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REVIEW

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Postmicturition dribble in men with no previous urogenital surgery: Systematic review and meta-analysis of treatment modalities

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Abstract

Introduction: Postmicturition dribble (PMD) is common in males. Little is known about PMD etiology, but it is either secondary to urethral/prostatic surgery or primary (no previous surgery). Despite PMD's high prevalence, the effectiveness of its treatment modalities remains lacking.

Objective: To undertake a systematic review of the available treatments for primary PMD in adult males and meta-analysis of their effectiveness.

Materials and Methods: We searched four electronic databases from inception to 2023 for original articles that evaluated PMD treatments in male adults without previous urethral/prostatic surgery (PROSPERO protocol CRD42023444591). Study quality and risk of bias were evaluated using established tools. We extracted a range of variables including treatment modality used and its effectiveness on PMD volume and patient complaint. Meta-analysis was undertaken where feasible, and where this was not feasible, narrative synthesis was conducted.

Results: Out of 335 studies, four were included (four clinical trials, $n = 344$ patients). Two trials used physical/behavioral therapy (pelvic floor muscle exercises [PFMEs], urethral milking); the other two employed phosphodiesterase (PDE5) inhibitors (tadalafil, Udenafil). All studies were of good quality, but physical/behavioral therapy studies had some risk of bias. As the two physical/behavioral therapy studies used heterogenous outcome measures, narrative synthesis showed PMD volume improvement with PFMEs more than with urethral milking, both modalities were more effective than counseling, and in one study, PFMEs were effective in reducing PMD self-reported complaint than counseling. Meta-analyses of the two PDE5 inhibitors studies showed a large effect size with high heterogeneity for decreased PMD volume favoring PDE5 inhibitors over placebo ($g = -0.86$, 95% confidence

interval [CI] −1.75; 0.02, $p = 0.05$; $I^2 = 88\%$); and a significant improvement equivalent to −1.06 points on the Hallym PMD Questionnaire score with no discernable heterogeneity (95% CI −1.65; −0.47, $p = 0.0004$; $I^2 = 0\%$), favoring PDE5 inhibitors compared to controls.

Conclusions: Physical/behavioral therapy and PDE5 inhibitors are effective primary PMD treatments. PMD management studies in males with no previous urethral/prostatic surgery are very scarce and lack the use of consistent/comparable outcome measures. Further studies addressing these deficiencies would benefit this very thin evidence base.

KEYWORDS

men's health, pelvic floor disorders, phosphodiesterase inhibitors, postmicturition dribbling, urinary incontinence

1 | INTRODUCTION

The International Continence Society defines postmicturition dribble (PMD) as the involuntary leakage of urine that immediately follows the cessation of urination, which usually happens after leaving the toilet in males, or after rising from the toilet in females.[1] PMD, as a form of male incontinence, seems to have been understudied,[2] and while incontinence in males has been historically thought to be infrequent, recent data indicate that it is a common and concerning problem.[3] PMD prevalence ranges between 8.7% and 63% of males across different age groups.[4,5] PMD constitutes the most common postmicturition condition in men, amounting to 53.4% of men with postmicturition complaints.[4–6]

The etiology of PMD remains under debate.[7] PMD can occur secondary to prostatic and urethral surgeries such as radical prostatectomy and urethroplasty.[8,9] Alternatively, it can present primarily without any previous urethral, penile, or pelvic surgery.[8,10] Several proposed theories suggest that PMD could be due to the absence of urethral milking.[8,10] Other etiologies include bladder neck obstruction, enlarged obstructing prostate, and urethral strictures.[7,9] In this paper, we use the term primary PMD to denote de novo PMD in men who did not have previous urethral/prostatic surgery, that is, not iatrogenic.

Measuring PMD is not a straightforward process, and there is no standardized tool to measure it. Many of patient-reported outcome tools used to assess lower urinary tract symptom (LUTS), including the widely used International Prostate Symptom Score, do not evaluate PMD nor its severity.[7] Likewise, while some LUTS assessment questionnaires (e.g., The LUTS Tool, and DAN-PSS-1) include questions about PMD, they are not specifically designed to assess PMD's severity and undesirable effects.[3,4] Recently, a five-item Hallym PMD questionnaire (HPMDQ) has been validated to evaluate PMD frequency, volume, patient frustration, quality of life, and response to treatment.[11]

The literature reveals knowledge gaps. To date, there is no consensus on a standardized treatment for PMD, with little known about the best management modality. To our knowledge, no systematic reviews or meta-analyses have been undertaken to summarize the effectiveness of different PMD management modalities. As a result of this thin evidence base, recent European and American LUTS guidelines[12,13] do not include recommendations on its management.

