Physical activity for primary dysmenorrhea: a systematic review and meta-analysis of randomized controlled trials

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Condensation: A systematic review and meta-analysis of randomized controlled trials of the effectiveness of physical activity as a treatment for primary dysmenorrhea

Short version of title: Physical activity for primary dysmenorrhea

Implications and Contributions

A. To determine whether physical activity can reduce pain in primary dysmenorrhea.

B. Increased physical activity reduced pain intensity by almost 2cm on the VAS scale and pain duration by almost four hours in primary dysmenorrhea.

C. This study provides improved and updated evidence that physical activity may be an effective treatment for primary dysmenorrhea.

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Structured Abstract

Background: Primary dysmenorrhea is cramping abdominal pain associated with menses. It is prevalent, affects quality of life, and can cause absenteeism. Although evidence based medical treatment options exist, women may not tolerate these or may prefer to use non-medical treatments. Physical activity has been recommended by clinicians for primary dysmenorrhea since the 1930s, but there is still no high quality evidence on which to recommendation exercise as treatment. use.

Objective: We sought to determine the effectiveness of physical activity for the treatment of primary dysmenorrhea

Data sources: Systematic literature searches of Medline, Embase, Cochrane, Web of Science, CINAHL, PsycINFO, SPORTDiscus, PEDro, AMED, WHO ICTRP, Clinicaltrials.gov and OpenGrey were performed, from database inception to 24th May 2017. Google searches and citation searching of previous reviews was also conducted.

Study eligibility criteria: Studies were selected using the following PICOS criteria: Participants: non-athlete females experiencing primary dysmenorrhea; Intervention: Physical activity delivered for at least two menstrual cycles; Comparator: Any comparator; Outcomes: Pain intensity or pain duration; Study type: Randomized controlled trials.

Study appraisal and synthesis methods: Study quality was assessed using the Cochrane Risk of Bias Tool. Random effects meta-analyses for pain intensity and pain duration were conducted, with pre-specified subgroup analysis by type of physical activity intervention. Strength of the evidence was assessed using GRADE.

Results: Searches identified 15 eligible randomized controlled trials; totalling 1681 participants. Data from 11 studies was included in the meta-analyses. Pooled results demonstrated effect estimates for physical activity versus comparators for pain intensity (-1.89cm on Visual Analogue Scale, 95% CI -2.96 to -1.09) and pain duration (-3.92 hours, 95% CI -4.86 to -2.97). Heterogeneity for both these results was high and only partly mitigated by subgroup analysis. Primary studies were of low or moderate methodological quality but results for pain intensity remained stable during sensitivity analysis by study quality. GRADE assessment found moderate quality evidence for pain intensity and low quality evidence for pain duration.

Conclusion: Clinicians can inform women that physical activity may be an effective treatment for primary dysmenorrhea but there is a need for high quality trials before this can be confirmed.

Key words: Exercise, Menstrual Pain, Physical Activity, Primary Dysmenorrhea

Main text

Introduction

Primary dysmenorrhea is pain occurring with menses in the absence of underlying pathology, commonly referred to as period pains or menstrual cramps by the lay press and public.[1-4] Women may consider primary dysmenorrhea to be a normal physiological state rather than a disorder.[5] However, studies consistently find it to be the most common gynaecological condition of adolescence,[6-8] also affecting 60 - 76% of adult menstruating women.[9,10] Severe symptoms are reported by 13 – 33%[11-13] of women with primary dysmenorrhea and absenteeism by 24 – 43%.[13-15] Approximately one third of women with primary dysmenorrhea have seen a health professional because of this condition.[16,17]

Standard, evidence based treatment is with non-steroidal anti-inflammatory medications (NSAIDs)[18] or oral hormonal contraceptives.[19] Other hormonal contraceptives may be helpful but the evidence for these is less robust.[8] Some women may not be able to use medications, or may prefer to avoid them. No complementary therapies have any high quality evidence of effectiveness.[20-27]

