, so prostate volume should be viewed as a risk marker rather than a strong stand-alone predictor.

Discussion

Main findings
This meta-analysis found that older age was the clearest and most consistent preoperative predictor of UI after HoLEP. The association was present in both continuous and categorical analyses, and the categorical analysis showed that older patients had roughly twice the odds of postoperative leakage. Higher BMI was also associated with UI when analyzed continuously, but the categorical analysis was not significant and was highly heterogeneous. Larger prostate volume showed a statistically significant association, although the effect size was small.
These findings fit the clinical pattern reported in large HoLEP cohorts. UI is most common in the early recovery period and usually improves over time. *Nam et al.* reported that most transient cases recovered within 3 months, while *Houssin et al.* found UI in 14.5% of patients at 3 months and 4.2% at 6 months (4, 5). This time-dependent recovery is important: a patient who leaks at 2 weeks does not necessarily have persistent incontinence.
Age probably reflects several processes rather than one isolated mechanism. Older patients may have lower external sphincter reserve, weaker pelvic floor function, reduced tissue elasticity, more detrusor overactivity, and a slower ability to adapt after the obstructing adenoma is removed. These changes can make small perioperative effects clinically visible. Anatomical studies also support this explanation. A shorter membranous urethral length has been linked to slower continence recovery after HoLEP, which suggests that baseline sphincter anatomy and functional reserve matter (15, 17).
The moderate heterogeneity in the continuous age analysis also deserves attention. Some studies reported effects per year, while others used transformed or standardized estimates. Older-age thresholds were not identical. The direction of effect was broadly consistent, but the exact increase in risk for each additional year cannot be treated as uniform across all settings.
BMI may increase leakage through higher intra-abdominal pressure, which places more stress on a recovering sphincter. It may also act as a marker for diabetes, frailty, reduced mobility, or metabolic disease. *Elsaqa et al.* found that obesity and frailty were associated with short-term UI, while larger multicenter data also linked elevated BMI with UI at 3 and 6 months (5, 19).
The difference between the continuous and categorical BMI results is not necessarily contradictory. Categorizing BMI removes information and depends heavily on the selected cut-off. A patient just below an obesity threshold may be biologically similar to a patient just above it. The high heterogeneity in the categorical analysis suggests that BMI is more useful as a gradual risk marker than as a simple yes-or-no label. It should not be used alone to deny or delay HoLEP.
A larger prostate often requires a wider enucleation plane, longer operating time, more energy, and more manipulation near the prostatic apex and membranous urethra. This can increase temporary edema or sphincter irritation. Larger glands are also linked to a greater amount of tissue removed, and both factors may overlap with operator experience and enucleation technique (14, 16). The pooled OR for prostate volume was close to 1.00. This does not mean there is no association, but it does mean the increase in risk for each reported volume increment is small. The effect may become clinically meaningful only across a large difference in gland size or when combined with older age, higher BMI, preoperative incontinence, diabetes, or a technically difficult procedure. Prostate volume therefore works better as one part of a broader risk profile than as a single decision rule.
The results can support more practical preoperative counseling. Older patients, patients with a higher BMI, and patients with a large prostate should be told that temporary leakage may be more likely and that recovery may take longer. This information should be balanced with the fact that most early UI improves within a few months. The goal is to set realistic expectations, not to discourage an otherwise appropriate operation. For higher-risk patients, clinicians may consider earlier pelvic floor muscle instruction, closer follow-up at 4-6 weeks and 3 months, and more careful review of diabetes, baseline urgency, mobility, and preoperative continence. A randomized study suggested that preoperative pelvic floor

muscle exercise can support earlier continence recovery (20). Technical strategies that protect the apical mucosa and membranous urethra may also help, although these factors were not pooled in the present analysis (21, 22). Future studies should use a shared definition of UI, report stress and urgency components separately, use validated severity measures, and assess outcomes at fixed time points such as 1, 3, 6, and 12 months. Prospective models should combine patient factors with anatomical measures, baseline bladder function, and operator-related variables. This would provide a more useful risk estimate than any single predictor alone.

Conclusions

Older age was the most consistent preoperative predictor of urinary incontinence after HoLEP. Higher BMI was associated with UI when analyzed continuously, but not when simplified into broad categories. Larger prostate volume also showed an association, although the effect per reported increment was small. These variables can improve preoperative counseling and help identify patients who may benefit from earlier continence rehabilitation and closer follow-up, but none should be used as a stand-alone reason to withhold HoLEP.

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Declarations

Ethical approval and consent for participate: *Not applicable. This systematic review and meta-analysis used data from previously published studies.*

Consent for publication: *Not applicable.*

Availability of data and material: *All data generated or analyzed during this study are included in this article.*

Competing interests: *The authors declare that they have no competing interests.*

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