The aim of the current study is to summarize the effectiveness of the available treatment modalities for primary PMD among adult males. The specific objectives were to (1) systematically search the literature for original studies on PMD treatment modalities; (2) group the identified modalities into relevant categories based on common attributes; and (3) undertake, as appropriate, narrative, and meta-analytic synthesis of the findings of retrieved studies, to determine the effectiveness of these modalities.

The findings of the current review will provide summaries and estimates of the effectiveness of the available treatment modalities, thus contributing to the evidence base to guide practice guidelines, policy, and research.

2 | MATERIALS AND METHODS

2.1 | Data sources and search strategy

We undertook a systematic search of the literature from inception to June 1, 2023 and the search was updated on July 27, 2023 using the electronic databases Scopus,

PubMed, ScienceDirect, and the Cochrane Library Database, searching the title and abstract of the available literature. The key search terms used were: "postmicturition dribble" OR "postmicturition dribbling" OR "post-micturition dribble" OR "post-micturition dribbling" OR "postvoid dribble" OR "postvoid dribbling" OR "post-void dribble" OR "post-void dribbling" AND "treatment." Reference lists of all included studies were searched for more eligible studies. We used the same combination of search terms in each database. This review with meta-analyses was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[14] The protocol for the current review was registered on the PROSPERO database (CRD42023444591).

2.2 | Eligibility criteria and study selection

This review included all original articles published in English language of any study design that assessed treatment of primary PMD in adult males aged >18 years regardless of whether the PMD was solitary or associated with other LUTS. Studies in which the full text could not be found in English language were excluded. Moreover, studies evaluating PMD in females, pediatrics and studies evaluating PMD secondary to urethral or prostatic intervention were excluded. In addition, we excluded all literature not reporting original data, conference abstracts and case reports (≤4 patients). In case of duplicate reports, the most recent study was included. All retrieved abstracts were screened by two independent researchers (A. A. and M. M.) evaluating their inclusion and exclusion criteria. Any disagreements between both researchers was evaluated by a third researcher (W. E. A.).

2.3 | Quality and risk of bias assessments

As the current systematic review included clinical trials applying treatment modalities for PMD, we used The Jadad scale for quality assessment [15] This scale has been widely used in the assessment of randomized controlled trials (RCTs).[16] The Jadad scale provides a score from 0 (very poor) to 5 (rigorous) is given to each RCT.[15]

For risk of bias assessments, we used the criteria suggested by the CLARITY Group at McMaster University for assessing the risk of bias for RCTs.[17] The tool comprises six items, each evaluated on a scale were "definitely or probably yes" assigned to a low risk of bias, while "definitely or probably no" assigned to a high risk of bias. CLARITY group tools have been widely utilized.[18–20] Two independent trained researchers (M. A. and A. G.) assessed the quality and risk of bias of each included study.

2.4 | Data extraction

Data were extracted using a predefined data sheet including study characteristics including author, year, country, study design, sample size, intervention modality, outcome measures, follow-up duration), baseline population characteristics (patient age, body mass index, initial PMD volume), and our primary outcomes of the effect of intervention which were PMD volume and self-reported PMD complaint. Data were extracted by A. A. and revised by H. M. No additional information beyond the published data was retrieved.

2.5 | Analysis

2.5.1 | Narrative synthesis

For studies with heterogenous designs and outcomes, we undertook a narrative synthesis[21] evaluating the study populations, interventions, comparison, and outcomes.

2.5.2 | Statistical analysis and quantitative synthesis

Where possible, random effects meta-analysis was undertaken in RevMan version 5.4 (Cochrane Collaboration), and figures were created using GraphPad Prism 9. Meta-analysis of PMD volume was conducted using a standardized mean difference (Hedges g) to account for inconsistent measures/units across the studies. The effect size was interpreted using the thresholds outlined by Sawilowsky,[22] where 0.1 = very small effect size, 0.2 = small effect size, 0.5 = medium effect size, and 0.8 = large effect size, 1.2 = very large effect size, and 2.0 = huge effect size. Meta-analysis of patient self-reported PMD complaints for studies that reported HPMDQ scores was undertaken using a raw mean difference (unstandardized).

Heterogeneity was interpreted using χ^2 and I^2. The alpha was set at 0.10 for the χ^2 test in accordance with Cochrane recommendations.[23] Similarly, I^2 was interpreted in accordance with Cochrane recommendations, considering both the magnitude and direction of the effects and the strength of the evidence of heterogeneity,

while taking guidance from the recommendations of Higgins et al.[24] (≈25% considered as low, ≈50% considered as moderate, and ≈75% considered as high).

