Effectiveness of physical therapy interventions for coccydynia: a systematic review with a narrative synthesis

Mohammad Sidiq[1], Hariharasudhan Ravichandran[2,3], Balamurugan Janakiraman[4], Aksh Chahal[1], Richa Hirendra Rai[5], Ahmed Hamoud Alotaibi[6], Ali Hamoud Alotaibi[7], Abdullah Saad Alotaibi[8], Aminu Alhassan Ibrahim[9], Eid Abed Alharbi[7], Faizan Zaffar Kashoo[10], Hemlata Vats[5]

[1]Department of Physiotherapy, School of Allied Health Sciences, Galgotias University, Greater Noida, Uttar Pradesh, India
[2]Alvas College of Physiotherapy and Research Centre, Moodbidri, Dakshina Kannada, Karnataka, India
[3]Faculty of Physiotherapy, Meenakshi Academy of Higher Education and Research (MAHER), Tamil Nadu, India
[4]SRM College of Physiotherapy, Faculty of Medicine and Health Sciences, SRM Institute of Science and Technology (SRMIST), Kattankulathur, Tamil Nadu, India
[5]School of Physiotherapy, Delhi Pharmaceutical Sciences and Research University, New Delhi, India
[6]Department of Anesthesia, Northern Area Armed Forces Hospital, Hafar Al Batin, Saudi Arabia
[7]Department of Nursing, Northern Area Armed Forces Hospital, Hafar Al Batin, Saudi Arabia
[8]Department of Laboratory Sciences, Northern Area Armed Forces Hospital, Hafar Al Batin, Saudi Arabia
[9]Physiotherapy Department, Tishk International University, Erbil, Iraq
[10]Department of Physical Therapy and Health Rehabilitation, College of Applied Medical Sciences, Majmaah University, Al Majma'ah, Saudi Arabia

ABSTRACT

Introduction: Various physical therapy interventions for coccydynia have been evaluated, but their effectiveness has not yet been comprehensively synthesized. This systematic review aims to evaluate the effectiveness of physical therapy interventions in adults with coccydynia.
Methods: A systematic search of relevant randomized controlled trials (RCTs) was conducted in PubMed/MEDLINE, EMBASE, CINAHL, Scopus, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and Physiotherapy Evidence Database (PEDro). Outcomes of interest included pain, function, mobility, and patient satisfaction. Due to the heterogeneity of the included studies, a narrative synthesis was performed.
Results: A total of 515 adults with coccydynia across 10 studies were included in the review. Physical therapy interventions, including extracorporeal shock wave therapy, kinesiotaping plus exercise, levator anus stretching or massage, manipulation alone or manipulation plus electrotherapy or exercise, and muscle energy technique, showed significant improvements in pain and function in the short term. Additionally, kinesiotaping plus exercise showed significant short-term improvement in trunk mobility. In the intermediate term, manipulation alone and levator anus stretching or massage were effective at reducing pain, whereas manipulation alone was effective at improving function. In the long term, levator anus stretching or massage showed sustained improvement in pain.
Conclusions: Overall, physical therapy interventions led to short-term improvements in pain and function for adults with coccydynia. However, there is a need for high-quality studies with long-term follow-ups to compare the efficacy of various physical therapy interventions, both in isolation and in combination.
Keywords: Coccydynia, Function, Pain, Physical therapy interventions, Review, Randomized controlled trials

What's already known about this topic?	What does this study add?
• *Coccydynia is a rare but painful and debilitating condition with uncertain pain sources and a lack of clinical guidelines.* • *Although previous studies on physical therapy interventions show promising results, their effectiveness has not yet been comprehensively synthesized.*	• *This is the first review to comprehensively synthesize the effectiveness of physical therapy interventions for adults with coccydynia.* • *Of the ten studies evaluated, extracorporeal shock wave therapy, kinesiotaping, manipulation, massage, muscle energy technique, and stretching showed short-term improvements in pain, function, and trunk mobility.*

Introduction

Pain is a debilitating and distressing sensation that significantly impairs an individual's function and quality of life. Coccydynia, commonly known as tailbone pain, is a relatively rare medical condition characterized by discomfort or pain in

the coccyx region and is generally reported to be more prevalent in women (1,2). The pain often impacts the emotional well-being of patients, as it typically worsens during activities such as prolonged sitting, leaning back while seated, extended standing, and transitioning from sitting to standing (3). Primary coccydynia arises without any identifiable underlying cause, while secondary coccydynia may result from single-axis trauma, weight gain, change in postural biomechanics, childbirth, rapid weight-loss related to gastric by-pass surgery, degenerative spine disorders, infections, or previous surgeries leading to tissue inflammation and adhesions (2,4-10).

The coccyx, located at the lower end of the spine, forms a tripod structure with the ischial tuberosities. Muscle attachments on the coccyx help distribute weight evenly while sitting and provide structural support to surrounding areas. The shape of the coccyx may also be linked to the development of primary coccydynia (11). Moreover, individuals with a higher body mass index (BMI) are three times more likely to develop coccydynia compared to those with a normal BMI (10). Although most acute cases of coccydynia typically resolve within weeks to months with or without conservative treatment (3), some individuals may go on to experience persistent pain and develop chronic coccydynia, leading to debilitating symptoms that significantly interfere with daily life, with activities such as sitting, defecation, and sexual intercourse commonly being affected (10).

Effective management of coccydynia is necessary to avoid invasive procedures such as prolotherapy, radiofrequency ablations, and partial or complete coccygectomy. These procedures may have long-term consequences or result in further disability (12-17). Unfortunately, no clinical treatment guidelines for coccydynia are currently available to guide clinicians. As a result, conservative management options are considered first-line treatments and are generally preferred over surgical or minimally invasive procedures (3,18). Noninvasive methods include the use of specialized cushions, rest, non-steroidal anti-inflammatory drugs, and various physical therapy modalities (e.g., manipulation, soft-tissue techniques, electrotherapy, exercise, and patient education) to alleviate pain, prevent repetitive trauma, and restore near-normal biomechanics (19,20). Physical therapy modalities are tailored based on the patient's pain presentation, history, medical condition, anatomical involvement, and physiological findings, and in collaboration with functional assessments (20).

Studies evaluating physical therapy interventions for coccydynia have demonstrated promising results (21-33). A previous systematic review included 64 studies, of which only 5 were randomized controlled trials (RCTs), and concluded that non-surgical interventions are effective in providing pain relief for coccydynia (34). However, the review included minimally invasive procedures such as injection and ganglion block procedures, which are not considered physical therapy interventions and did not report functional outcomes. Additionally, the review only included studies published up to January 2020 (32). Given that newer trials (22, 28, 29, 35) have been published, and there has been a lack of a systematic review evaluating the effectiveness of these interventions, this is a key evidence gap for future reviews. Therefore, this systematic review aims to evaluate the effectiveness of physical therapy interventions for adults with coccydynia based on data from available RCTs.

Methods

Protocol registration

The protocol for this review was registered with the International Prospective Register of Systematic Reviews (PROSPERO), with registration number CRD42022344003. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (36) were followed for reporting this review. The PRISMA checklist is provided as Additional File 1 (See supplementary material).

Search strategy

A systematic literature search was conducted in the following databases: PubMed/MEDLINE, EMBASE, CINAHL, Scopus, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and Physiotherapy Evidence Database (PEDro) from their inception to March 31, 2024. Additionally, grey literature using Google was searched for potentially relevant studies. Citation chaining was employed for the selected studies to identify additional relevant studies using forward and backward citation tracking in PubMed/MEDINE, Scopus, and Web of Science. The search included key terms and synonyms, including both plural and singular forms identified through MeSH databases, combined using Boolean operators ("AND" and "OR") (Additional File 2).

