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Physiotherapeutic management of primary dysmenorrhea for adolescent students: a systematic review and meta-analysis

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Abstract

Primary dysmenorrhea (PD) affects up to 80% of adolescent girls, significantly impacting their school attendance and quality of life. This systematic review and meta-analysis evaluated the efficacy of physiotherapeutic interventions, including acupressure, massage, exercise, and transcutaneous electrical nerve stimulation (TENS), in managing PD among adolescents. Following PRISMA guidelines and utilizing the PICO framework, a comprehensive search was conducted across four electronic databases (Scopus, PubMed, Medline, and Cochrane Library) and grey literature for English-language randomized controlled trials (RCTs) published between May 2000 and May 2025. Ten RCTs involving 1,496 participants met the inclusion criteria, focusing on adolescents aged 10–19 years with PD. Pain reduction, measured using visual analogue scale (VAS) and numerical rating scale (NRS), was the primary outcome, with significant improvements observed across most interventions. A meta-analysis supported the effectiveness of these therapies, though heterogeneity in study designs and interventions was noted. The findings suggest that physiotherapy is a promising non-pharmacological approach for PD management, with potential benefits for both physical and psychological health. However, the findings should be interpreted with caution due to study heterogeneity and moderate methodological quality. Further high-quality trials are recommended to strengthen the evidence base and guide clinical practice.
Trial Registration Number: PROSPERO 2025 CRD420251074405.

Key words: primary dysmenorrhea; menstrual pain; physiotherapy; physiotherapeutic treatment; non-pharmacological treatment.

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Introduction

Dysmenorrhea, or menstrual pain, is a common gynaecological problem, affecting over 70% of young women.[1] Primary dysmenorrhea (PD), characterized by cramping lower abdominal pain without an identifiable underlying pathology, is particularly prevalent in adolescents, defined by the World Health Organization as individuals between the ages of 10 and 19.[2] Approximately 80% of girls in this developmental stage experience PD,[3] causing significant pain that can substantially interfere with their daily activities, academic pursuits, and social engagement.[4] Approximately 20% of affected students report missing school, while 40% experience impaired classroom performance and reduced participation in group activities.[1,5,6] The World Health Organization has recently emphasized the need to advance menstrual health and rights globally, highlighting the potential for targeted interventions to alleviate this burden.[3]

The underlying mechanism of PD is believed to involve the overproduction of prostaglandins in the endometrium. After ovulation, the withdrawal of progesterone leads to the accumulation of ω-6 fatty acids, triggering a cascade that increases the synthesis of inflammatory prostaglandins, particularly prostaglandin F2α.[7-10] These prostaglandins are thought to cause uterine contractions and vasoconstriction, resulting in local tissue ischemia and hypoxia, which produces the characteristic cramping pain.[7,11] Adolescents may be more susceptible to PD due to factors such as immature uterine function, narrower cervical os, and more dramatic hormonal fluctuations.[12-16]

While various pharmacological and non-pharmacological interventions have been studied for managing PD in women,[10,17-19] the evidence specifically focused on the adolescent population is limited. Physiotherapies are promising non-pharmacological options for adolescent students due to their accessibility, low cost, and empowering nature.[20,21] While several reviews have evaluated individual physiotherapy interventions for PD, most have focused on adult women, neglecting the 10-19 year old adolescent population.[22-31] Given the physiological differences between adolescents and adults, as well as the unique impact of PD on adolescent students' daily lives, dedicated research is needed to optimize dysmenorrhea management for this underrepresented population.

This systematic review aims to evaluate the efficacy and safety of different physiotherapy interventions for improving menstrual pain in adolescent students with PD, using pain severity as the

primary outcome compared to usual care (e.g., self-care, no treatment, or medication). Gaps in the current evidence base will be identified, and recommendations will be made to guide future research and clinical practice. The review will address the following questions:

- What is the effectiveness of physiotherapeutic management in treating PD among adolescent students?
- How do various physiotherapy modalities help for PD symptom improvement?

Methods

This systematic review adhered to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[32] To efficiently screen and identify pertinent studies for inclusion, eligibility criteria were developed. The research question was designed using the PICO (Population, Intervention, Comparison, Outcome) framework.[33]

Population

The population for this review included female adolescents with PD who were current students (primary, secondary, or college). The sample included participants aged 10 to 19 years; studies involving participants less than 20 were also considered if the reported mean age was under 19 years. Adults, pregnant/postpartum individuals, and those with secondary dysmenorrhea were excluded. Studies involving hormonal contraceptive use were also excluded.

Intervention

Eligible interventions were non-pharmacological physiotherapies, including physical modalities (e.g., heat/cold, massage, acupuncture) and mind-body practices (e.g., yoga, tai chi, meditation), used alone or in combination to manage PD symptoms in adolescents.

Comparator

Comparators could include no treatment, waitlist groups, or standard medical care. Reviews evaluating herbal medicines or surgical procedures were excluded.

Outcome

Outcomes measured menstrual pain from baseline to intervention end, comparing mean differences between control and intervention groups to determine efficacy. The major outcome measures for pain are visual analogue scale (VAS)[34,35] and numerical rating scale (NRS).[34] Studies not reporting original pain via standardised instruments will be excluded. Secondary outcomes may include need for rescue medication, school or work absenteeism, levels of distress and anxiety, as well as treatment satisfaction and safety. At each point of measurement, the outcome, means, standard deviation, 95% CI, or *p*-values will be collected for analysis.

Study design

Given their recognition as the 'gold standard' for evaluating healthcare interventions,[36,37] RCTs and clinical trials published between 2000 and May 2025 in English were included. However, study protocols, pilot studies, case studies/discussion papers, and review articles will not be considered for inclusion in this review.