3 | RESULTS

3.1 | Included studies

A total of 335 records were initially identified in the literature search; 240 were duplicates and removed, and 90 records did not meet the prespecified inclusion criteria (Figure 1). After full-text screening, five studies were included; however, one was subsequently excluded as it assessed treatment outcome within a process of questionnaire validation.[25] Hence, four articles that met the inclusion criteria were included in the current review.[26–29] Narrative synthesis was undertaken for two articles on physical/behavioral therapy with heterogenous design and outcomes.[26,27] Two articles on pharmacotherapy for PMD were included in the meta-analysis.[28,29]

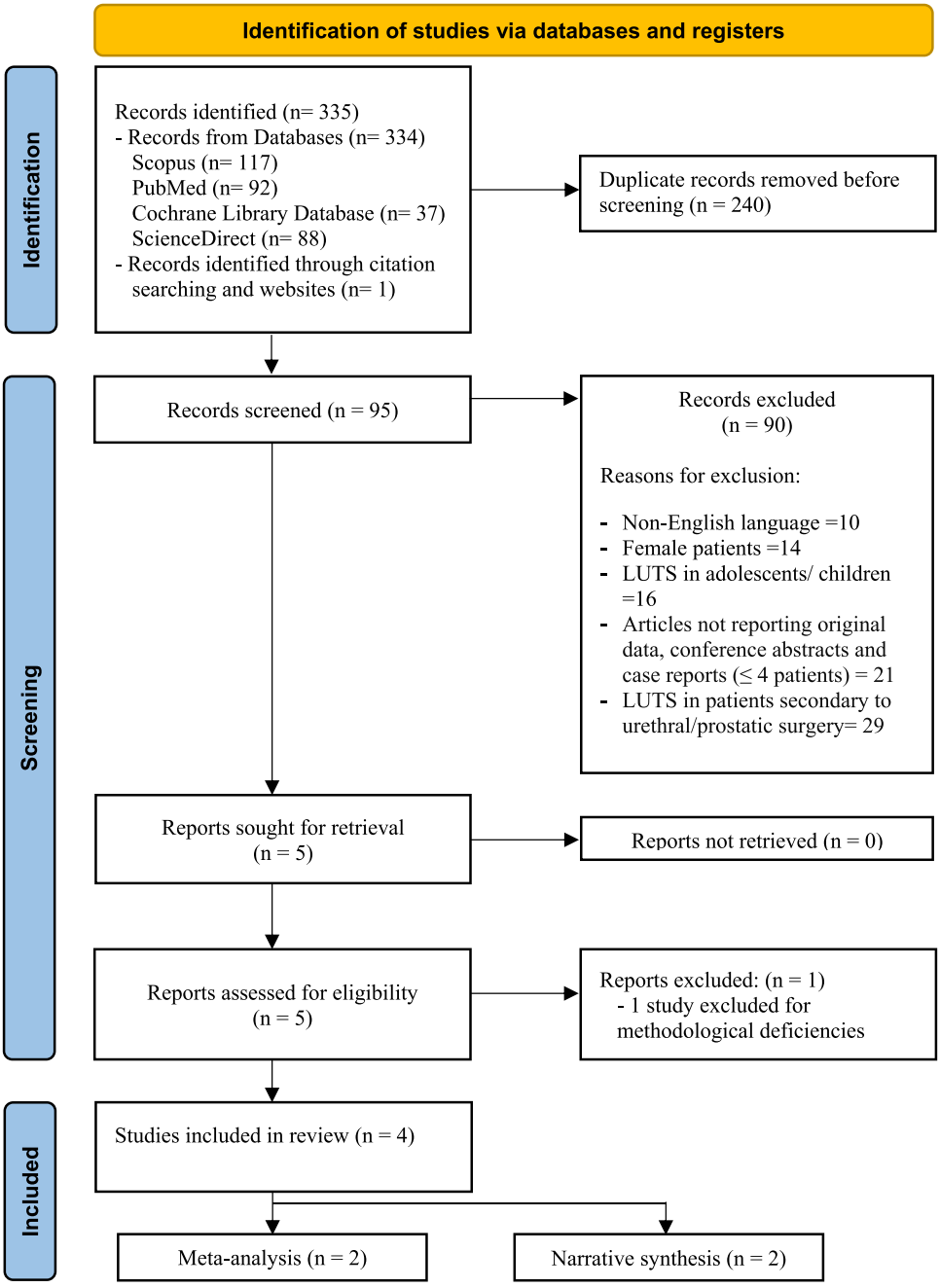

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 study flow diagram.[14]

3.2 | Quality and risk of bias assessments

Table 1 shows the quality assessments of the included studies according to the Jadad scale.[15] Two RCTs scored five while the other two scored four reflecting excellent to good quality.

Table 2 depicts the risk of bias assessment following the CLARITY risk of bias assessment tool. The two physical/behavioral therapy RCTs[26,27] had low risk of bias regarding allocation generation but high risk of bias regarding allocation concealment/blinding and missing data. On the other hand, the two pharmacotherapy RCTs[28,29] exhibited an overall low risk of bias.