Scientific and grey literature searches were further supplemented by manual searches of relevant review articles and reference lists from all included articles. Two reviewers (HR and BJ) independently performed the search, and any disagreements were resolved through discussion with the first author (MS). After removing duplicate articles, two reviewers (MS and AC) independently screened titles and abstracts to identify potentially relevant studies. Disagreements were resolved through discussion and, when necessary, with the involvement of a third reviewer (RHA and AHA Jr). Two additional reviewers (AHA Sr and ASA) independently evaluated the full texts for potential inclusion based on the review's inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria were: (1) studies published in English with accessible full text, (2) RCTs or quasi-randomized trials involving male or female participants aged ≥18 years, (3) studies evaluating physical therapy interventions (e.g., manipulation, electrotherapy, exercise, massage, ergonomics/education, kinesiotaping, etc.) for patients diagnosed with coccydynia lasting at least 2 months, (4) studies evaluating pain, function/disability, mobility, or patient satisfaction as outcomes, and (5) studies comparing physical therapy interventions against each other or to comparator interventions such as sham, placebo, advice only, or usual care. The exclusion criteria were: (1) studies involving participants with coccydynia and other conditions such as pregnancy

or post-operative surgery, (2) scoping reviews, systematic reviews, case reports, opinion pieces, or case studies, and (3) studies on the effect of topical applications.

Data extraction

Data extraction was conducted independently by two reviewers (AHA Sr and ASA) in duplicate and compared after completion. A custom Excel Spreadsheet was designed to collect information about study details (author, publication year, setting/country), study design (e.g., RCT, quasi-randomized trial), participants (e.g., sample size, mean age), intervention (e.g., manipulation, exercise, electrotherapy), comparisons (e.g., sham, placebo, no-interventions, or other interventions), outcomes (e.g., pain intensity, disability/function, trunk mobility, patient satisfaction).

Risk of bias assessment

Two independent reviewers (AC and RHR) evaluated the risk of bias in the included studies. Any disagreements in grading were resolved through discussion, and if necessary, a third reviewer (HV) was consulted. The Cochrane Risk of Bias (RoB 2.0) tool (37) was used to assess the risk of bias in the included studies. The assessment was conducted for each outcome in the included studies (i.e., assessment at outcome level). Studies were evaluated across five domains of bias: 1) bias related to the randomization process, 2) bias arising from deviations in the intended intervention, 3) bias due to missing outcome data, 4) bias in the measurement of outcome, and 5) bias in the selection of the reported result. Each domain was categorized as low risk, some concerns, or high risk. The overall risk of bias was interpreted as follows:

(a) Low risk of bias: when all domains were judged to have a low risk of bias.
(b) Some concerns: when at least one domain raised some concerns but no domain was judged to be at high risk of bias.
(c) High risk of bias: when at least one domain was rated as high risk of bias, or multiple domains were judged to have some concerns that substantially lowered the confidence in the result.

Data synthesis

Initially, we planned to conduct a meta-analysis; however, this was deemed impractical due to heterogeneity in the interventions across studies. Although a few studies evaluated manipulation, variations in the approaches also precluded a meta-analysis. Therefore, a narrative synthesis of the studies was conducted based on the interventions and outcomes of interest. For available individual study data, treatment effects were extracted as mean differences (MD) and associated 95% confidence intervals (CI) using RevMan 5.4 software. As one study (25) reported median and range, the MD and 95% CI were calculated by estimating the mean and standard deviation (SD), as recommended by Wan et al. (38) as follows: Median = mean, $SD = (b - a)/c$, where $b - a$ is the range, and c is 2 if the sample size (n) < 15, 4 if $15 \leq n < 70$, or $n \geq 70$.

Results

Study selection

A total of 354 records were retrieved from the literature search, and after the removal of duplicates, the title and abstract of 342 studies were screened for potential eligibility (Fig. 1). Full texts of 231 studies were screened, of which 10 studies were deemed eligible (21-29,35) and finally included in the narrative synthesis based on the study stipulated criteria. The PRIMSA flow diagram, as depicted in Fig. 1, provides a summary of the study selection process.

Study characteristics

The included studies comprised a total of 563 participants, with a mean age ranging from 31 to 45 years. The intervention period spanned 1 to 4 weeks, and follow-up durations varied from 1 month to 2 years. The studies were conducted in several countries, including France (25,26), Turkey (28,35), Taiwan (24), Egypt (21), India (23,27), and Pakistan (22,29) (Table 1). All studies were hospital-based.

Regarding the outcome measures (Table 2), the pain was assessed using the following scales: seven studies used the Visual Analog Scale (VAS) (21,23-26,28,35), two studies used the Numerical Pain Rating Scale (NPRS) (22,29), one study used pain pressure threshold (PPT) (27), and another study used the (modified) McGill Pain Questionnaire (MPQ) (25). For functional outcome, two studies applied the Paris (functional coccydynia impact) Questionnaire (PQ) (25,28), four studies used the Oswestry Disability Index (ODI) (21,24,28,35), three studies used the Dallas Pain Questionnaire (DPQ) (22,25,29), and four studies evaluated pain-free sitting duration (22,23,27,29) as a functional measure. Mobility was assessed in one study using the Modified Schober Test (MMST) (21). Additionally, one study measured patient satisfaction using a 5-level self-satisfaction scale (24).

Interventions and comparators employed across the studies varied significantly and included the following: massage (26), mobilization (27), stretching (22,25,27-29), kinesiotaping (21), intrarectal manipulation (25,28), short wave diathermy (SWD) (25), coccygeal manipulation (23), conventional therapy (seat cushioning plus sitz bath plus phonophorosis) (25), transcutaneous electrical nerve stimulation (TENS) (23), reverse Kegel exercise (28), extracorporeal shock wave therapy (ESWT) (24,35), muscle energy technique (MET) (29), primal reflex release technique (PRRT) (22), and phonophoresis (21). For ease of synthesis, the interventions were grouped into six main categories (Table 2). All heating and electrical modalities used as comparators were collectively termed "electrotherapy."