Search strategy

A comprehensive search strategy was developed to systematically search four electronic databases (Scopus, PubMed, Medline, and Cochrane Library) and grey literature. The core keywords were «dysmenorrhea,» «menstrual pain,» «period pain,» and «period cramp,» combined with synonyms and controlled vocabularies (e.g., Medical Subject Headings (MeSH) terms) to cover the PICO framework. All relevant titles, abstracts, keywords, or full text were retrieved using these search terms in order to locate all potentially eligible studies. Detailed search strategies and specific search strings for each individual database are provided in *Table S1*.

Study selection

For the study selection, the search results were imported into EndNote software, facilitating the tracking of the literature throughout the systematic review process.[38,39] Duplicate citations were automatically removed. A three-step screening process (title, abstract, full-text) was used to verify the eligibility of the studies, and the reference lists were manually searched to identify any additional relevant articles. The first author and the reviewer independently retrieved and reviewed the eligible articles. Any disagreements were resolved through discussion.

Data collection process and data items

The relevant information from each eligible study was extracted and summarized using data extraction forms. This included study identification, methodology, participant characteristics, details of the intervention and control groups, and outcome measures. Statistical figures such as means, standard deviations, 95% confidence interval (CI) and *p*-values indicating statistical significance were collected at each measurement point, whenever available. The primary outcome measure was the assessment of the mean difference in pain severity levels between the control and intervention groups or pre- and post-intervention. A *p*-value below 0.05 was considered indicative of a significant difference. Other outcomes, such as stress, anxiety, or other PD symptoms reported in the individual studies, were summarized in the data extraction form.

Risk of bias in individual studies

The Cochrane risk of bias tool recommended by the Cochrane Handbook for systematic reviews of interventions was employed.[40] Additionally, the methodological quality of the eligible studies was evaluated using the Physiotherapy Evidence Database (PEDro) quality appraisal tool, which is specifically designed for assessing RCTs in physiotherapy.[41] If eligible studies lack sufficient detail, the criterion item will be recorded as «unclear.» The PEDro final score does not include the eligibility criteria in its calculation,[42] with a maximum score of 10. The final score indicates the level of methodological quality and is classified as poor (score ≤3), fair (score ranging from 4 to 5), or high (score ranging from 6 to 10).[43] Studies graded as poor-level were excluded from this review after assessing the risk of bias using the PEDro methodology.

Meta-analysis

A meta-analysis was conducted using Review Manager software (RevMan version 5.3), which is the commonly employed software for analysing data across the research studies.[44] However, the analysis was limited due to the clinical heterogeneity observed among the studies. To quantify the degree of heterogeneity, the I^2 statistic was utilized, where different percentages indicated varying levels of heterogeneity: 25% represented low heterogeneity, 50% represented medium heterogeneity, and 75% represented high heterogeneity. If the I^2 value was 50%, a random effects model was employed. The outcomes included in the analysis were based on data of menstrual pain from VAS, or NRS. Forest plots were generated to depict and summarize individual effect sizes with 95% CI.

Results

The PRISMA flow diagram (Figure 1) provides a summary of the search strategy and study selection process. The comprehensive search process was conducted in four electronic databases (Scopus, PubMed, Medline, and Cochrane Library) using the predefined search queries, with the final search date of 31 May 2025. This initial search identified a total of 7,106 potential studies. After removing duplicates, the title screening process excluded 6,275 studies deemed irrelevant to the review topic. The remaining 831 studies proceeded to abstract screening, where a further 546 studies were excluded. The full-text screening of the remaining 285 studies against the defined eligibility and methodological quality criteria resulted in the exclusion of 275 studies. Ultimately, 10 studies[45-54] met the eligibility criteria and were included in the final systematic review.