3.3 | Study characteristics and baseline patient data

The four included articles comprised four RCTs (344 patients). Physical/behavioral therapy in PMD was evaluated two single-blind RCTs ($n = 104$ patients). One RCT had three limbs, assessing urethral milking versus PFME versus counseling[26]; the other evaluated PFME and biofeedback versus counseling.[27]

PDE5 inhibitors in PMD were assessed by two double-blind RCTs[28,29] that evaluated Tadalafil[28] or Udenafil.[29] against placebo ($n = 240$ patients) (Table 4). Tables 3 and 4 outline the baseline patient characteristics, which were not different between the intervention versus control groups in any of the four studies. The four studies included PMD patients but excluded those with previous urologic surgery. One study excluded previous urologic surgery, but not those with history of transurethral resection of the prostate (TURP), evaluating the effectiveness of PFME on erectile dysfunction and on PMD in a crossover design.[27]

3.4 | Differences in PFME treatment modalities

While both physical therapy studies applied PFME as a treatment option, the PFME regimens were different. Paterson et al. applied exercises to fast and slow twitch muscles and described training as if controlling flatus or interrupting urine stream.[26] They also examined the effects of urethral milking as the third arm of the intervention.[26] On the other hand, Dorey et al. advised patients to exercise in different positions (lying, sitting, standing) together with a 50% lift while walking, and postvoid squeeze out exercise aided by manometric biofeedback (Table 5).[27]

3.5 | Study outcome measures

Table 6 outlines the nature of the primary and secondary outcomes of the four included RCTs. The primary

TABLE 1 Quality assessments of included studies.[a]

Study	Randomization	Blinding	Account of all patients	Total score
Paterson et al., 1997[26]	2	1	1	4
Dorey et al., 2004[27]	2	1	1	4
Yang et al., 2019[28]	2	2	1	5
Ko et al., 2020[29]	2	2	1	5

[a]Jadad scale. [15]

TABLE 2 Risk of bias assessment.[a]

Study/domain	1	2	3a	3b	3c	3d	3e	4	5	6
Paterson et al., 1997[26]	A	D	D	D	A	D	A	C	A	B
Dorey et al., 2004[27]	A	D	D	A	A	A	A	C	B	B
Yang et al., 2019[28]	A	A	A	A	A	A	A	A	B	B
Ko et al., 2020[29]	A	A	A	A	A	A	A	A	B	B

Note: Tool responses: A: Definitely yes (low risk of bias); B: Probably yes; C: Probably no; D: Definitely no (high risk of bias). Tool items: (1) Allocation sequence adequately generated?; (2) Allocation adequately concealed?; (3) Blinding of (3a) patient, (3b) healthcare providers, (3c) data collectors, (3d) outcome assessors, (3e) data analysts; (4) Loss to follow-up (missing outcome data) infrequent?; (5) Reports of study free of selective outcome reporting?; and (6) Study apparently free of other problems that could put it at a risk of bias?

[a]Tool to assess the risk of bias for randomized controlled trials contributed by the CLARITY Group at McMaster University.[17]

TABLE 3 Included studies of physical/behavioral therapy for treatment of PMD.

Study	Controls	Intervention		*p* Value	Follow-up
	Counseling/lifestyle advice	PFME	Urethral milking		
Paterson et al., 1997[26] Australia					13 weeks
Patients, *n*	15	14	15		
Age, years	69.5 ± 2.4	70.8 ± 2.7	69.3 ± 3.1		
BMI, kg/m^2	26.12[a]	26[a]	31.2[a]		
PMD volume, g[b]	7.56 ± 127	11.68 ± 5.43	10.43 ± 2.99		
Dorey et al., 2004[27] UK					6 months
Patients, *n*	27 (15)[c]	27 + 22[d] (36)[c]			
Age, years	59.2 ± 8.62	53.9 ± 13		0.082	
BMI, kg/m^2	28.8 (3.41)	26.9 (4.1)		0.69	
PMD volume	—	—			

Abbreviations: —, not reported; BMI, body mass index; PFME, pelvic floor muscle exercise; PMD, postmicturition dribble.

[a]Calculated value using data provided in the study.

[b]PMD volume on 4-h pad test in grams.

[c]Total number of patients with postmicturition dribbling within the study population.

[d]Number of controls crossing into intervention.

TABLE 4 Included studies of PDE5 inhibitors for treatment of PMD.

Study	Controls	PDE5 inhibitors		*p* Value	Follow-up
	Placebo	Tadalafil[a]	Udenafil[b]		
Yang et al., 2019[28] South Korea					
Patients, *n*	43	44			
Age, years	62.6 ± 6.5	60.8 ± 7.3		0.464	12 weeks
BMI, kg/m^2	24.3 ± 2.2	24.6 ± 3.8		0.739	
PMD volume, mL	1.02 ± 0.19	0.97 ± 0.20		0.654	
Ko et al., 2020[29] South Korea					
Patients, *n*	68		70		
Age, years	57.28 ± 9.08		58.31 ± 9.55	0.519	12 weeks
BMI, kg/m^2	25.00 ± 2.39		24.75 ± 2.4	0.553	
PMD volume[c]	19.23 ± 25.37		19.88 ± 23.8	0.881	

Abbreviations: BMI, body mass index; PDE5, phosphodiesterase 5; PMD, postmicturition dribble.