There are plausible mechanisms by which physical activity may reduce pain in primary dysmenorrhea. Pain during menstruation is thought to be mediated by uterine prostaglandins, which stimulate myometrial contractions.[8] Pain sensitization,[8] psychosocial[28,29] and cultural factors[30] may also play a role. Physical activity reduces stress,[31,32] has anti-nociceptive properties,[33-36] reduces levels of PGF2α[37,38] (the prostaglandin subtype most closely linked with primary dysmenorrhea).[8] Intense exercise has significant impacts on the menstrual cycle, with female athletes found to

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have fewer ovulatory cycles and lower oestrogen and progesterone levels.[39] However, the effects of moderate exercise during the menstrual cycle are less well understood.[40]

Physical activity has been recommended by clinicians for primary dysmenorrhea since the 1930s,[41,42] and this advice is reiterated on popular[1,3] and medical[4,43] websites, as well as in patient information provided by the American College of Obstetrics and Gynecology.[44] However, based on current evidence, the effectiveness of physical activity is uncertain,[26,27,45] with even less known about which types of exercise might be beneficial or when these exercises should be performed. Four reviews of interventional studies of physical activity for primary dysmenorrhea have been published (two narrative reviews in 1998[45] and 2008[26] and two systematic reviews in 2010 and 2016).[27] Results from these reviews were inconclusive due to lack of primary studies.[27] The most recent systematic review published in 2016[46] deviates substantially from the Cochrane library guidelines and PRISMA reporting standards in a number of ways. The protocol was not registered, no inclusion criteria were reported for the types or length of intervention, no sample search strategy was provided, studies were excluded based on publication status and language, no information regarding excluded studies was reported, and no data regarding statistical heterogeneity was provided. Additionally, there appeared to be low return rates on the initial searches for potentially eligible studies and there are discrepancies in the methodological descriptions in different sections of the report. We performed scoping searches which identified a number of new trials since the searches of this previous review were performed. An updated review is therefore required.

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Objective

We sought to systematically review the evidence from randomized controlled trials (RCTs) of the use of physical activity as treatment for primary dysmenorrhea. We sought to perform subgroup analyses based on type of intervention, type of comparator, and whether participants were adolescents or adults.[47]

Methods

This review was conducted in accordance with systematic review methodologies as per the Cochrane Handbook and has been reported in compliance with the PRISMA statement. It is based upon a prospectively registered protocol, available at: www.crd.york.ac.uk/PROSPERO/ (registration number 42017062202).[47]

The search strategy was developed building on search strategies from previous similar reviews.[26-28,32,33,48,49] The following databases were used: Medline, Embase, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Science Citation Index, Social Sciences Citation Index, CINAHL, PsycINFO, SPORTDiscus, PEDro, AMED, Conference Proceedings Citation Index, Social Sciences Conference Proceedings Citation Index, WHO International Clinical Trials Registry Platform, Clinicaltrials.gov and OpenGrey. Google searches and citation searching of previous reviews were also conducted.

Indexing terms (where possible) and text words (title, abstract, key words and text search) were used for "physical activity" and "dysmenorrhea" terms. Language, date or publication type restrictions were not applied. “Humans” filters were used on some databases with large return rates (e.g. Medline) to enable easier handling of search results. Validated RCT filters were used where required,[50-52] the inbuilt search filter was used for CINAHL. The Medline search strategy (see Appendix A) was piloted for sensitivity and specificity using studies found during the initial scoping searches.

No changes were required following piloting. Searches performed on other databases used the same text terms as the piloted Medline search, with index terms adapted for the specific database.

Eligibility criteria

Published and unpublished studies, in any language, were included where the following PICOS criteria were met:

- Participants: Non-athlete females with regular menstruation, experiencing primary dysmenorrhea (diagnosis as defined by report), not using hormonal contraception
- Interventions: Physical activity interventions delivered over two or more menstrual cycles; as a single intervention or as a co-intervention, in any setting and via any mode of delivery
- Comparators: Any comparator that did not involve physical activity, including active comparators and usual care or no treatment
- Outcomes: Pain intensity (most painful day or average pain intensity on days that pain was experienced) measured by a validated tool, or pain duration measured in hours
- Study type: RCTs