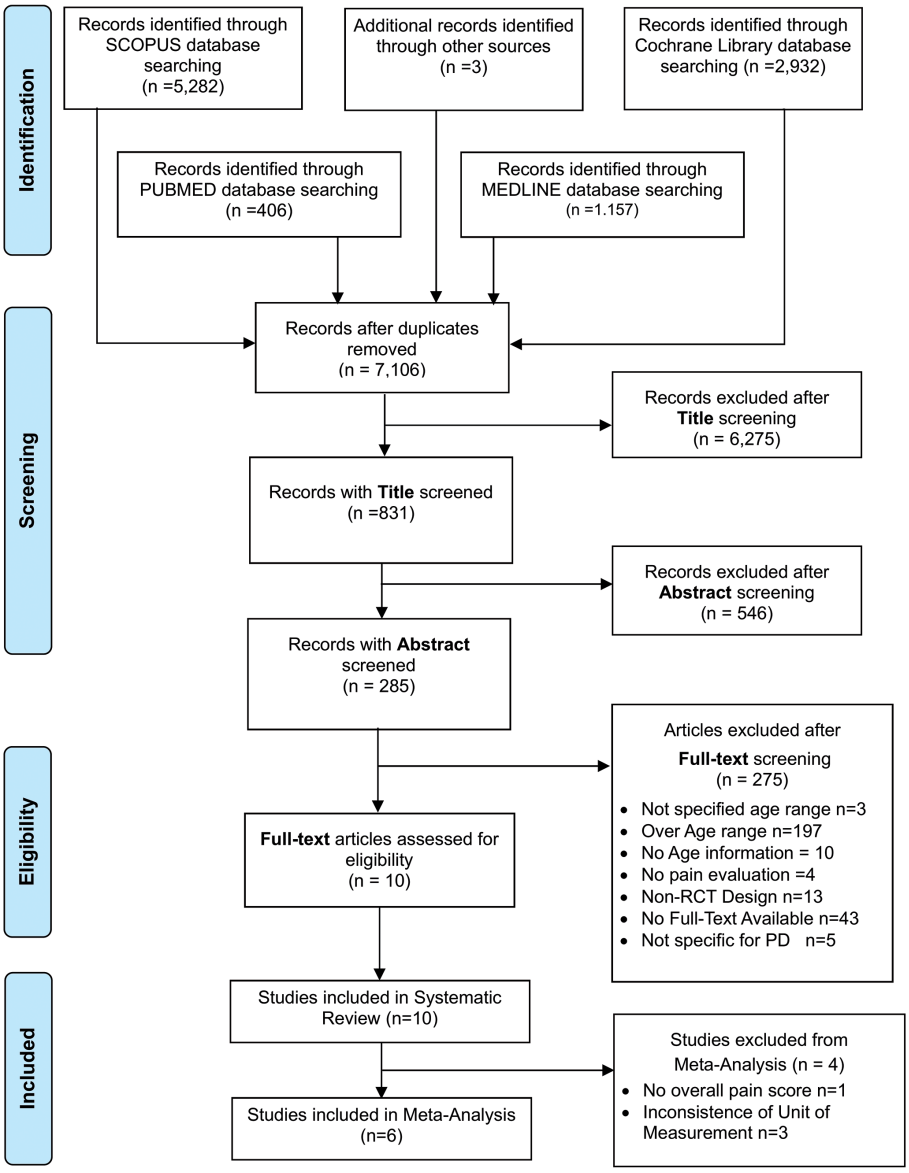

Figure 1. PRISMA flowchart of articles selection process.

Assessment of study quality

Study quality was assessed using the PEDro scale and Cochrane Risk of Bias tool. Scores ranged from 5 to 8, classifying studies as fair to high quality. The results were presented in Table 1 and Figure 2, respectively. None were excluded for poor methodological quality. All studies adhered to the inclusion and exclusion criteria during the screening and recruitment process. However, half of the studies[45,47,50-52] relied solely on participants' history for the diagnosis of PD, while the other five studies included clinical or ultrasound examinations to rule out secondary dysmenorrhea.

Most studies had low risk for random sequence generation except one study[48] reported using allocation by school educational districts rather than a true random process. The included studies commonly showed unclear or high risk in allocation concealment and blinding. This indicated the participants, care providers, and/or outcome assessors were not adequately blinded to the group allocation, which introduces the potential for performance and detection biases.

Baseline measures of pain intensity, the primary outcome, were provided in all studies, with the treatment groups showing similar baselines, except for one study[49] that reported a significant difference in baseline pain intensity between the ibuprofen and two treatment groups. Moreover, one study[45] did not provide adequate follow-up due to a high dropout rate, resulting in the loss of certain results. Additionally, three studies[45,51,52] did not perform any intention-to-treat analysis. Outcome data were generally completed; all studies conducted inter-group comparisons for pain intensity and reported the results using mean and standard deviation as point estimators.

Study characteristics

The study characteristics of the included studies are detailed in Table 2. The studies encompassed a diverse range of designs and interventions. The majority of studies utilised a two-arm design with an intervention group, while two studies[45,52] employed three intervention groups, and one study[49] incorporated two intervention groups for comparison. The studies encompassed a total of 1,496 participants, with sample sizes ranging from 64 to 216 across different studies. The age of the participants varied from 13 to 19, and their menarche age ranged from 11.08 to 13.19. However, two studies[49,50] did not report any information regarding the participants' menarche age.

In the included studies, the intervention group underwent treatments such as ibuprofen, acupressure, massage, Transcutaneous electrical nerve stimulation (TENS), and exercise. In comparison, the control groups received no intervention or placebo treatments. Acupressure and TENS interventions were typically administered during the first three days of menstruation, while exercise interventions spanned 8 weeks to 3 months. Notably, specific acupressure treatments had follow-up periods ranging from once after the first cycle to three times over 6 months.[45,51] One study[47] focused on yoga as a treatment method but did not specify a treatment regimen for the intervention group.

Figure 2. Summary of risk of bias.

Table 1. PEDro critical appraisal score.

Study	Eligibility criteria	Random allocation	Concealed allocation	Baseline comparability	Participant blinding	Therapist blinding	Assessor blinding	Adequate follow-up	Intention-to-treat analysis	Between-group analysis	Point estimate and variability	Total score (0 to 10)
Pouresmail and Ibrahimzadeh[49]	Y	Y	U	N	N	U	U	Y	Y	Y	Y	5
Chen and Chen[51]	Y	Y	U	Y	N	N	Y	Y	N	Y	Y	6
Chen and Chen[45]	Y	Y	U	Y	Y	N	U	N	N	Y	Y	5
Shahr-jerdy *et al.*[48]	Y	N	N	Y	N	N	N	Y	Y	Y	Y	5
Parsa and Bashirian[46]	Y	Y	U	Y	Y	N	U	Y	Y	Y	Y	7
Vasantha[50]	Y	Y	U	Y	N	N	N	Y	Y	Y	Y	6
Cha and Sok[47]	Y	Y	U	Y	Y	Y	N	Y	Y	Y	Y	8
Fallah and Mirfeizi[52]	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	8
Manisha and Anuradha[53]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Manisha and Anuradha[54]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7

Y, yes; N, no; U, unclear.

Table 2. Study characteristics and results.