[a]5 mg for 12 weeks.

[b]75 mg daily for 12 weeks.

[c]PMD volume measured by the number of wet grids on the paper test.

outcomes included the improvement of PMD volume on the 4-h pad weight.[26] and follow-up of PMD complaints through self-report and HMPDQ.[27–29] The secondary outcomes included a variety of evaluations pertaining to pelvic muscle strength, erectile function, prostate symptoms, and PMD volume. These were assessed using a range of digital, visual, manometric, self-reported questionnaires, and pad tests evaluations.

TABLE 5 Treatment modalities of studies of physical/behavioral therapy for PMD.

Study	Controls	Intervention	
	Counseling/lifestyle advice	PFME	Urethral milking
Paterson et al., 1997[26]	Drinking habits, hints to alleviate edema, dietary advice, relaxation therapy	Training/Exercises to: – Tighten/lift pelvic floor muscles as if controlling flatus or interrupting urine flow mid-stream – Observe penile/scrotal lift in front of mirror; recognize inappropriate tightening of abdominal/gluteal muscles – Fast twitch muscle fibers were exercised through series of five one-second-contractions and gradually increase the number of contractions. Slow twitch fibers were trained by repeating maximum contraction as many times as possible with gradually increasing the duration and power of contraction – Participants were asked to spread the exercises through the day in different positions – Muscle strength was assessed at each visit and graded through digital evaluation to assess patient compliance	Insights/Training: – Perineal anatomy – How to practice urethral milking – Education sheet
Dorey et al., 2004[27]	Lifestyle changes only in five, 30-min periods, consecutive weeks	Training/Exercises: – For pelvic floor in lying, sitting, standing positions, with 50% lift while walking occasionally; postvoid "squeeze out" pelvic floor muscle contraction – To tighten/lift as if interrupting urine flow, observe penile retraction and scrotal lift – Manometric biofeedback was performed initially – Treatments were given in five 30-min periods in consecutive weeks and a list of home exercises were given to patients receiving the intervention – Home exercises included performing the exercises in three maximal contractions in standing, sitting, and lying positions during morning and evening with increasing durations – Further instructions for lifting the pelvic floor 50% while walking, "squeeze out" after urination, and tightening pelvic floor muscles during sexual activity to get stronger erection and delay ejaculation – Digital anal measurement and manometric measurement was undertaken during follow-up visits	

Abbreviations: PFME, pelvic floor muscle exercise; PMD, postmicturition dribble.

3.6 | Data synthesis

For the two physical/behavioral therapy studies, the primary outcome measure of one was the 4-h pad weigh test,[26] while for the other, it was patients' self-reports.[27] Hence, such heterogeneity in outcome measures was more suited to narrative synthesis.[21] On the other hand, both PDE5 studies were considered to be similar enough to meta-analyze.

TABLE 6 Measurement of primary and secondary outcomes of included RCTs by treatment modality.

Modality/study	Measurement of outcomes	
	Primary outcomes	**Secondary outcomes**
Physical/behavioral therapy		
Paterson et al., 1997[26]	4-h pad weight test	Digital and visual evaluation of pelvic muscle strength
Dorey et al., 2004[27]	Self-report of PMD 24-h pad weight test (abandoned)	Digital anal manometric measurements and muscle strength grade
PDE5 inhibitors		
Yang et al., 2019[28]	Difference in HPMDQ total score (improvement marked by decrease in score ≥2)	– Difference is HPMDQ each question – PMD volume – Difference in IPSS score – Difference in IIEF score
Ko et al., 2020[29]	Difference in HPMDQ total score (improvement marked by decrease in score ≥2)	– Improvement of sexual function in IIEF score – Improvement of LUTS in IPSS score – PMD volume using paper test

Abbreviations: HPMDQ, The Hallym Post-Micturition Dribble Questionnaire; IIEF, International Index of Erectile Function; IPSS, International Prostate Symptom Score; LUTS, lower urinary tract symptoms; PMD, postmicturition dribble; RCT, randomized controlled trial.

TABLE 7 Improvements in PMD outcomes by type of physical/behavioral therapy interventions.