Manipulation [three studies (23,25,28)]: These studies employed a similar manipulation technique as the primary intervention but differed in their comparators. One (23) of the studies compared coccygeal manipulation plus electrotherapy (phonophorosis, TENS) against the same electrotherapy using VAS and PFSD in patients with clinical diagnosis of idiopathic coccydynia. Similarly, the second study (25) compared intrarectal manipulation plus electrotherapy (i.e., SWD) and electrotherapy alone using VAS, (modified) DPQ, (modified) MPQ, and PQ in patients with chronic coccydynia. The third
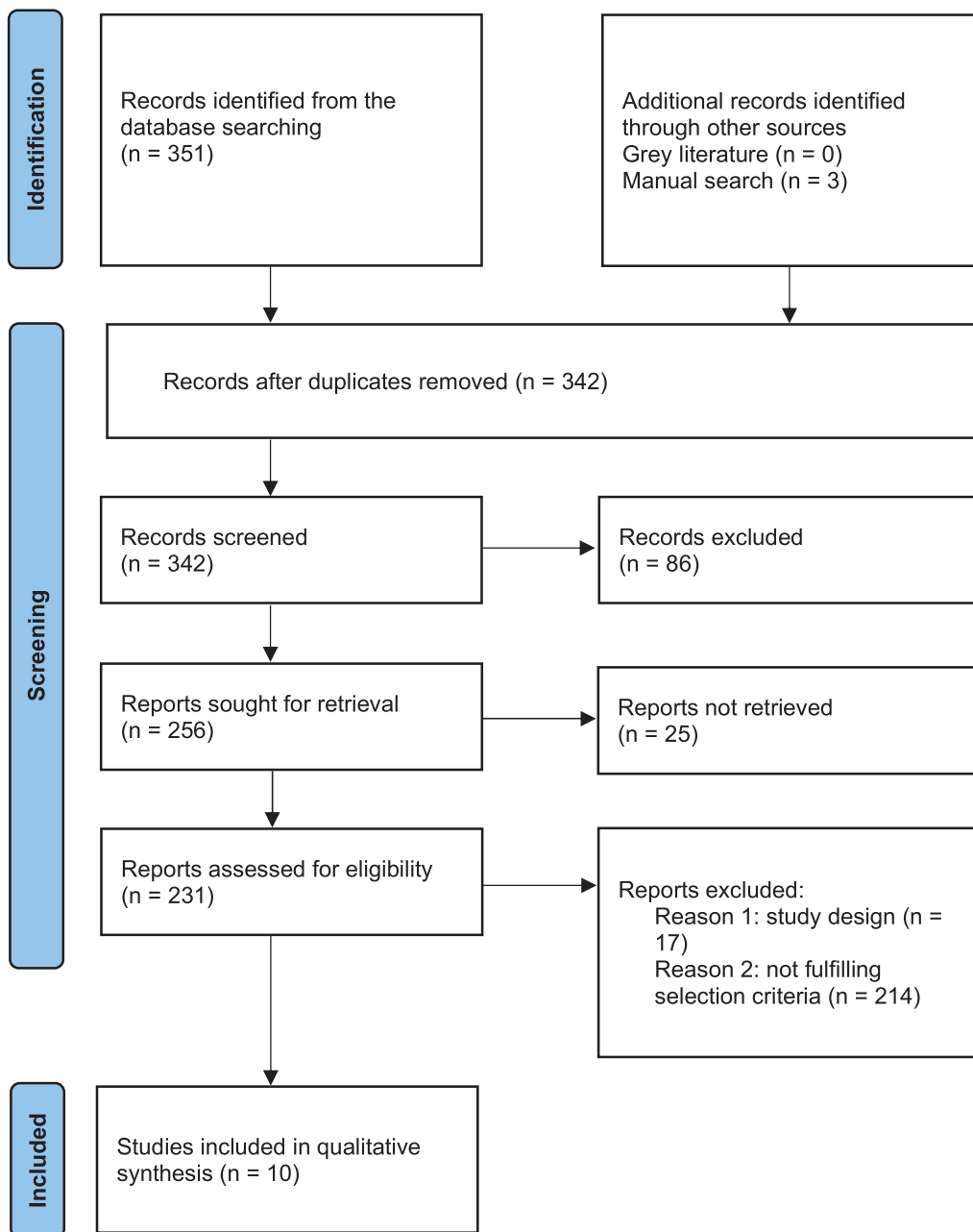
study (28) compared manipulation plus exercise (piriformis and iliopsoas stretching and reverse Kegal exercise) and exercise alone using the VAS, ODI, and PQ in patients with chronic coccydynia.

Stretching/massage [two studies (26,27)]: These studies targeted different muscle groups. One pilot study (26) compared levator anus stretch, levator anus and coccygeus massage, and sacrococcygeal mobilization using the VAS in patients with chronic coccydynia. The other study (27) compared piriformis and iliopsoas stretching, piriformis and iliopsoas stretching plus Maitland's rhythmic oscillatory thoracic mobilization, and conventional therapy (seat cushioning, sitz bath, and phonophoresis) using VAS and PFSD in patients with a clinical diagnosis of coccydynia.

Kinesiotaping [one study (21)]: This study compared combined kinesiotaping plus exercise and exercise alone using VAS, MMST, and ODI in patients with obesity-induced coccydynia.

Extracorporeal shock wave therapy [two studies (24,35)]: One study (35) compared the radial ESWT, focused ESWT, and sham ESWT using VAS and ODI in patients with coccydynia. The other study (24) compared ESWT and electrotherapy (SWD and IFT) using VAS, ODI, and self-reported satisfaction scores in patients with a first-time diagnosis of coccydynia.

Primal reflex release technique [one study (22)]: This study compared PRRT with piriformis and iliopsoas stretching using NPRS, DPQ, and PFSD in patients with a clinical diagnosis of coccydynia.

TABLE 1 - Characteristics of the included studies (*n* = 10)

Author & Year	Setting (country)	Design	Participants	Intervention	Comparator	Outcomes
Maigne and Chatellier. (2001) (26)	Hospital (France)	Pilot RCT	*N* = 74 Patients with chronic coccydynia (> 2 months) Mean age = 45.2 ± 14.8 years	Levator anus stretching (n = 25) Levator anus massage (n = 24) Duration = 3 min, 3 sessions for 10 days	Mobilization of coccyx (n = 25) Duration = 3 min, 3 sessions for 10 days	VAS assessed at baseline, 7 days, 30 days, 6 months, and at 2 years
Maigne et al. (2006) (25)	Hospital (France)	RCT	*N* = 102 Patients with chronic coccydynia (> 2 months) Mean age = 45.2 ± 11.5 years	Intrarectal manipulation (n = 51) Duration = 5 min, 3 sessions for 10 days	SWD (n = 51) Applied at the sacrum, 3 sessions for 10 days	VAS, (modified) MPQ, PQ, and (modified) DPQ at baseline, 1 month, and at 6 months follow-up
Khatri et al. (2011) (23)	Hospital (India)	RCT	*N* = 36 Patient with chronic coccydynia (> 2 months) Mean age = 31.0 ± 8.87 years	Coccygeal manipulation + phonophoresis (1MHz × 1 W/cm^2 × 8 min) + TENS (20–30 min) + coccygeal pillow advice, for 10 days	Phonophoresis (1MHz × 1 W/cm^2 × 8 min) + TENS (20–30 min) + coccygeal pillow advice), for 10 days	VAS, and PFSD at baseline and after 10 successive days
Lin et al. (2015) (24)	Hospital (Taiwan)	RCT	*N* = 41 Patients with a first-time diagnosis of coccydynia Mean age = 44.7 ± 14.8 years	ESWT, 2000 shots in the coccyx area per session for 4 sessions (5 Hz,3-4 bars) (n = 20) One session per week for 4 weeks	SWD combined with IFT for 20 min each thrice a week for 4 weeks	VAS, ODI, and Self-satisfaction score at baseline, 5th week, and 2 months
Mohanty et al. (2017) (27)	Hospital (India)	RCT	*N* = 48 Patients with a clinical diagnosis of coccydynia Mean age = not reported	Piriformis and iliopsoas stretching (n = 16) Piriformis and iliopsoas stretching plus Maitland thoracic mobilization (n = 16) Duration = 3 weeks	Conventional therapy (seat cushioning + Sitz bath + phonophorosis) (n = 16) Duration = 3 weeks	PPT using a modified syringe algometer and PFSD at baseline, after 3 weeks and 1 month follow-up
Abdel-Aal et al. (2020) (21)	Hospital (Egypt)	RCT	*N* = 60 Patients with obesity-induced coccydynia Age range = 45–60 years, with BMI > 32 kg/m^2	Kinesiotaping + exercise (n = 30) Duration = 3 weeks	Sham kinesiotaping + exercise (n = 30) Duration = 3 weeks	VAS, MMST, and ODI assessed at baseline, 3 weeks, and 1 month follow-up
Seemal et al. (2022) (22)	Hospital (Pakistan)	RCT	*N* = 46 Patients with a clinical diagnosis of coccydynia Mean age = 33.5 ± 11.3 years	PPRT + hot pack (n = 23) Duration = 12 sessions for 4 weeks	Piriformis stretching with hot pack (n = 23) Duration = 12 sessions for 4 weeks	NPRS, DPQ, and PFSD assessed at baseline and 1 month post-intervention
Zia et al. (2023) (29)	Hospital (Pakistan)	RCT	*N* = 50 Females with coccydynia Age range = 18–40 years Mean BMI Group 1 = 25.7 ± 2.34 kg/m^2, Group 2 = 26.2 ± 2.36 kg/m^2	MET to piriformis and iliopsoas (n = 25) Duration = 10 sessions (5 days/week)	Static stretching of piriformis and iliopsoas (n = 25) Duration = 10 sessions (5 days/week)	NPRS, (modified) DPQ, and PFSD at baseline and 2 weeks