Study	Study characteristics					Results
	Study design / study duration	Participants				
		Age (year)	Total participants and no. of dropout (%)	Intervention group (group total)	Age (years) Mean (SD) / Age at menarche (years) Mean (SD)	
Pouresmail and Ibrahimzadeh[49]	Randomised clinical trial / 4 days in a menstrual cycle	14-18	Total: 216 Dropout: 0 (0%)	CG: Sham acupressure (72) EG I: ibuprofen (72) EG II: acupressure (72)	Not reported Not reported Not reported	1) Both acupressure and ibuprofen significantly reduced the severity of primary dysmenorrhea, with no significant difference between these two groups. 2) The sham acupressure group also showed some effect but was significantly less effective compared to acupressure and ibuprofen. 3) All three groups showed statistical significance in pain reduction (p<0.01). 4) The visual-linear analogue scale indicated significant differences in pain reduction post-treatment (p=0.001) for all groups, but they did not start with identical levels of pain severity (p=0.0237).
Chen and Chen[51]	Randomised control trial / 2 menstrual cycles including 1 cycle for follow-up period	<20	Total: 81 Dropout: initial test: 12 (14.8%) self-treat: 29 (38%)	CG: no intervention (41) EG: acupressure (40)	17.5 (1.54) / 12.50 (1.38) 18.06 (1.28) / 12.37 (1.35)	1) The acupressure group demonstrated a significant reduction in menstrual pain during the initial test (p=0.04) and the self-treatment follow-up (p=0.003) when compared to the control group. 2) The acupressure group exhibited a significant reduction in anxiety during the initial test ($p\leq$0.001) when compared to the control group. However, no significant difference was found in terms of anxiety reduction during the self-treatment follow-up.
Chen and Chen[45]	Randomised clinical trial / 6 months with 3 time of protest assessments after 1st month, 3 month and six months	<20	Total: 200 Dropout: 66 (33%)	CG: no intervention (50) EG I: acupressure at Zusanli (50) EG II: acupressure at Hegu (50) EG III: acupressure at Hegu and Sanyinjiao (50)	16.77 (1.19) / 12.38 (1.08) 16.75 (1.36) / 12.26 (1.27) 16.83 (1.79) / 12.07 (1.23) 16.88 (2.09) / 12.39 (1.31)	1) Acupressure at the matched points (Hegu and Sanyinjiao) significantly reduced menstrual pain, distress, and anxiety over a six-month follow-up period. Specifically, significant reductions in pain were observed at one month (p=0.04), three months (p=0.01), and six months (p=0.02) compared to the control group. 2) Menstrual distress was significantly reduced at one month (p=0.01), three months (p<0.001), and six months (p<0.001) in the acupressure group at the matched points (Hegu and Sanyinjiao).

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Table 2. Continued from previous page.

Study	Study characteristics					Results
	Study design / study duration	Participants				
		Age (year)	Total participants and no. of dropout (%)	Intervention group (group total)	Age (years) Mean (SD) / Age at menarche (years) Mean (SD)	
						3) Anxiety was also significantly reduced at three months (p=0.01) and six months (p=0.03) in the acupressure group at the matched points (Hegu and Sanyinjiao). 4) Acupressure group at the single point Hegu was effective in reducing menstrual pain comparing with control group at the one-month (p=0.04), three-month (p=0.03), and six-month follow-up tests (p=0.02) but had no significant effect on distress or anxiety. 5) Acupressure group at Zusanli acupressure showed no significant effects on menstrual pain, distress and anxiety.
Shahr-jerdy *et al*.[48]	Randomised control trial / 8 weeks	15-17	Total: 179 Dropout: 0 (0%)	CG: No Intervention – (55 from 2 schools) EG: Stretching Exercise (124 from 4 schools)	16 / 12 16 / 13	1) In the exercise group, the pain intensity showed significant reductions measuring visual analogue scale from 7.65 to 4.88 (p<0.001); pain duration from 7.84 to 3.86 h (p<0.001); medication use from 1.65 to 0.79 tablets (p<0.001). 2) In the control group, a significant reduction was observed only for pain duration (p<0.001).
Parsa and Bashirian[46]	Randomised control trial / first day of a menstrual cycle	14-18	Total: 64 Dropout: 0 (0%)	CG: placebo TENS (32) EG: active TENS (32)	15.96 (0.89) / 12.34 (0.93) 16.40 (1.01) / 12.37 (0.94)	1) The results showed that pain intensity (visual analogue scale) significantly decreased in the active TENS group (from 6.312 to 2.406, paired t-test=9.705, p=0.000) compared to the placebo group (from 6.625 to 5.00, paired t-test=5.970, p=0.000). 2) The reduction in pain intensity was significantly greater in the active TENS group than in the placebo group (independent t-test= -4.690, p=0.000). 3) The use of analgesics was also significantly reduced in the active TENS group (t=5.475, p<0.01).

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Table 2. Continued from previous page.

Study	Study characteristics					Results
	Study design / study duration	Participants				
		Age (year)	Total participants and no. of dropout (%)	Intervention group (group total)	Age (years) Mean (SD) / Age at menarche (years) Mean (SD)	
Vasantha[50]	Randomised control trial / 3 menstrual cycles	14-17	Total: 300 Dropout: 0 (0%)	CG: no intervention (150)	Not reported	1) The Yoga group showed a significant reduction in pain levels, with 71.3% reporting no pain and 28.7% reporting mild pain, compared to the control group where no significant improvement was observed. 2) The independent *t*-test for pain scores showed a statistically significant difference between the groups (t=38.125, $p<0.001$). 3) The associated factors of dysmenorrhea, including physical, psychological, and educational factors, showed significant improvements in the Yoga group (overall t=49.362, $p<0.001$). 4) The yoga group experienced a significant decrease in the number of days of menstrual flow compared to the control group ($p<0.01$).
				EG: yoga (150)	Not reported	
Cha and Sok[47]	Randomised control trial / 3 days in a menstrual cycle	16-19	Total: 91 Dropout: 0 (0%)	CG: placebo auricular acupressure (46)	16.8 (0.61) / 12.6 (1.27)	1) The auricular acupressure group showed significant reductions in abdominal pain (t=24.594, $p<0.001$), back pain (t=22.661, $p<0.001$), and primary dysmenorrhea (t=32.187, $p<0.001$) comparing with control group. 2) The auricular acupressure group showed a statistically significant improvement in distress levels compared to the placebo group ($p<0.001$).
				EG: auricular acupressure (45)	16.6 (0.92) / 11.8 (1.08)	
Fallah and Mirfeizi[52]	Randomised clinical trial / 8 weeks including 4 weeks follow up period	15-18	Total: 85 Dropout:7 (12.14%)	CG: No intervention (20)	15.54 (0.94) / 12.43 (0.67)	1) All intervention groups showed significant reductions in pain intensity, visual analogue scale, and total pain scores across all intervention groups compared to the control group ($p<0.001$). 2) The massage and stretching groups demonstrated significant decrease in the volume of menstrual bleeding ($p=0.016$ and $p=0.037$, respectively)
				EG I: stretch (22)	15.68 (0.95) / 12.42 (0.61)	
				EG II: massage (22)	15.53 (0.7) / 12.89 (0.66)	
				EG III: combined of stretch and massage (21)	15.76 (0.83) / 12.24 (0.89)	