Study		Controls	Intervention	
		Counseling/Lifestyle advice	**PFME**	**Urethral Milking**
Paterson et al., 1997[26]	4-h pad weight	No improvement	Improved: at 13 week, 4.7 g less in PMD amount from baseline	Improved: at 13 week, 2.9 g less urine loss from baseline
Dorey et al., 2004[27]	Self-reported PMD	No improvement	75% of PMD patients reported no PMD at 6 months	
	Secondary outcome	No correlation between PMD, IIEF5, manometric pressure, and digital anal pressure at any assessment for all study groups		

Abbreviations: IIEF5, International Index of Erectile Function; PFME, pelvic floor muscle exercise; PMD, postmicturition dribble.

3.6.1 | Narrative synthesis: Physical/behavioral therapy

In terms of the actual outcomes of physical/behavioral therapy interventions for PMD, Table 7 shows that for both RCTs,[26,27] compared to counseling and lifestyle advice, PFME exhibited significant improvements in PMD complaints and volume. In one of these two RCTs,[26] although the two interventions of urethral milking and PFME led to improved PMD volume, PFME showed superior results compared to urethral milking (i.e., lower PMD volume on the 4-h pad test).[26]

3.6.2 | Meta-analysis: PDE5 inhibitors

Table 8 depicts PMD outcomes from treatment with PDE5 inhibitors, as reported in two RCTs.[28,29] Both Tadalafil 5 mg and Udenafil 75 mg were effective in reducing patient complaints assessed via the HPMDQ score and PMD volume.[28,29] Figure 2 shows the forest plot of the meta-analysis of the standardized mean difference in PMD volume for PDE5 inhibitors versus placebo. The effect size (g) = −0.86 (95% confidence interval [CI] −1.75; 0.02; $p = 0.05$; $I^2 = 88\%$) in favor of PDE5 inhibitors over placebo.

Figure 3 shows the forest plot of the meta-analysis of the differences in HPMDQ score for PDE5 inhibitors versus placebo. The results indicate a significant effect for decreasing the HPMDQ score, equivalent of −1.06 points (95% CI −1.65; −0.47) on the HPMDQ in favor of PDE5 inhibitors when compared to placebo ($p = 0.0004$). The analysis for HPMDQ score demonstrated no significant heterogeneity ($I^2 = 0\%$; χ^2, $p = 0.66$).

TABLE 8 Improvements in PMD outcomes by PDE5 inhibitors interventions.

Study/improvement variable	Placebo			PDE5 inhibitor			Between-group effects *p* Value
	Pre	Post	Change	Pre	Post	Change	
Yang et al., 2019[28] Tadalafil							
HPMDQ	5.03 ± 2.20	4.24 ± 2.11	31.9%[a]	5.47 ± 2.11	3.30 ± 1.89	68.8%[a]	0.001
PMD volume, mL	1.02 ± 0.19	0.80 ± 0.20	−0.22 ± 0.28[b]	0.97 ± 0.20	0.49 ± 0.26	−0.48 ± 0.46[b]	0.046
Ko et al., 2020[29] Udenafil							
HPMDQ	5.18 ± 2.01	4.38 ± 2.07	26.9%[a]	5.43 ± 1.82	3.17 ± 2.15	61.7%[a]	0.001
PMD volume	19.23 ± 25.37	14.4 ± 18.37		19.88 ± 23.80	8.27 ± 7.76		0.035

Note: Italicized cells indicate statistical significance.

Abbreviations: HPMDQ, Hallym Post-Micturition Dribble Questionnaire; PDE5, phosphodiesterase 5; PMD, postmicturition dribble.

[a]% of patients with HPMDQ total score Improvement (i.e., decrease) ≥2 points at 12 weeks.

[b]PMD volume by mL, assessed by proportion of wetting of pad for 1 min after voiding.

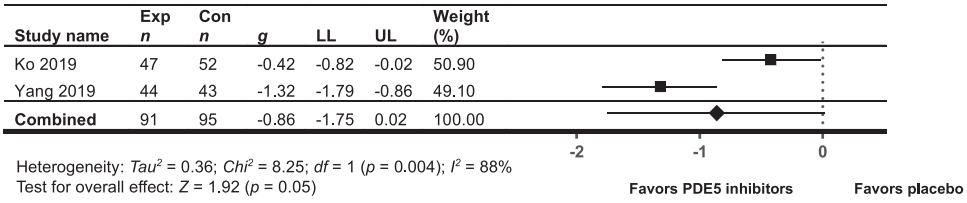

FIGURE 2 Forest plot of improvements in PMD volume: PDE5 inhibitors versus placebo. PDE5, phosphodiesterase 5; PMD, postmicturition dribble.