(*Cont.*)

TABLE 1 - (*Cont.*)

Author & Year	Setting (country)	Design	Participants	Intervention	Comparator	Outcomes
Şah et al. (2023) (35)	Hospital (Turkey)	RCT	*N* = 60 Patients with coccydynia (1–3 months) Subacute cases Age range = 18–65 years Mean BMI = 26.2 ± 3.0 kg/m^2	Radial ESWT (8Hz, 1.6 bar pressure, 0.02-0.60 mJ/mm2 energy) (n = 20) Duration = 3 min 8 sec/session, 1 session/week for 4 weeks, along with oral painkiller	Focused ESWT (8Hz, 1.8 bar pressure, 0.02-0.60 mJ/mm2 energy) (n = 20) Sham ESWT (1Hz, 1 bar pressure, no energy) Duration = 3 min 8 sec/session, 1 session/week for 4 weeks, along with oral painkiller	VAS, and ODI at baseline, 1 month, 2 months and 4 months
Tufekci et al. (2024) (28)	Hospital (Turkey)	RCT	*N* = 46 Patients with chronic coccydynia (> 3 months) Mean age = 41.0 ± 7.47 years	Intrarectal manipulation of coccyx once a week for 4 weeks, + exercise (piriformis and iliopsoas stretching, + reverse Kegel exercise) (n = 23) 3 days/ week for 4 weeks	Exercise alone (as used for the intervention group) 3 days/week for 4 weeks (n = 23)	VAS, ODI, and PQ at 1 month and 6 months follow-up

ADL, Activities of daily living; BMI, Body mass index; DPQ, Dallas Pain Questionnaire; ESWT, Extracorporeal shock wave therapy; IFT, Interferential therapy; MET, Muscle energy technique; MMST, Modified-Modified Schober Test; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PFSD, Pain-free sitting duration; PPT, pain pressure threshold; PRRT, Primal reflex release technique; PQ, Paris (functional coccydynia impact) Questionnaire; RCT, randomized controlled trial; SWD, Short wave diathermy; TENS, Transcutaneous electrical nerve stimulation; VAS, Visual Analog Scale; *N* = study sample size.

Muscle energy technique [one study (29)]: This study compared MET and static piriformis and iliopsoas stretching using NPRS, (modified) DPQ, and PFSD in females with coccydynia.

Two studies reported no adverse events associated with treatments (21,25).

Risk of bias within studies

The risk of bias assessment for each outcome in the included studies is shown in Table 3. Of the ten studies, four (50%) were rated as having a low risk of bias (21,24,26,28), four (40%) were rated as having a high risk of bias (22,23,25,27), and one (10%) was rated as having some concerns (21) for all the evaluated outcomes. A high risk of bias was predominantly observed in the domains related to bias in the measurement of outcome due to either unblinding of the outcome of assessors or inappropriate measurement of the outcome. Some concerns were observed in the domains related to bias arising from deviations in the intended intervention since the therapists delivering intervention knew the participants' treatment group and blinding participants was impossible due to the nature of the intervention. Additionally, the lack of detailed information about the randomization process resulted in some concerns in the domain related to bias in the randomization process. No domain was entirely free of a high risk of bias or some concerns. Notably,

the outcome of PFSD was associated with a high risk of bias across all the included studies (Table 3).

Synthesis of results

Manipulation versus electrotherapy or exercise

Three studies (23,25,28) reported intrarectal manipulation to be effective at reducing pain and improving function in the short term (Table 4). One (23) of the studies reported significant improvements in pain [MD in VAS = 3.90, 95% CI 2.93-4.86) and function (MD in PFSD = 24.0, 95% CI 17.6-30.3] in favor of manipulation plus electrotherapy (phonophoresis and TENS) compared to the same electrotherapy at 10 days post-intervention. However, this study had a high risk of bias for all evaluated outcomes and lacked follow-up (23). Similarly, the second study (25) reported significant reduction in pain (MD in VAS = −14.5, 95% CI −24.2 to −4.70; MD in (modified) MPQ = −6.5, 95% CI −11.1 to −1.85) and improvement in function (MD in (modified) DPQ = −10.5, 95% CI −18.2 to −2.71; MD in PQ = −20.0, 95% CI −29.3 to −10.6) favoring manipulation over electrotherapy at 1-month post-intervention. Additionally, the manipulation group demonstrated better outcomes twice (22%) as often as the electrotherapy group (12%) at 6 months follow-up. This study (25), however, had a high risk of bias for all evaluated outcomes and incomplete data for the 6 months follow-up, limiting the ability to compute the

TABLE 2 - Summary of outcomes and interventions (*n* = 10)

Interventions	Study	Outcomes			
		Pain	Function	Mobility	Satisfaction
Intra-rectal manipulation	Tufekci et al. (2024) (28)	VAS	ODI, PQ		
	Maigne et al. (2006) (25)	VAS, (modified) MPQ	(modified) DPQ, PQ		
	Khatri et al. (2011) (23)	VAS	PFSD		
Piriformis and iliopsoas stretching, Piriformis and iliopsoas stretching plus thoracic mobilization	Mohanty et al. (2017) (27)	PPT	PFSD		
Levator anus massage, Levator anus stretching		VAS			
Extracorporeal shock wave therapy	Maigne and Chatellier. (2001) (26)	VAS	ODI		
	Şah et al. (2023) (35)	VAS	ODI		
Kinesiotaping plus exercise	Lin et al. (2015) (24)	VAS	ODI		Self-satisfaction score
Muscle energy technique	Abdel-Aal et al. (2020) (21)	NPRS	(modified) DPQ PFSD	MMST	
Primal reflex release technique	Zia et al. (2023) (29)	NPRS	(modified) DPQ PFSD		

DPQ, Dallas Pain Questionnaire; MMST, Modified-Modified Schober Test; MPQ, McGill Pain Questionnaire; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PFSD, Pain-free sitting duration; PPT, Pain pressure threshold; PQ, Paris (functional coccydynia impact) Questionnaire; VAS, Visual Analog Scale

magnitude of the treatment effect. The third study (28) had a low risk of bias for all evaluated outcomes and reported a significant reduction in pain (MD in VAS = −13.4, 95% CI −20.3 to −6.58) and improvement in function (MD in ODI = −7.65, 95% CI −11.5 to −3.72 and MD in PQ = −12.6, 95% CI −19.6 to −5.57) favoring manipulation plus exercise compared to exercise alone at 1-month post-intervention. However, no therapeutic superiority was observed at the 6-month follow-up in any of the outcomes, although sustained benefits were observed more in the manipulation plus exercise group.

Levator anus stretching versus levator anus massage versus joint mobilization

One pilot RCT (26) with a low risk of bias reported a 25.7% success rate in pain reduction at 6 months, similar to the rate observed at 7 days, and a 24.3% success rate at 2 years follow-up for both levator anus stretching and levator anus and coccygeus massage. Although outcomes varied depending on the cause of coccydynia, both stretching and massage had similar and better results than mobilization after 7 days, at 6 months, and 2 years follow-up (Table 4). However, this study (26) had incomplete data to estimate the magnitude of treatment effects in terms of MD and 95% CI.

Piriformis and iliopsoas stretching with or without mobilization versus conventional therapy

One study (27) reported piriformis and iliopsoas stretching alone or combined with mobilization to be more effective

than conventional therapy at reducing pain and improving function at 3 weeks post-intervention and 1-month follow-up (*p* < 0.001) (Table 4). Adding mobilization to stretching did not provide any additional benefit over stretching alone. However, the study had a high risk of bias for all evaluated outcomes and incomplete data, making it impossible to estimate the magnitude of the treatment effects.