Athletes were excluded as those exercising at very high levels have different menstrual cycle characteristics to moderate or low level exercisers.[39] Hormonal contraception also significantly alters menstrual cycle physiology. Those with irregular menstruation are likely to have an underlying gynecological disorder and therefore consideration to excluding these women should be made in the primary studies. An author defined diagnosis of primary dysmenorrhea was used as the diagnosis is

usually based on history and examination, with pelvic examination typically avoided in adolescents.[53]

Title and abstract screening was performed independently by two reviewers and any discrepancies were resolved by consensus between the two reviewers. Full text screening for inclusion of eligible studies was completed by two independent reviewers; discrepancies were resolved by consensus between these reviewers. Study authors were contacted for missing information with a reminder sent after three weeks if there had been no reply. In total, 20 study authors were contacted for further information regarding 17 studies but only five replied.

Data extraction

The data extraction form was adapted from the Cochrane Good Practice Data Extraction form[54] and was piloted prior to use. Data from included studies was extracted for participants (setting, population, method of diagnosis, inclusion / exclusion criteria, sample size, age range), intervention (type of intervention, method, timing and frequency of delivery, duration), comparators (type of comparator, timing and duration), and outcomes (time point measured, measurement tool, mean, variance). Data extraction was completed by two independent reviewers using the full text copy and any supplementary information (protocols, correspondence from authors). The main publication was used as the reference and other sources were used to obtain any information that was not reported in the main study publication. Discrepancies were resolved by consensus between the two reviewers.

Assessment of risk of bias

The Cochrane Collaboration Risk of Bias Tool was used[55] with one adaption: "blinding of participants / personnel" was changed to "blinding to study purpose / group" as physical activity interventions do not allow complete blinding.[26,56] Studies could therefore still be rated to be of high methodological quality despite being at high risk of bias. The main biases considered in the "other bias" section were recall bias, interviewer bias, contamination, the Hawthorne effect and the effect of co-interventions. Studies were assessed for quality at the study level by two independent reviewers using the Cochrane guidance.[50] Discrepancies were resolved by consensus. Quality assessment was used for descriptive purposes and sensitivity analysis only.

Data synthesis

Review Manager 5.3 (Revman) was used for statistical analyses. Meta-analyses of pain intensity and duration were performed as specified in the review protocol.[47] Where trials compared two physical activity interventions against one comparator, they were considered as two separate trials;[57-60] the number of participants in the comparator group was evenly divided between the trials to avoid double-counting of comparators. The variance was adjusted accordingly where required. The final participant number (n) was not provided for three studies;[60-62] for these studies n was assumed to be the total randomized. Results for Ortiz 2015[63] were obtained from a graph; they did not specify the measure of variance so this was assumed to be standard deviation.

Results were combined using the weighted mean difference, as most studies reported pain intensity using a visual analogue scale (VAS) in centimetres and pain duration in hours. VAS is a 10cm, usually horizontal, line anchored by the phrases "no pain" and "worst pain imaginable" at each end. One study[64] used the McGill questionnaire,

which cannot be converted to VAS, so data from this trial could not be included in the meta-analysis. The remaining studies reported pain intensity using VAS in millimetres[63] and pain duration in days.[62,65] These results were converted to centimetres and hours respectively before analysis. A correlation coefficient of 0.6 was used to estimate the standard deviation of the mean difference where this was not provided, based on the result obtained in an RCT of a physical activity intervention in a similar population.[66] Inverse variance methods were used for weighting in the meta-analyses. The random effects model was used as it was anticipated there may be a high degree of heterogeneity. I^2 was used to assess heterogeneity; an I^2 value greater than 50% was considered to indicate substantial heterogeneity.[50] Funnel plots were produced to look for publication bias.

Cluster RCTs could not be included in the meta-analyses as no intra-cluster correlation coefficient was reported in the eligible trials. Separate pooling of cluster RCTs was performed for pain duration but only one cluster randomized study reported pain intensity in a format that could be used. Subgroup analysis was not possible for comparator type as specified in the protocol due to insufficient primary studies. Subgroup analysis by age, which was also specified in the protocol, was not possible as most included studies did not provide enough detail on age ranges.