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Table 2. Continued from previous page.

Study	Study characteristics					Results
	Study design / study duration	Participants				
		Age (year)	Total participants and no. of dropout (%)	Intervention group (group total)	Age (years) Mean (SD) / Age at menarche (years) Mean (SD)	
Manisha and Anuradha[53]	Randomised controlled trial / 1st day of a menstrual cycle	14-19	Total: 140 Dropout: not reported	CG: no intervention (not reported) EG: High frequency TENS (not reported)	17.50 (1.327) / 13.19 (1.081) 17.21 (1.178) / 12.94 (1.089)	1) In the TENS group, statistically significant differences were observed in Numerical Pain Rating Scale of the Pre-Post treatment for lower abdomen (mean difference=4.17, p<0.001), referred lower back (mean difference=4.77, p<0.001), and referred bilateral thigh (mean difference=3.31, p<0.001). 2) Systolic (mean difference= 6.26, p<0.001) and diastolic blood pressure (mean difference=5.89, p<0.001) were significantly normalized in the TENS group. 3) No significant improvements were observed in the control group.
Manisha and Anuradha[54]	Randomised controlled trial / 1st day of a menstrual cycle	14-19	Total: 140 Dropout: not reported	CG: no intervention (not reported) EG: high frequency TENS (not reported)	17.50 (1.327) / 13.19 (1.081) 17.01 (1.489) / 12.80 (1.269)	1) In the TENS group, statistically significant differences were observed in Numerical Pain Rating Scale of the Pre-Post treatment for lower abdomen (mean difference=4.81, p<0.001), referred lower back (mean difference=4.51, p<0.001), and referred bilateral thigh (mean difference=4.41, p<0.001). 2) Systolic (mean difference= 7.46, p<0.001) and diastolic blood pressure (mean difference=7.40, p<0.001) were significantly normalized in the TENS group. 3) No significant improvements were observed in the control group.

CG, control group; EG, experimental group.

In relation to the intervention methods summarised in Table 3, the exercise treatments involve stretching exercises and yoga, focusing on muscle strength and conditioning in the abdominal, pelvic, and groin regions. The manual therapies involve acupressure treatment and massage therapy. Acupressure treatments targeted specific acupoints using thumb pressure or skin paper tape while massage therapies were directed at the abdomen. TENS interventions utilized electrical stimulation for relief from lower back and abdominal pain. In the study by Pouresmail and Ibrahimzadeh,[49] a comparative analysis was conducted to assess the effectiveness of acupressure intervention. The experimental group utilized medication as one of the interventions for comprehensive assessment, providing insights into the comparative efficacy of acupressure in relation to medication-only interventions.

Outcome measurement

Pain intensity was reported as the primary outcome measure in the included studies. The outcome results focused on post-intervention measurements between intervention and control groups. These

findings are summarised in Table 2. Additionally, five studies[46,48,52,53] conducted additional intra-group comparisons to illustrate the changes in pain intensity from pre-intervention to post-intervention within their own respective groups.

Pain intensity

The included studies utilised the common measures of menstrual pain by VAS[45-49,51,52] or the NRS[50] / Numeric Pain Rating Scale (NRPS).[53,54] All the acupressure treatment in the included studies were generally found significant PD reduction comparing with the control group except one study[45] with one of the experimental groups for acupressure at Zusanli acupoint. This sustained effective could be lasted to the second menstruation cycle[51] or even to 6 months.[45] For the other treatments in this review, a significant PD improvement was also revealed in TENS, stretching exercise, massage, Yoga and ibuprofen when comparing with the control group. Furthermore, two studies of TENS therapy[53,54] and a study of auricular acupressure[47] specifically reported the significant pain reduction in lower abdominal and back pain during the menstruation but did not measure the overall pain intensity. In addition, a study of yoga training[50] only provided the mean difference score % of treatment groups to show the statistically significant pain improvement between groups.

Other outcomes

In addition to pain relief, the studies included also showed significant improvement in other PD symptoms. When compared to the control group, the application of acupressure at the acupoints Hegu and Sanyinjiao[45] consistently resulted in a significant reduction in distress and anxiety for a period of six months. On the other hand, acupressure only at acupoint Sanyinjiao[51] led to an improvement in distress and anxiety, but the significant reduction in anxiety was not sustained until the next menstrual cycle. Furthermore, the acupressure at the ear acupoints also demonstrated an immediate effect to have significant distress reduction.

The other outcome measures in the studies of exercise and TENS such as analgesic effect, blood pressure, and more were identified.