Extracorporeal shock wave therapy (ESWT) versus sham versus electrotherapy

Two studies (24, 35) with a low risk of bias for all evaluated outcomes determined the effect of ESWT (Table 4). In one (35) of the studies, both focused and radial ESWT significantly reduced pain and improved function at 2 and 4 months compared to baseline. However, no significant difference in pain reduction was found between the two ESWT types, although focused ESWT showed a slight advantage over radial ESWT. For functional improvement, radial ESWT was superior to focused ESWT (MD = −11.2, 95% CI −21.3 to −2.33) and sham (MD = −18.0, 95% CI −28.0 to −7.92) at the 4-month follow-up only (35). The other study (24) reported a significant reduction in pain favoring ESWT over electrotherapy at 5th-week post-intervention (MD = −12.7, 95% CI −24.5 to −0.85) and 2 months follow-up (MD = −18.5, 95% CI −31.6 to −5.37). However, there was no significant difference in functional improvement between the groups. Additionally, 70% of patients in the ESWT group reported good to excellent satisfaction, which was higher than the satisfaction rate in the electrotherapy group (Table 4).

TABLE 3 - Risk of bias assessments using RoB 2.0 for the included studies (*n* = 10)

Study (Author & Year)	Outcome	D1: Bias in randomization	D2: Bias from deviations	D3: Bias from missing data	D4: Bias in measurement	D5: Bias in reporting	Overall judgment
Maigne & Chatellier (2001) (26)	Pain (VAS)	Low	Low	Low	Low	Low	Low
Maigne et al. (2006) (25)	Pain (VAS)	Low	Some concerns	Low	High	Low	High
Maigne et al. (2006) (25)	Pain (modified MPQ)	Low	Some concerns	Low	High	Low	High
Maigne et al. (2006) (25)	Function (modified DPQ)	Low	Some concerns	Low	High	Low	High
Maigne et al. (2006) (25)	Function (PQ)	Low	Some concerns	Low	High	Low	High
Khatri et al. (2011) (23)	Pain (VAS)	Some concerns	Some concerns	High	High	Low	High
Khatri et al. (2011) (23)	Function (PFSD)	Some concerns	Some concerns	High	High	Low	High
Lin et al. (2015) (24)	Pain (VAS)	Low	Low	Low	Low	Low	Low
Lin et al. (2015) (24)	Function (ODI)	Low	Low	Low	Low	Low	Low
Lin et al. (2015) (24)	Self-satisfaction score	Low	Low	Low	Low	Low	Low
Mohanty et al. (2017) (27)	Pain (PPT)	Some concerns	Some concerns	Low	Low	Some concerns	High
Mohanty et al. (2017) (27)	Function (PFSD)	Some concerns	Some concerns	Low	High	Low	High
Abdel-Aal et al. (2020) (21)	Pain (VAS)	Low	Low	Low	Low	Low	Low
Abdel-Aal et al. (2020) (21)	Function (ODI)	Low	Low	Low	Low	Low	Low
Abdel-Aal et al. (2020) (21)	Mobility (MMST)	Low	Low	Low	Low	Low	Low
Seemal et al. (2022) (22)	Pain (NPRS)	Low	Low	Low	High	Low	High
Seemal et al. (2022) (22)	Function (modified DPQ)	Low	Low	Low	High	Low	High
Seemal et al. (2022) (22)	Function (PFSD)	Low	Low	Low	High	Low	High
Zia et al. (2023) (29)	Pain (NPRS)	Low	Low	Low	Low	Low	Low
Zia et al. (2023) (29)	Function (modified DPQ)	Low	Low	Low	Low	Low	Low
Zia et al. (2023) (29)	Function (PFSD)	Low	Low	Low	High	Low	High
Şah et al. (2023) (35)	Pain (VAS)	Some concerns	Low	Low	Low	Low	Some concerns
Şah et al. (2023) (35)	Function (ODI)	Some concerns	Low	Low	Low	Low	Some concerns
Tufekci et al. (2024) (28)	Pain (VAS)	Low	Low	Low	Low	Low	Low

Study (Author & Year)	Outcome	D1: Bias in randomization	D2: Bias from deviations	D3: Bias from missing data	D4: Bias in measurement	D5: Bias in reporting	Overall judgment
Tufekci et al. (2024) (28)	Function (ODI)	Low	Low	Low	Low	Low	Low
Tufekci et al. (2024) (28)	Function (PQ)	Low	Low	Low	Low	Low	Low

Abbreviations /Notes
D1 (Bias in randomization): Concerns about random sequence generation or allocation concealment.
D2 (Bias from deviations): Whether participants and personnel were blinded (when feasible) and whether interventions were delivered as intended.
D3 (Bias from missing data): How missing outcome data (dropouts, attrition) were handled.
D4 (Bias in measurement): Whether outcome assessment could be influenced by knowledge of the assigned intervention.
D5 (Bias in reporting): Whether all pre-specified outcomes and time points were reported or if selective reporting is suspected.
Dallas Pain Questionnaire; MMST, Modified-Modified Schober Test; MPQ, McGill Pain Questionnaire; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PFSD, Pain-free sitting duration; PPT, Pain pressure threshold; PQ, Paris (functional coccydynia impact) Questionnaire; VAS, Visual Analog Scale

Kinesiotaping plus exercise versus exercise

One study (21) with some concerns related to the risk of bias in all evaluated outcomes reported kinesiotaping plus exercise to be more effective than exercise alone for improving pain (MD = −6.83, 95% CI −8.99 to −4.66 at 3 weeks; MD = −8.70, 95% CI −10.6 to −6.71 at 1 month), reducing disability (MD = −5.70, 95% CI −6.92 to −4.47 at 3 weeks; MD = −5.80, 95% CI −6.76 to −4.83 at 1 month), and increasing trunk flexion (MD = 0.80, 95% CI 0.23 to 1.36 at 3 weeks; MD = 0.53, 95% CI 0.18 to 0.87 at 1 month) (Table 4). However, the specific contribution of kinesiotaping alone could not be isolated, as it was only evaluated in combination with exercise.

Muscle energy technique (MET) versus stretching

One study (29), which had a low risk of bias overall but a high risk of bias for the PSFD outcome, reported MET to be superior to static stretching for improving pain (MD = −2.04, 95% CI −3.19 to −1.60) and function (MD in (modified) DPQ = −2.04, 95% CI −3.66 to −0.4; MD in PFSD = 37.4, 95% CI 19.4 to 55.3) at 2 weeks post-intervention (Table 4).

Primal reflex release technique (PRRT) versus stretching

One study (22) with a high risk of bias reported PRRT to be superior to stretching for improving pain (MD = −1.95, 95% CI −2.71 to −1.20) and function (MD in (modified) DPQ= −22.6, 95% CI −36.7 to −8.41; MD in PFSD = 274.3, 95% CI 196.6-352.0) at 1-month post-intervention (Table 4).

Discussion

Main findings and interpretation of the results

Pain medication and physical therapy are typically regarded as first-line treatments for musculoskeletal disorders. This review evaluated the effectiveness of physical therapy approaches for adults with coccydynia, which could contribute to the development of clinical guidelines for coccydynia. However, less than half of the studies in this review had a low risk of bias in all evaluated outcomes, suggesting that the overall findings should be interpreted cautiously. Reliable conclusions can only be drawn from studies free of bias.

Ten RCTs were included, evaluating the effects of various interventions (i.e., manipulation, stretching, massage, ESWT, kinesiotaping, MET, and PRRT) on pain and function (21–29,35), mobility (21), and patient satisfaction (24). Most interventions were passive, with a few studies combining them with other treatments such as kinesiotaping plus exercise (21) and manipulation plus electrotherapy (23) or exercise (28). Notably, no study explored active exercise as a standalone intervention, likely because manual treatments target the underlying misalignment or restricted movement in the sacrococcygeal joint, which is believed to be the primary perpetrator of pain.