Strength of the evidence

The strength of the evidence was assessed by GRADE at the outcome level for pain intensity and pain duration using GRADE Pro / GDT. Two independent reviewers performed GRADE assessment with discrepancies resolved by consensus. A starting rating of high quality evidence was downgraded by one level for serious concerns (or

by two levels for very serious concerns) for risk of bias, inconsistency, indirectness, imprecision and publication bias.

Results

Searches were performed on 24th May 2017, resulting in 582 returns once duplicates were removed. The returns for individual databases are given in Appendix B. The PRISMA flow diagram, representing the flow of studies through the selection process, is shown in Figure 1. 69 articles were assessed at the full text stage, with 54 excluded at this stage. A list of studies excluded at this point can be found, with reasons for exclusion, in Appendix C.

Nine studies were only found in Persian or Mandarin. These papers were assessed with the assistance of native Persian and Mandarin speakers. Where the full text could not be located the study authors were contacted where possible. Two theses and one conference abstract could not be located by any method and were thus excluded at the full text stage.

Study characteristics

Fifteen RCTs, all published since 2011, met the review inclusion and exclusion criteria. This resulted in a total of 1681 participants across all included studies.[57-65,67-76] Details of these studies are presented in Table 1. Included studies were small or medium sized single-centre trials from a range of countries but primarily Iran or India. Most studies recruited university students. Diagnosis of primary dysmenorrhea was usually based on clinical history,[58,60-62,64,67,68,71-76] four studies performed a clinical examination for all participants,[59,63,65,69] and three used ultrasound[59,65,69] to exclude secondary causes. A range of physical activity interventions were used. These could

be categorised into: aerobic exercise,[58,60,63,67,71,73,76] stretching exercises,[59,61-64,67-69,74,75] yoga[60,65,70,72] or Kegels exercises.[57,58,63,76] Ortiz 2015 used a mixed intervention.[63] The majority of studies asked participants to perform exercises throughout the menstrual cycle, but not during menstruation.[59,61,62,68,69,71,74] Reyhani 2013 asked participants to exercise by brisk walking for the first three days of menstruation.[73] Rakhshaee 2011 asked participants to perform yoga in the luteal phase of the menstrual cycle.[72]

Synthesis of results

Meta-analysis of pain intensity (Figure 3) produced a pooled effect estimate of -1.89cm (95% CI -2.96 to -1.09), representing a statistically significant reduction in pain intensity for those in the intervention (physical activity) group relative to comparators. Heterogeneity was high (I^2 = 95%).

Subgroup analysis by intervention demonstrated effect sizes of -1.29cm (95% CI -2.38 to -0.21, I^2 83%) for aerobic exercise interventions; -1.67cm (95% CI -2.70 to -0.63, I^2 94%) for stretching exercise interventions; -1.81cm (95% CI -2.37 to -1.61, I^2 0%) for yoga interventions; -1.68cm (95% CI -2.43 to -0.93, I^2 0%) for Kegels exercise interventions and -4.70cm (95% CI -5.15 to -4.25) for the single mixed intervention trial. Studies that could not be included in the meta-analysis demonstrated the same direction of treatment effect.[64,69,71,72,75]

Meta-analysis of pain duration (Figure 4) produced a pooled estimate of effect of -3.92 hours (95% CI -4.86 to -2.97), representing a reduction in pain duration for those in the intervention (physical activity) group relative to comparators. Heterogeneity was high (I^2 = 78%). Data from two cluster RCTs was combined with a similar pooled effect size of -3.34 hours (95% CI -4.15 to -2.53).

Subgroup analysis by intervention demonstrated effect sizes of -15.64 hours (95% CI -26.96 to -4.32, I^2 49%) for aerobic exercise interventions; -3.53 hours (95% CI -4.25 to -2.81, I^2 82%) for stretching exercise interventions; -6.74 hours (95% CI -13.4 to -0.03, I^2 32%) for yoga exercise interventions; and -21.00 hours (95% CI -38.70 to -3.30) for the single Kegels exercise intervention.