Meta-analysis

In this review, three studies[47,53,54] did not report the overall pain intensity, while one study[50] did not explicitly present the pain intensity for the entire group as a combined value. Therefore, a total of six studies[45,46,48,49,51,52] evaluated the pain intensity of PD using VAS as the primary measurement tool, and involving 782 participants, were included in this meta-analysis (Figure 3). The studies were categorised into four subgroups representing different therapies for PD.

The manual therapy subgroups consisted of three studies on acupressure[45,49,51] and one study on massage treatment.[52] The subtotal analysis revealed a statistically significant weighted mean difference in pain intensity, with a 95% CI ranging from -1.00 to -0.23. The exercise therapy subgroup included two studies[48,52] on sketching exercise, which also demonstrated a significant weighted mean difference in pain intensity, with a 95% CI ranging from -1.54 to -0.93. The remaining two subgroups each had one study, showing significant differences with 95% CIs ranging from -1.89 to -0.80 for TENS[46] and from -1.73 to -0.42 for the combination treatment of massage and exercise.[52]

Considering all subgroups together, the overall analysis indicated a significant weighted mean difference in pain intensity for PD, with a 95% CI ranging from -1.17 to -0.52. Heterogeneity analysis revealed variability in the results among the studies, with significant heterogeneity observed in the overall analysis (I^2=77%). However, the subgroup differences analysis suggested that there was no statistically significant variation among the different therapies (Chi^2=7.46, df=3, P=0.06, I^2=59.8%).

Further meta-regression or sensitivity analyses were not feasible as this review primarily stemmed from the small number of studies within each subgroup, which reduced the statistical power necessary for robust analyses.

Discussion

This systematic review examined the effectiveness of physiotherapy interventions for PD among adolescent students. Ten studies were analysed, focusing on various physiotherapy modalities such as exercise, manual therapy (acupressure and massage), TENS. Meta-analysis results indicated a significant reduction in pain intensity with these physiotherapy interventions compared to no intervention or placebo. However, the meta-analysis revealed substantial heterogeneity among the included studies (I^2=77%), indicating considerable variability in the results. Likely contributors to this high heterogeneity include differences in treatment dose, duration, diagnos-

Table 3. Summary of intervention methods.

Physiotherapy treatment	Studies	Application
Exercise	Fallah and Mirfeizi[52] Shahr-jerdy *et al*.[48]	Stretching exercises or yoga were involved. The duration of the exercise program spanned over 8 weeks, encompassing two menstrual cycles. Participants dedicated 10 to 20 min, twice a day, and engaged in these exercises three days per week.
Acupressure	Cha and Sok[47] Chen and Chen[45,51] Pouresmail and Ibrahimzadeh[49]	Pressure applied on various acupoints, including Hegu (LI-4), Sanyinjiao (Sp6), Zusanli (ST36), and Daheng (SP15), using thumb pressure or skin paper tape with auricular acupressure needle on specific ear acupoints.
Massage	Fallah and Mirfeizi[52]	A 10-min massage specifically targeting the abdomen.
TENS	Manisha and Anuradha[53,54] Parsa and Bashirian[46]	Electrical stimulation was generated from a TENS device, with settings of 0-100 Hz and 90-100 pulses / second, applied for 20 min in the area experiencing lower back pain and abdominal pain.
Medication	Pouresmail and Ibrahimzadeh[49]	Ibuprofen was used with a recommended dosage of three tablets per day. The administration of ibuprofen began one day prior to the onset of menstruation and continued for a consecutive period of three days.

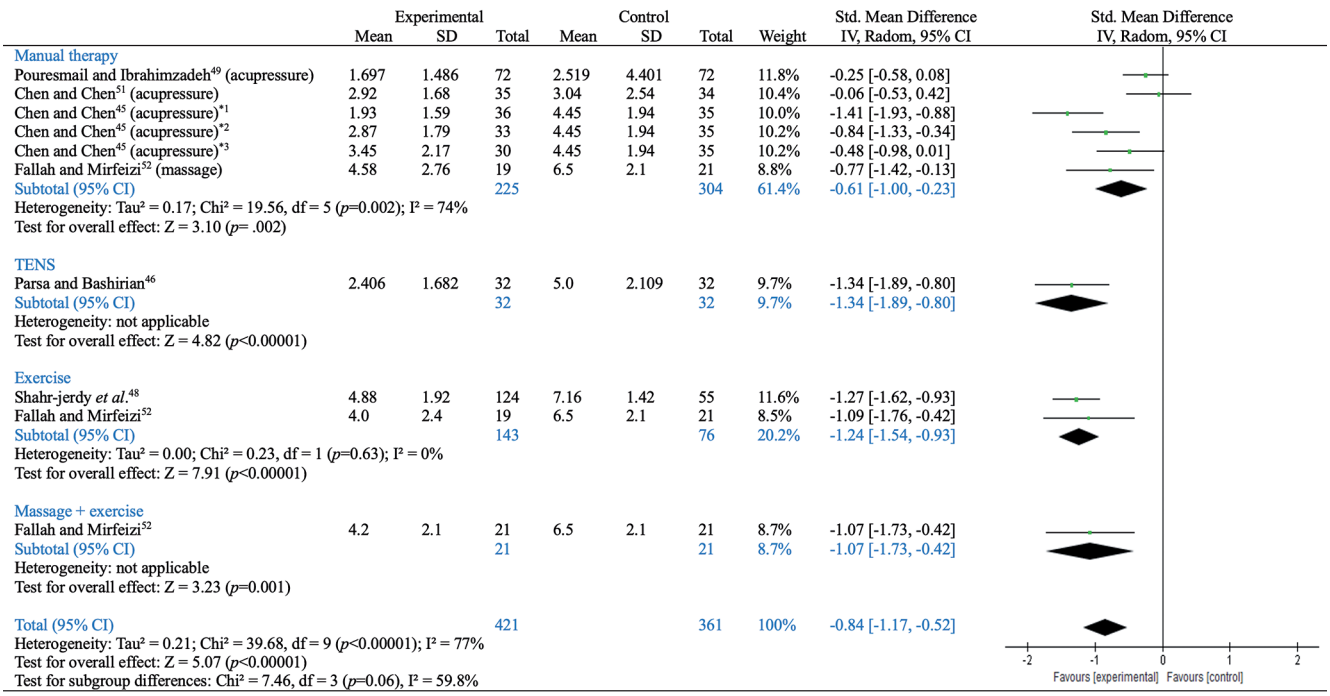

Figure 3. Pooled Mean Difference (95% CI) of effect of physiotherapy in pain relief. *1, at acupoint Hegu and Sanyinjiao; *2, at acupoint Hegu; *3, at acupoint Zusanli.