Despite slight variations in the outcomes evaluated, current evidence suggests that, in the short term (up to 3 months post-intervention), physical therapy interventions including ESWT, kinesiotaping plus exercise, levator anus stretching or massage, manipulation alone or manipulation plus exercise or electrotherapy, and MET are effective at reducing pain and improving function (based on seven studies (21,24-26,28,29,35). Additionally, kinesiotaping plus exercise is effective at improving trunk mobility [based on one study (21)], whereas ESWT led to greater treatment satisfaction [based on one study (24)]. In the intermediate term (up to 6 months), manipulation alone and levator anus stretching or massage are effective at reducing pain [based on two studies (25,26)], whereas manipulation alone is effective at improving function [based on one trial (25)]. Only one study reported long-term (up to 2 years) pain reduction, which was associated with levator anus stretching or massage (26). No study evaluated the long-term effect of physical therapy intervention on function or trunk mobility.

Manipulation

Manipulation alone (25), or combined with electrotherapy (23) or exercise (28), was effective in alleviating pain in the short term (23,25,28) and the intermediate term (25). This approach may provide immediate relief by addressing anatomical anomalies such as misaligned coccyx reducing tension in the pelvic floor muscles. The addition of electrotherapy or exercise is believed to provide a positive reinforcement effect. Although one study (25) reported sustained benefits of manipulation for up to 6 months, significant methodological concerns in this study undermine the

TABLE 4 - Main findings of the included studies (*n* =10)

Author & Year	Main findings (authors' synthesis)
Maigne and Chatellier. (2001) (26)	The success rate for manual treatments, defined as the reduction in pain from baseline, was 25.7% at 6 months, consistent with the 7-day results, and remained at 25.7% after 2 years. Outcomes varied based on the underlying cause of coccydynia, with massage and stretching demonstrating greater effects than mobilization. Additionally, individuals with normal coccyx mobility experienced better results, achieving a success rate of 43.8%, compared to those with luxation, hypermobility, or immobile coccyx.
Maigne et al. (2006) (25)	Compared to electrotherapy, manipulation led to significant improvements in VAS (MD = −14.5, 95% CI −24.2 to −4.70; *p* = 0.004), (modified) MPQ (MD = −6.5, 95% CI −11.1 to −1.85; *p* = 0.007), (modified) DPQ (MD = −10.5, 95% CI −18.2 to −2.71; *p* = 0.009), and PQ (MD = −20.0, 95% CI −29.3 to −10.6; *p* = 0.001) at 1-month post-intervention. At 6 months, the manipulation group demonstrated 11 good outcomes (22% of patients), with ≥ 60% improvement in the individual global score compared to ≥ 50% at 1 month. In contrast, the control group showed six good outcomes (12% of patients).
Khatri et al. (2011) (23)	Compared to electrotherapy (phonophoresis and TENS), manipulation significantly reduced VAS (MD = 3.90 95% CI 2.93 to 4.86; *p* = 0.0001) and improved PSFD (MD = 24.0, 95% CI 17.6 to 30.3; *p* = 0.0002) 10 days post-intervention.
Lin et al. (2015) (24)	ESWT led to a significant reduction in VAS compared to electrotherapy (SWD plus IFT) at 5th-week post-intervention (MD = −12.7, 95% CI −24.5 to −0.85; *p* = 0.042) and 2 months follow-up (MD = −18.5, 95% CI −31.6 to −5.37; *p* = 0.009). Approximately 70% of patients receiving ESWT reported good to excellent treatment satisfaction, which was significantly higher than those receiving electrotherapy (*p* = 0.003). No statistically significant difference in ODI between the groups at any time point (*p* > 0.05).
Mohanty et al. (2017) (27)	Piriformis and iliopsoas stretching, either alone or combined with mobilization, resulted in greater improvements in VAS and PFSD compared to conventional therapy at 3 weeks post-intervention and 1-month follow-up (*p* < 0.001).
Abdel-Aal et al. (2020) (21)	Compared to exercise alone, kinesiotaping plus exercise resulted in significantly greater improvements in VAS (MD = −6.83, 95% CI −8.99 to −4.66; *p* < 0.001 at 3 weeks post-intervention; MD = −8.70, 95% CI −10.6 to −6.71; *p* < 0.001 at 1-month follow-up), ODI (MD = −5.70, 95% CI −6.92 to −4.47; *p* < 0.001 at 3 weeks post-intervention; MD = −5.80, 95% CI −6.76 to −4.83; *p* < 0.001 at 1-month follow-up), and MMST (MD = 0.80, 95% CI 0.23 to 1.36; *p* < 0.001 at 3 weeks post-intervention; MD = 0.53, 95% CI 0.18 to 0.87; *p* < 0.001 at 1-month follow-up).
Seemal et al. (2022) (22)	Compared with stretching, PRRT resulted in significantly greater improvements in NPRS (MD = −1.95, 95% CI −2.71 to −1.20; *p* < 0.001), DPQ (MD = −22.6, 95% CI −36.7 to −8.41; *p* = 0.003), and PFSD (MD = 274.3, 95% CI 196.6 to 352.0; *p* < 0001) at 1-month post-intervention.
Zia et al. (2023) (29)	Compared to static stretching, MET resulted in significantly greater improvements in NPRS (MD = −2.40, 95% CI −3.19 to −1.60; *p* < 0.001), DPQ (MD = −2.04, 95% CI −3.66 to −0.41; *p* = 0.017), and PFSD (MD = 37.4, 95% CI 19.4 to 55.3; *p* < 0.001) at 2 weeks post-intervention.
Şah et al. (2023) (35)	Radial ESWT showed significant reductions in VAS scores 1-month post-intervention compared to baseline. Both focused and radial ESWT significantly reduced VAS and ODI scores at 2 and 4 months. For the between-group difference in VAS, focused ESWT was superior to sham at 1 month (MD = 1.50, 95% CI 0.40 to 2.59; *p* = 0.017) and 4 months (MD = −1.50, 95% CI −2.73 to −0.26; *p* = 0.022) but comparable to radial ESWT (*p* > 0.05). Radial ESWT was superior to sham (MD = −1.40, 95% CI −2.45 to −0.34; *p* = 0.013) at 2 months only. For the between-group difference in ODI, radial ESWT was superior to focused ESWT (MD = −11.2, 95% CI −21.3 to −2.33; *p* = 0.020) and sham (MD = −18.0, 95% CI −28.0 to −7.92; *p* = 0012) at 4 months follow-up.
Tufekci et al. (2024) (28)	Compared to exercise alone, manipulation plus exercise resulted in significantly greater improvements in VAS (MD = −13.4, 95% CI −20.3 to −6.58; *p* < 0.001), ODI (MD = −7.65, 95% CI −11.5 to −3.72; *p* < 0.001), and PQ (MD = −12.6, 95% CI −19.6 to −5.57–7.65; *p* < 0.01) at 1-month post-intervention. Though sustained effects were more pronounced in the manipulation plus exercise group at 6 months follow-up, there was no significant difference between the two interventions (*p* > 0.05).

CI, confidence interval; DPQ, Dallas Pain Questionnaire; ESWT, Extracorporeal shock wave therapy; IFT, Interferential therapy; MD, mean difference; MET, Muscle energy technique; MMST, Modified-Modified Schober Test; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PFSD, Pain-free sitting duration; PRRT, Primal reflex release technique; PQ, Paris (functional coccydynia impact) Questionnaire; SWD, short wave diathermy; TENS, Transcutaneous electrical nerve stimulation; VAS, Visual Analog Scale

reliability of its conclusions. Moreover, the effects of manipulation as a standalone could not be substantiated in the studies using electrotherapy (23) or exercise (28) as an adjunct, though a combination approach is often recommended (39). Despite promising results, the sustainability of these benefits remains uncertain due to the lack of long-term follow-up (23,28). Therefore, while combining intrarectal manipulation and exercise (28) seems to be a valuable option compared to combining with electrotherapy (23), clinicians should remain cautious and consider incorporating follow-up assessments

to evaluate sustained benefits. Moreover, given that the application of transrectal manual techniques is feasible and acceptable in the Western population (40), further evaluation is warranted across diverse cultural settings. The technique involves digital rectal evaluation before and after the intervention to palpate the coccyx. As such, patient preferences, such as therapist gender, need to be considered.