Four studies could not be included in the meta-analysis (WHY? and six further studies did not report on both pain intensity and pain duration in a way that could be utilised for pooled effect estimates (see Appendix E for reasons for exclusion from the meta-analysis).

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Sensitivity analysis was performed for type of comparator and timing of intervention (not specified in protocol), with no significant change in the combined estimate of treatment effect. Funnel plot asymmetry was seen for both outcomes. Pain intensity did not demonstrate the classical funnel shape, possibly due to the heterogeneity of primary studies. The funnel plot for pain duration suggested publication bias. This is potentially due to selective outcome reporting as five studies included in the pain intensity meta-analysis did not publish data on pain duration, and most studies were found to be at a high risk of selective outcome reporting. However, results remained statistically significant when the smaller studies contributing to this asymmetry were removed.

Analysis of absenteeism was planned but this was only reported in one study with no measure of variance given.[62]

Risk of bias of included studies

Most included studies were at high risk of bias in multiple areas of study design, or did not report sufficiently in order for a conclusion to be made about the risk of bias (see Figure 2). The randomization process was not fully described for most studies[58,60-62,64,68,69,71,72,74-76] and allocation concealment was only performed in two studies.[63,70] No studies reported blinding participants to study purpose or group and only one study reported blinding outcome assessors.[63] Most studies did not report how or when they measured pain intensity.[57-61,63,65,68-70] Registered protocols were found for three studies,[58,62,64,74-76] of which two proposed outcomes that were not reported in the final study.[74,75] Selective outcome reporting is also suggested by the range of outcomes reported across studies. Results were sometimes reported incompletely;[63,64,68,75] for example, Aboushady 2016[68] did not report post-intervention pain intensity in the control group. Most studies reported no loss to follow up.[57,58,62,64,65,68-70,73-76] Those studies that did report loss to follow up did not use intention to treat analysis.[59,63,72] The remaining studies did not report how many participants completed the intervention and follow up.[60,61,71]

Most biases would be expected to affect the results such that they increased the magnitude of the treatment effect. However, when low quality studies were removed (Score < 3 on risk of bias assessment in Figure 2), there was an increase in the pooled estimate of treatment effect for pain intensity (from -1.89cm (95% CI -2.96 to -1.09) to -2.87cm (95% CI -5.10 to -0.63)). Only one study of moderate quality assessed pain duration with a non-significant estimate of treatment effect of -2.64 hours (95% CI -11.58 to 6.30) suggesting that the evidence for the effect of physical activity on pain duration is less reliable.

Comment

Main findings

This systematic review and meta-analysis suggests that physical activity may be an effective intervention for primary dysmenorrhea. However, these results should be interpreted with caution, as heterogeneity was high and only partially mitigated by sub group analysis. Studies were of low or moderate quality, mainly due to performance bias and potential selective outcome reporting. Nevertheless, results for pain intensity remained stable when low quality studies were removed providing some reassurance of the treatment effect observed. All studies demonstrated an improvement in pain (intensity and / or duration) with intervention, including those that could not be included in the meta-analysis. The overall assessment of the strength of evidence using GRADE showed moderate quality evidence for pain intensity and low quality evidence for pain duration (see Figure 5).

As well as considering the statistical significance and methodological quality of the results it is important to place these within a clinical context. No minimal clinically important difference (MCID) is available in the literature for pain intensity measured by VAS in primary dysmenorrhea, but the MCID in endometriosis is 1cm.[77] This suggests that the pooled estimate, at almost 2cm, is clinically significant. There are no reported values for the MCID for pain duration in primary dysmenorrhea or similar conditions.