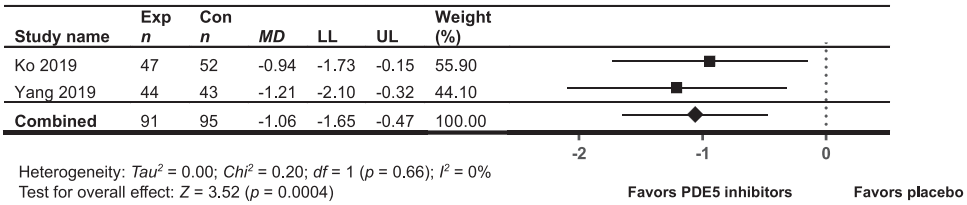

FIGURE 3 Forest plot of improvements in HPMDQ score: PDE5 inhibitors versus placebo. HPMDQ, Hallym Post-Micturition Dribble Questionnaire; PDE5, phosphodiesterase 5.

4 | DISCUSSION

Due to lack of previous reviews, our systematic review and meta-analysis aimed at synthesizing evidence about the current management options for primary PMD in adult males, only four studies matched our search criteria.[26–29] All four studies were RCTs, two addressed physical therapy/behavioral modalities (PFME, urethral milking)[26,27] and the other two focused on PDE5 inhibitor treatments (Tadalafil, Udenafil).[28,29] The narrative synthesis of physical/behavioral therapy studies proved their effectiveness in reducing PMD volume and patient complaints. While the meta-analysis of the two PDE5 inhibitors showed a highly significant effect in reducing HPMDQ score, with a borderline improvement in PMD volume. Below we discuss each of the findings in detail.

4.1 | Effectiveness of physical/behavioral therapy

4.1.1 | Physical therapy—pelvic floor muscles exercises

Narrative synthesis of PFME outcomes (two studies) showed that it was effective in decreasing PMD volume.[26] and

reducing the self-reported PMD complaints.[27] With the exception of the two studies included in this report, there appears to be no literature on the effect of PFME on primary PMD. Hence, we compare our results with parallel literature on PMD secondary to prostate surgery where PFMEs were reported to improve terminal dribbling and PMD complaints after TURP.[30] On the other hand, the value of PFMEs on urinary incontinence secondary to radical prostatectomy was found to be uncertain.[31] Nevertheless, PFMEs showed promising results in treating PMD in our review, and future research is needed to support or refute this evidence.

4.1.2 | Behavioral therapy—urethral milking

One study included in our analysis assessed the impact of urethral milking on PMD (an RCT with three arms; counseling/lifestyle advice, PFME, urethral milking).[26] This study found that while urethral milking reduced PMD volume compared to counseling, it was not as effective as PFME.[26] A study which was excluded from the current review as it undertook a simultaneous validation of a Turkish translation of the HPMDQ questionnaire while testing the effectiveness of urethral milking on PMD reported that urethral milking improved PMD among 55 participants.[25] Testing of effectiveness should normally be undertaken after full validation of a given questionnaire, not simultaneously. There is no other research on the effect urethral milking on PMD. However, our findings align with other reports on PMD management approaches. For instance, an opinion report found that patients employed varied techniques, including urethral milking, to mitigate PMD symptoms.[2] Similarly, a survey in the Netherlands highlighted that clinicians particularly recommended urethral milking for PMD patients.[32] While urethral milking education seems widespread among medical professionals and patients, the extent of patient compliance and conclusive evidence regarding its efficacy in PMD treatment warrant further investigation.

4.2 | Effectiveness of pharmacotherapy with PDE5 inhibitors to treat PMD

While the etiology of PMD remains unclear, studies have suggested that it results from intrinsic or iatrogenic impairment of postvoid urethral milking that may be related to weakness in the bulbospongiosus and ischiocavernosus muscles.[8,10] The mechanism by which PDE5 inhibitors improve PMD is unknown; however, their enhancement of the urethro-corporocavernosal reflex may be one of the mechanisms of action.[28] Furthermore, studies that examined the association between PMD and erectile dysfunction[33,34] found that those with PMD have greater odds of erectile dysfunction (odds ratio 1.54),[33] and using the HPMDQ, there was an inverse correlation between both the HPMDQ score and PMD volume versus the IIEF-5 questionnaire score that measures erectile dysfunction.[34] Such findings, in addition to the recent introduction of Tadalafil 5 mg for the management of male LUTS with erectile dysfunction,[12] supported the use of Tadalafil and Udenafil in the management of PMD.

The results of the present meta-analyses indicate potential effects of PDE5 inhibitors on PMD volume compared to placebo; however, the small number of studies and high heterogeneity make it difficult to draw conclusions. The standardized mean difference (improvement) of −0.86 is a large effect size, although significance was borderline ($p = 0.05$) due to the high heterogeneity. This was probably due the different measures of PMD volume (volume by mL vs. number of wet grids on paper towel) that may not be appropriate for pooling within a meta-analysis. This suggests an urgent need for a more consistent measure of PMD volume.