Stretching and massage

Compared to joint mobilization, levator anus stretching or massage therapies were effective in alleviating pain both in the short and long term (26). Similarly, the superiority of piriformis and iliopsoas stretching with or without mobilization over conventional therapy was demonstrated for both pain and function in the short term (27). These therapies likely work by enhancing blood flow, reducing muscle tension, and increasing flexibility (41, 42). The demonstrated effects of levator stretching or massage across various follow-up points (7 days, 6 months, and 2 years) suggest that these interventions may offer both immediate and sustained benefits. However, the high risk of bias in the study demonstrating the efficacy of piriformis and iliopsoas stretching (27), coupled with the limited number of studies evaluating stretching as a treatment for coccydynia, highlights the need for more robust trials to elucidate these findings.

Kinesiotaping

Although kinesiotaping showed short-term improvements in pain, function, and trunk mobility (21) among obese with coccydynia, the effects could have also been attributed to exercise used as an adjunct. However, this dual approach likely offers synergistic benefits as kinesiotaping might provide support and reduce strain (43), while exercise helps strengthen muscles and improve function. This finding supports the integration of multimodal strategies in the management of coccydynia. Additionally, no side effects were reported in association with kinesiotaping (21), confirming its safety. As kinesiotaping application over the coccyx could facilitate bacterial invasion in the skin and lead to cellulitis, regular monitoring is mandatory (43). The lack of long-term follow-up and limited studies make it challenging to draw definitive conclusions about the sustainability effect of kinesiotaping as well as its efficacy as a standalone treatment for coccydynia.

Extracorporeal shock wave therapy (ESWT)

ESWT proved to be effective for alleviating pain and improving function, particularly in the short term (24, 35). Its therapeutic mechanism may include neovascularization (44), reduced substance P-immunoreactive neurons (45), and decreased levels of inflammatory mediators (46). High patient satisfaction levels further support its use (24). However, the type of ESWT may influence outcomes, with radial ESWT showing superior improvement in function compared to focused ESWT (35). Thus, tailoring the type of ESWT to individual patient needs could lead to better clinical outcomes. However, the lack of long-term follow-up data in

existing studies limits understanding of its sustained effects, which is an obvious research gap for future studies.

Muscle energy technique (MET)

The findings that MET was better for pain and function over static stretching in the short term (29) suggest MET as one of the promising hands-on approaches for coccydynia. This technique involves active patient participation through isometric contraction and relaxation, which may stimulate joint proprioceptors, alter motor programming, and promote hypoalgesia (47). Moreover, increased mobility and function may be related to mechanisms promoting hypoalgesia, an increase in stretch tolerance, and possibly viscoelastic change in the muscle (47, 48). However, the limited number of studies calls for further research to confirm these benefits and establish standardized protocols for MET application in coccydynia.

Primal reflex release technique (PRRT)

Compared to piriformis stretching, PRRT shows superior effects in reducing pain and improving function in the short term (22). PRRT induces reciprocal inhibition between agonist and antagonist muscles, leading to a complementary suppression of the autonomic nervous system. This reduces reflexive muscle tone through the release of acetylcholine and serotonin, which contributes to pain reduction. This process may also positively impact the patient's psychological state. Nonetheless, the methodological weakness in the study examining PRRT (22) and the lack of adequate relevant trials require a cautious interpretation of the results. Further research with adequate follow-up is essential to support the efficacy of PRRT for coccydynia.

Limitations

Regarding the limitations of the included studies, there is a lack of adequate trials evaluating physical therapy interventions, particularly active treatments, for coccydynia. Many studies lacked true control groups, long-term outcome evaluation, and sufficient sample sizes. Although some studies were methodologically sound, many had critical issues in areas such as randomization, blinding of outcome assessors, and inappropriate outcome measurements, raising concerns about the validity of their results. Additionally, three studies (25–27) had incomplete data, which could not be retrieved.

With respect to the limitations of this review, first, a meta-analysis was not conducted due to substantial heterogeneity in the interventions employed by the included studies. Second, the small number of studies on various physical therapy interventions limits the robustness and generalizability of the conclusions. Lastly, the inclusion of only English-language published studies may have excluded other relevant research that could have contributed to the findings.

Recommendation for future research

Future high-quality RCTs with adequate sample size and long-term follow-up are needed to evaluate the effectiveness

of different physical therapy interventions either in isolation or combination to enable the pooling of data using a formal analysis like meta-analysis. Placebo-controlled trials are also crucial to establish treatment efficacy while minimizing bias and isolating the true impact of interventions. Key methodological areas, including randomization, blinding, and measurement of outcomes, should be addressed in future studies to ensure accurate quantification of effects and reliable evidence. Furthermore, studies should standardize intervention protocols, include cost-effectiveness analyses, and improve overall methodological reporting.

Conclusions

Based on the findings from the included studies, physical therapy interventions, including ESWT, kinesiotaping, manipulation, massage, MET, and stretching, show promise in improving pain and function in adults with coccydynia in the short term. However, the long-term effects of these interventions remain unclear. Further, high-quality RCTs are needed to compare the efficacy of various physical therapy interventions, both in isolation and in combination.

List of abbreviations

ADL: Activities of daily living; BMI: Body mass index; DPQ: Dallas Pain Questionnaire; ESWT, Extracorporeal shock wave therapy; IFT: Interferential therapy; MET: Muscle energy technique; MMST: Modified-Modified Schober Test; NPRS: Numeric Pain Rating Scale; ODI: Oswestry Disability Index; PFSD: Pain-free sitting duration; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; PRRT: Primal reflex release technique; PQ: Paris (functional coccydynia impact) Questionnaire; RCT: Randomized controlled trial; SWD: Short wave diathermy; TENS: Transcutaneous electrical nerve stimulation; VAS, Visual Analog Scale

Disclosures

Ethical approval and consent to participate: Not applicable, as this study is a review and does not involve human participants.

Consent for publication: Not applicable. No identifying images or other personal or clinical details of participants are presented here.

Data availability statement: All data generated and/or analyzed during this study are available from the corresponding author upon reasonable request.

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References

1. Fogel GR, Cunningham PY III, Esses SI. Coccygodynia: evaluation and management. J Am Acad Orthop Surg. 2004;12(1):49-54. PubMed

2. Nathan ST, Fisher BE, Roberts CS. Coccydynia: a review of pathoanatomy, aetiology, treatment and outcome. J Bone Joint Surg Br. 2010;92(12):1622-1627. PubMed

3. Lirette LS, Chaiban G, Tolba R, et al. Coccydynia: an overview of the anatomy, etiology, and treatment of coccyx pain. Ochsner J. 2014;14(1):84-87. PubMed

4. Gavriilidis P, Kyriakou D. Sacrococcygeal chordoma, a rare cause of coccygodynia. Am J Case Rep. 2013;14:548-550. PubMed

5. Kim HS, Yang SH, Park HJ, et al. Glomus tumor as a cause of coccydynia. Skeletal Radiol. 2013;42(10):1471-1473. PubMed

6. Maigne JY, Guedj S, Straus C. Idiopathic coccygodynia. Lateral roentgenograms in the sitting position and coccygeal discography. Spine. 1994;19(8):930-934. PubMed

7. Maigne JY, Pigeau I, Aguer N, et al. Chronic coccydynia in adolescents. A series of 53 patients. Eur J Phys Rehabil Med. 2011;47(2):245-251. PubMed