tic criteria, baseline severity of PD, and intervention protocols. For instance, the included studies varied in the duration of interventions, ranging from single-session treatments (e.g., TENS or acupressure during menstruation) to longer-term interventions like 8-week exercise programs. Additionally, the diagnostic criteria for PD were inconsistent, with some studies relying solely on participant history while others incorporated clinical or ultrasound examinations to rule out secondary dysmenorrhoea. Baseline severity of pain also differed across studies, potentially influencing treatment outcomes. Consequently, the findings should be interpreted with caution due to potential biases, such as lack of blinding or placebo effects, identified in the included studies.

Exercise interventions were found to provide relief from PD,[11,21,55,56] with regular physical activity linked to reduced prostaglandin levels, adipose tissue mass and stress,[57,58] potentially improving blood flow, endorphins, and nerve transmitters to alleviate pain.[55,59,60] Studies by Shahr-jerdy *et al.*,[48] Vasantha,[50] and Fallah and Mirfeizi[52] demonstrated positive outcomes with low-intensity exercises like yoga and stretching. Subgroup analysis revealed a significant reduction (p<0.00001) in pain intensity in studies involving stretching exercises, although there was heterogeneity in results possibly due to varying exercise regimens. Yoga, known for reducing inflammatory markers and mood changes related to menstruation,[7,61] aligns with findings from other systematic reviews.[7] However, the effectiveness of exercise in managing dysmenorrhea has elicited mixed results, with varying impacts on emotional symptoms like anxiety.[62-64] possibly influenced by individual pain responses and diverse exercise protocols.[65]

The manual therapies of acupressure and massage have been recognized as effective approaches for managing PD.[66-69] Acupressure involves applying pressure to specific acupoints to stimulate energy flow, endorphin production, and pain relief,[55] while massage manipulates soft tissues to enhance circulation, reduce tension, and induce relaxation.[70] These modalities have shown promise in alleviating menstrual pain and enhancing overall well-being in individuals with PD. Subgroup analysis in the meta-analysis revealed a significant reduction in pain intensity with manual therapy for PD (p=0.002). Studies on acupressure in this research[45,47,49,51] consistently reported relief from menstrual pain and distress, although variations in acupoint selection may influence treatment outcomes.[45,71] This is supported by a study that found over 20 different acupoints were selected among 392 prescriptions for managing PD.[71] The findings indicate the importance of standardized procedures and clinical protocols for acupressure treatment in PD, including guidelines for frequency, duration, pressure application, and point selection. Moreover, the studies reviewed[45,49,51] primarily focused on self-acupressure, where individuals perform the technique themselves over a specific period. Engaging in self-acupressure requires proper knowledge and training to avoid risks. Massage therapy involves the process of muscle relaxation, targeting specific points around the abdomen, sides, and back to alleviate menstrual pain. Techniques like effleurage, petrissage, and friction increase blood flow, enhance oxygen and nutrient supply to reproductive organs, and reduce stress, promoting overall well-being and psychological relief in individuals with PD. An included study[52] demonstrated that combining stretching exercises and massage resulted in a significant reduction in pain intensity, duration, and blood loss compared to no intervention. The therapeutic benefits of massage were consistent with previous studies.[70,72-74] While various massage techniques have been developed across different cultures to relieve pain and tension,[75] there is a lack of robust scientific evidence to support

current guidelines.[60] Tailoring massage therapy to individual needs under the guidance of qualified professionals is crucial to achieve optimal effects.

TENS treatment, considered a promising alternative for managing menstrual pain, involves high-frequency stimulation at specific areas to reduce pain intensity.[76] Studies comparing TENS with placebos or no intervention consistently showed a significant reduction in menstrual pain in this review. This aligns with previous systematic reviews,[76,77] indicating the effectiveness of high-frequency TENS in reducing menstrual pain. The treatment operates based on the pain gate theory,[78] modulating pain signals to prevent them from reaching the brain. While some studies noted placebo effects,[46,79] the effectiveness of TENS depends on factors like dosing, interactions with other medications, and the timing of outcome measurements.[80] Ensuring the TENS intensity is strong yet comfortable, and adjusting it as needed, can enhance its analgesic effect.[81] Consistent TENS use may lead to sustained pain relief by reducing sensitization and restoring inhibition over time.[80,81]

The findings of this review underscore the critical importance of physiotherapy and exercise-based rehabilitation in the holistic management of PD. These modalities do not merely offer symptomatic relief but address underlying physiological mechanisms such as prostaglandin regulation and endorphin release while simultaneously mitigating psychological comorbidities like anxiety and distress. Unlike pharmacological treatments, which may carry side effects, physiotherapy is generally safe, non-invasive, and cost-effective, making it particularly suitable for the adolescent population. Furthermore, interventions such as home-based stretching and self-acupressure foster patient empowerment, allowing individuals to take an active role in their health and reducing dependence on medication. Regular engagement in these rehabilitation programmes promotes sustained, long-term improvements in both pain management and overall well-being.