Conversely, the meta-analysis of HPMDQ score found a statistically significant decrease in HPMDQ score by 1.06 points ($p = 0.0004$), with no detectable heterogeneity. This analysis suggests positive effects of PDE5 inhibitors compared to placebo, although the small number of studies reporting data means that the results of this analysis should be interpreted with some caution. While both studies[28,29] defined improvement as a decrease in HPMDQ score of ≥2 which is higher than the pooled value of 1.06 points that we observed in the metanalysis, both studies reported a significantly larger number of people with an improvement in HPMDQ score of ≥2 in the treatment groups compared to placebo. This indicates that there are likely valuable beneficial effects of treatment of PDE5 inhibitors on PMD. The presence of only two studies reporting these findings highlights a need for further research investigating the effects of PDE5 inhibitors on PMD treatment outcomes.

4.3 | Limitations and opportunities for future research

The current systematic review was limited by the very few studies that assessed primary PMD (four clinical trials).[26–29] The absence of homogenous study designs and lack of comparable outcome measures across physical/behavioral therapy studies hindered a deeper analysis of therapeutic measures in meta-analysis. Table 9 illustrates some of the challenges that will need to be addressed to develop a more

TABLE 9 Challenges limiting evidence of effectiveness of current PMD treatment/s and opportunities for future research.

Parameter	Challenge	Current measurement methods	Deficiency	Opportunities for future research
Evaluation of PMD volume	Limited volume of PMD after each void	4-h pad test[26]	– Does not assess: Number of voids during the 4 h; PMD amount after each void – Affected by body moisture and evaporation	– Need for standardized pads for evaluating PMD volume with more accuracy – Pads should be weighed after individual void by enough time
		Folded paper towel fixed to patient's undergarments while walking 1 min after voiding. (Number of wet grids/ Proportion of wetting)[28,29]	– Too brief: 1 min is too limited to conclude total PMD volume – Inaccurate:Paper towel is delicate and can leak urine to undergarments, rendering the volume PMD not accurate Counting number of wet grids can be cumbersome and inaccurate – Proportion of paper towel wetting is not a method for measuring volume	– Explore the time period required: long enough to capture all PMD volume, short enough to prevent evaporation – Use of standardized pads with standardized weight – Weigh pads after voiding on sensitive balance
Self-report	Self-reports commonly used for LUTS do not include evaluation for PMD and its bothersome	Self-reported questionnaire[27]	Validity and reliability of questionnaire have not been established to be generalized	– Psychometric properties of questionnaire need to be established – Development of new PROs tools specialized and validated for PMD patients
		HMPDQ[28,29]	Validated for testing and quantifying PMD in two languages only, it is not adapted worldwide	– Adoption of HMPDQ in future studies can add to available evidence
Patient population	Despite wide prevalence of PMD, limited sample sizes of PMD patients used in available RCTs (<100)[26–29]		Limited power of studies to be able to detect evidence should it exist	Wider scale RCTs enrolling larger sample sizes of PMD patients

Abbreviations: HMPDQ, The Hallym Post-Micturition Dribble Questionnaire; LUTS, lower urinary tract symptoms; PMD, postmicturition dribbling; PROs, patient reported outcomes; RCTs, randomized controlled trials.

solid evidence base on PMD treatment effectiveness and to guide recommends and solutions for future research. Such findings recommend that future trials for PMD should employ objective assessments of the volume of dribbling and ways of accurately weighing the amount of dribble after each void. In addition, the use of standardized questionnaire/s to measure the changes in the level of bothersome of patients and to follow the improvements through treatment is essential.

5 | CONCLUSION

Despite the high prevalence of PMD in males, the available literature on its management is extremely scarce and lacks consensus. The current systematic review identified, with difficulty, a limited number of studies that evaluated treatments primary PMD among males. Among the identified treatments, PFMEs showed promising results in reducing PMD volume and self-reported complaints. On the other hand, urethral milking, although evaluated in a single RCT, may help reducing PMD volume. PDE5 inhibitors, specifically tadalafil 5 mg and Udenafil 75 mg, exhibited strong potential for reducing patient-reported PMD complaints and had a promising effect on reducing PMD volume. More research into PMD treatments is urgently required. This would include the development and use of validated and consistent objective measurements of PMD volume, better methodologies to detect and evaluate improvements in pelvic floor muscle strength, as well as patient complaints and undesirable symptoms to enhance the thin evidence base.

AUTHOR CONTRIBUTIONS

Ahmed Albakr and Walid El Ansari contributed to the design of the research. Ahmed Albakr, Walid El Ansari, Heba Megahed, Mohammed Mahdi, Merilyn Lock, and Mohamed Arafa contributed to the implementation of the research. Merilyn Lock contributed to the analysis of the results. Walid El Ansari, Ahmed Albakr, Mohammed Mahdi, Heba Megahed, Merilyn Lock, and Mohamed Arafa contributed to the writing of the manuscript. Hanaa Al Hothi and Ardalan Ghafouri contributed to the reviewing and editing of the manuscript. All authors read and agreed on the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study involves only information that is freely available in the public domain.

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