8. Pennekamp PH, Kraft CN, Stütz A, et al. Coccygectomy for coccygodynia: does pathogenesis matter? J Trauma. 2005;59(6):1414-1419. PubMed

9. Richette P, Maigne JY, Bardin T. Coccydynia related to calcium crystal deposition. Spine. 2008;33(17):E620-E623. PubMed

10. Garg B, Ahuja K. Coccydynia – A comprehensive review on etiology, radiological features and management options. J Clin Orthop Trauma. 2021;12(1):123-129. PubMed

11. Postacchini F, Massobrio M. Idiopathic coccygodynia. Analysis of fifty-one operative cases and a radiographic study of the normal coccyx. J Bone Joint Surg Am. 1983;65(8):1116-1124. PubMed

12. Antoniadis A, Ulrich NHB, Senyurt H. Coccygectomy as a surgical option in the treatment of chronic traumatic coccygodynia: a single-center experience and literature review. Asian Spine J. 2014;8(6):705-710. PubMed

13. El Mohsen Arafa A, El Rady Mahmoud A, Zayan M, et al. Coccygectomy for posttraumatic coccygodynia: A long-term prospective study. Curr Orthop Pract. 2017;28(5):484-488. CrossRef

14. Haddad B, Prasad V, Khan W, et al. Favourable outcomes of coccygectomy for refractory coccygodynia. Ann R Coll Surg Engl. 2014;96(2):136-139. PubMed

15. Hanley EN, Ode G, Jackson Iii BJ, et al. Coccygectomy for patients with chronic coccydynia: a prospective, observational study of 98 patients. Bone Joint J. 2016;98-B(4):526-533. PubMed

16. Karadimas EJ, Trypsiannis G, Giannoudis PV. Surgical treatment of coccygodynia: an analytic review of the literature. Eur Spine J. 2011;20(5):698-705. PubMed

17. Wray CC, Easom S, Hoskinson J. Coccydynia. Aetiology and treatment. J Bone Joint Surg Br. 1991;73(2):335-338. PubMed

18. Benditz A. Therapieoptionen bei der Coccygodynie. (Treatment options for coccygodynia). Orthopadie (Heidelb). 2024;53(2):100-106. PubMed

19. Shi Y, Wu W. Multimodal noninvasive non-pharmacological therapies for chronic pain: mechanisms and progress. BMC Med. 2023;21(1):372. PubMed

20. Delitto A, George SZ, Van Dillen L, et al. Orthopaedic Section of the American Physical Therapy Association. Low back pain. J Orthop Sports Phys Ther. 2012;42(4):A1-A57. PubMed

21. Abdel-Aal NM, Elgohary HM, Soliman ES, Waked IS. Effects of kinesiotaping and exercise program on patients with obesity-induced coccydynia: a randomized, double-blinded, sham-controlled clinical trial. Clin Rehabil. 2020;34(4):471-479. PubMed

22. Seemal P, Ayub A, Diilshad M, et al. Comparing primal reflex release technique and stretching exercises on pain and function in coccydynia. Iran Rehabil J. 2022;20(4):623-632. CrossRef

23. Khatri SM, Nitsure P, Jatti RS. Effectiveness of coccygeal manipulation in coccydynia: a randomized control trial. Indian J Physiother Occup Ther. 2011;5(3):110-112.

24. Lin SF, Chen YJ, Tu HP, et al. The effects of extracorporeal shock wave therapy in patients with coccydynia: a randomized controlled trial. PLoS One. 2015;10(11):e0142475. PubMed

25. Maigne JY, Chatellier G, Faou ML, et al. The treatment of chronic coccydynia with intrarectal manipulation: a randomized controlled study. Spine. 2006;31(18):E621-E627. PubMed

26. Maigne JY, Chatellier G. Comparison of three manual coccydynia treatments: a pilot study. Spine. 2001;26(20):E479-E483. PubMed

27. Mohanty PP, Pattnaik M. Effect of stretching of piriformis and iliopsoas in coccydynia. J Bodyw Mov Ther. 2017;21(3):743-746. PubMed

28. Tufekci O, Yilmaz K, Gercek H, et al. The effectiveness of manipulation in combination with exercise for patients with coccydynia: six months follow-up of a randomized controlled trial. Int J Osteopath Med. 2024;51:100711. CrossRef

29. Zia W, Bashir MS, Arshad MU, et al. Effects of muscle energy technique and static stretching of piriformis and iliopsoas in females with coccydynia. Journal of Xi'an Shiyou University. 2023;19(1):642-647. Natural Science Edition.

30. Marinko LN, Pecci M. Clinical decision making for the evaluation and management of coccydynia: 2 case reports. J Orthop Sports Phys Ther. 2014;44(8):615-621. PubMed

31. White WD, Avery M, Jonely H, et al. The interdisciplinary management of coccydynia: a narrative review. PM R. 2022;14(9):1143-1154. PubMed

32. Origo D, Tarantino AG, Nonis A, et al. Osteopathic manipulative treatment in chronic coccydynia: a case series. J Bodyw Mov Ther. 2018;22(2):261-265. PubMed

33. Haghighat S, Mashayekhi Asl M. Effects of extracorporeal shock wave therapy on pain in patients with chronic refractory coccydynia: a quasi-experimental study. Anesth Pain Med. 2016;6(4):e37428. PubMed

34. Andersen GØ, Milosevic S, Jensen MM, et al. Coccydynia-the efficacy of available treatment options: a systematic review. Global Spine J. 2022;12(7):1611-1623. PubMed

35. Şah V, Elasan S, Kaplan Ş. Comparative effects of radial and focused extracorporeal shock wave therapies in coccydynia. Turk J Phys Med Rehabil. 2023;69(1):97-104. PubMed

36. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372(71):n71. PubMed

37. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomized trials. BMJ. 2019;366:l4898. PubMed

38. Wan X, Wang W, Liu J, et al. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol. 2014;14:135. PubMed

39. Skelly AC, Chou R, Dettori JR, et al. Noninvasive nonpharmacological treatment for chronic pain: a systematic review update. Comparative effectiveness review no. 227. Agency for Healthcare Research and Quality; 2020.

40. Nourani B, Norton D, Kuchera W, et al. Transrectal osteopathic manipulation treatment for chronic coccydynia: feasibility, acceptability and patient-oriented outcomes in a quality improvement project. J Osteopath Med. 2023;124(2):77-83. PubMed

41. Weerapong P, Hume PA, Kolt GS. The mechanisms of massage and effects on performance, muscle recovery and injury prevention. Sports Med. 2005;35(3):235-256. PubMed

42. MacAuley D, Best T. Evidence-based sports medicine. 2nd ed. Blackwell Publishing; 2007.

43. Kase K, Wallis J, Kase T. Clinical therapeutic applications of the Kinesio taping ® method. 2nd ed. Kinesio Taping Association; 2003.

44. Wang CJ, Wang FS, Yang KD, et al. Shock wave therapy induces neovascularization at the tendon-bone junction. A study in rabbits. J Orthop Res. 2003;21(6):984-989. PubMed

45. Hausdorf J, Lemmens MA, Kaplan S, et al. Extracorporeal shockwave application to the distal femur of rabbits diminishes the number of neurons immunoreactive for substance P in dorsal root ganglia L5. Brain Res. 2008;1207:96-101. PubMed

46. Notarnicola A, Moretti B. The biological effects of extracorporeal shock wave therapy (eswt) on tendon tissue. Muscles Ligaments Tendons J. 2012;2(1):33-37. PubMed

47. Thomas E, Cavallaro AR, Mani D, et al. The efficacy of muscle energy techniques in symptomatic and asymptomatic subjects: a systematic review. Chiropr Man Therap. 2019;27(1):35. PubMed

48. Ballantyne F, Fryer G, McLaughlin P. The effect of muscle energy technique on hamstring extensibility: the mechanism of altered flexibility. J Osteopath Med. 2003;6(2):59-63. CrossRef