Despite these positive outcomes, further research with larger sample sizes and diverse study designs is needed to validate these results comprehensively and enhance the understanding of different therapies for pain relief in PD. Moreover, the review highlights a strong correlation between psychological distress, anxiety, and PD occurrence, consistent with previous research.[82,83] Studies underscore the importance of addressing psychological factors in PD management, with interventions like yoga[50] and acupressure[45,47,51] showing promise in improving both physical and psychological aspects. These findings emphasize the potential benefits of integrating holistic approaches to effectively address PD symptoms.

Quality of evidence

While none of the study included in this review was classified as 'poor' based to the PEDro scale, some potential biases were still identified. Selection bias was evident in some studies, such as Pouresmail and Ibrahimzadeh[49] showing variations in baseline pain severity between groups. Only three studies[52-54] specified concealed allocation. Self-reported outcomes in most studies may introduce bias, with unmasked participants and healthcare providers common, consistent with previous reviews on interventions like acupoint stimulation,[8,56] TENS,[76] massage,[70] and physiotherapy treatment.[84] Dropout rates were noted in some studies exceeding 10%[45,51,52] with reasons including «withdrawal» and «discomfort, highlighting challenges faced by adolescent participants in consistently engaging with interventions. Additionally, diagnosing PD based solely on medical history without ruling out secondary dysmenorrhea may affect result generalizability.[45,47,50-52] Although statistical validity was high, internal validity considerations were necessary due to various biases identified.

Although a formal GRADE assessment was not conducted, the certainty of evidence in this review is considered moderate to low due to risk of bias in allocation concealment, lack of blinding, reliance on self-reported outcomes, and significant heterogeneity among the included studies. The limited number of studies within subgroups and variability in intervention protocols further contribute to this classification. These factors necessitate cautious interpretation of the findings and highlight the need for more robust research to strengthen the evidence base.

Strength and limitation of the review

This systematic review exhibited strengths in following the PRISMA guideline and utilizing Pedro for study selection and appraisal, ensuring a methodical and rigorous approach. The review aimed to provide a comprehensive overview of interventions, contributing valuable insights to the existing literature and accommodating diverse intervention approaches through a random effects model to address heterogeneity among included studies.

However, this review also acknowledges the limitations in the included studies, which may potentially impact the results of this study. Some studies lacked detailed information on randomization methods, allocation concealment, and biases, affecting overall study quality. Small sample sizes and high dropout rates in some studies could limit comparability and introduce bias. Inconsistent follow-up periods make assessing long-term efficacy challenging. The self-reported nature of pain in most studies prevented blinding, potentially leading to bias.[85] These limitations suggest that the conclusions drawn in this study are preliminary, and caution should be exercised[86] when interpreting the clinical efficacy of physiotherapeutic management for PD.

Furthermore, limitations in the review process were also identified. Selection bias may have been introduced by the criteria focusing solely on English publications, potentially excluding relevant non-English literature. Screening based on titles and abstracts across different databases could have led to the oversight of crucial studies. Significant heterogeneity among included studies posed challenges in identifying a superior intervention, underscoring the complexity of comparing diverse physiotherapeutic approaches. Furthermore, methodological variations hindered data pooling and comprehensive assessment of overall effects, highlighting the necessity for further high-quality, larger sample randomized controlled trials to validate the findings and strengthen the evidence base.

Implication for future research and practice

Considering the limitations identified in this review, addressing language bias by including studies published in languages other than English is crucial for a more comprehensive understanding of PD management across diverse cultural contexts. Developing inclusive search strategies that cover a wide range of databases can help minimize the risk of missing important literature. To tackle the significant heterogeneity in interventions observed in the included studies, future research should focus on creating standardized guidelines for different physiotherapeutic modalities in PD treatment. These guidelines would offer clear recommendations on techniques, protocols, and duration, ensuring consistency and comparability across studies for more accurate assessments of treatment efficacy. Moreover, establishing consistent and validated measurement tools for assess-

ing PD management outcomes is essential. Developing standardized questionnaires or scales capturing various PD aspects, such as pain intensity, psychological distress, and quality of life, would enable meaningful comparisons and facilitate meta-analyses to evaluate the overall effect of different physiotherapeutic interventions on PD management.

In terms of future practice, healthcare professionals should be mindful of the review's limitations and interpret the clinical efficacy of physiotherapeutic management for PD cautiously. In the absence of clear guidelines, treatment decisions should be individualised based on patient characteristics, preferences, and needs. Future research focusing on conducting high-quality, larger sample randomized controlled trials with standardized protocols and measurement tools is essential. These studies can provide robust evidence to guide clinical practice and contribute to the development of evidence-based guidelines for PD management.

Conclusions

This systematic review highlights the potential of various physiotherapy interventions, including exercise, acupressure, massage, and TENS, in managing PD among adolescent students. The findings suggest that these interventions may reduce pain intensity and offer a non-invasive, holistic approach to PD management. However, the certainty of evidence is moderate to low due to several limitations, including small sample sizes, significant heterogeneity in study designs, inconsistent diagnostic criteria, and reliance on self-reported outcomes. These methodological issues necessitate cautious interpretation of the results and preclude definitive conclusions about the effectiveness of these interventions. Therefore, further robust research incorporating larger sample sizes and diverse study designs is essential to validate these findings and enhance the understanding of the impact of different physiotherapeutic interventions on PD. Additionally, the correlation between psychological distress, anxiety, and PD occurrence underscores the importance of holistic management approaches that address both physical and psychological aspects, with interventions like yoga and acupressure showing promise in providing comprehensive care for individuals with PD.

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Online supplementary material:

Table S1. Search criteria for individual database.

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