Strengths and limitations

This review was conducted in accordance with systematic review methodologies as described in the Cochrane Handbook[50] and has been reported in compliance with the PRISMA statement[78]. A prospective protocol was registered on PROSPERO, ensuring methods were specified *a priori*, unlike previous reviews.[47] Substantially more RCTs

were found in this review than all previous reviews.. Searches used in this review were also more comprehensive than previous reviews; covering more databases, and identifying grey literature, such as theses and conference proceedings that were not identified in previous reviews. All eligible studies that were not published in English were translated so that they could be considered for inclusion. In compliance with current best practice guidelines for systematic reviews, eligibility screening, data extraction, quality assessment and strength of evidence assessment were all performed by two independent reviewers. The meta-analyses for this review contain the largest number of RCTs to date, and assess both pain intensity and pain duration (only the former has been previously assessed by meta-analysis). Our review is also the first to include subgroup analysis by type of physical activity. Interrogation of the data using sensitivity analysis and Funnel plots was performed, which was not the case in previous reviews. This review is also the first to report on strength of the evidence using GRADE. This review is therefore the most complete, up to date and methodologically rigorous review of the effectiveness of physical activity interventions for primary dysmenorrhea.

Despite this the findings remain limited by the number of primary studies, trial sample size and the quality of included studies. No high quality trials were identified, and reporting of trial methodology was not always clear. Publication bias was suggested for pain duration. The results of this review are subject to high levels of heterogeneity, introducing some uncertainty about the effectiveness of physical activity. Heterogeneity appeared to occur because studies evaluated a wide range of physical activity interventions. Attempts to resolve this by conducting subgroup analysis were somewhat limited because of insufficient primary studies. Insufficient data from primary studies also prevented reporting of one of the pre-specified outcomes

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(absenteeism) and two of the pre-specified subgroup analyses (adolescents and adults, comparator type).

Comparison with existing literature

Increased physical activity was identified as a small protective factor against experiencing dysmenorrhea in a 2006 systematic review of observational studies (odds ratio (OR) of 0.89, 95% CI 0.80 to 0.99).[28] A non-systematic review of controlled trials published in 1998 also found a beneficial effect, but noted there was a paucity of methodologically robust studies to confirm this.[45] Interestingly, the review authors considered three trials to be randomized despite not being reported as such, and not being considered as such in other reviews.[26,27] A non-systematic review in 2009[26] and a Cochrane library systematic review in 2010 (including both primary and secondary dysmenorrhea)[27] identified just one small RCT which demonstrated a beneficial effect of treadmill running.[79] This single trial had some methodological limitations and therefore the previous reviews concluded that there was insufficient evidence to recommend the intervention. The most recent systematic review found a beneficial effect of physical activity but similarly reported that included trials contained methodological flaws limiting the strength of their conclusions.[46]

Conclusions and Implications

This review provides moderate quality evidence that physical activity may reduce pain intensity and low quality evidence that it may reduce pain duration in primary dysmenorrhea., Whilst physical activity is currently recommended in clinical guidelines for primary dysmenorrhea, more high quality studies are needed before this can be confirmed. Future trials should adhere to international reporting guidelines, and seek

to minimise sources of bias. Trials that evaluate the optimum type and timing of physical activity interventions are also required.

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Table 1 – Description of included studies

"Cycles" refers to menstrual cycles

Study	n	Participants	Intervention(s)	Comparator(s)	Outcome(s)	Results
Aboushady 2016 [68]	80	School / college students, Saudi Arabia (16–21yrs)	• Instructional sessions (Menstrual care, stretches); exercises at home, 20-30mins, 2x/day, 3d/w for 8wks	Menstrual care instructional session only	Pain duration Pain intensity via VAS	Statistically significant difference in pain duration Pain intensity only reported as pre/post-test
Behbahani 2016 [64,75]	120	Non-medical students, Iran (18–25yrs)	• 4wks educational classes (physiology, nutrition, exercises), "isometric exercises" at home for 4wks	Acupressure during pain Ibuprofen 400mg 3x/day	Pain intensity via McGill questionnaire	Statistically significant reduction in pain intensity in exercise / acupressure groups compared to ibuprofen
Kaur 2013a [57] Kaur 2013b	24	Hostel at Post-Graduate Institute, India (19–25yrs)	Slow Kegels group: • Hot pack, 90x Kegel exercises alt days, 5–10s hold; for 8wks Fast Kegels group as above, no hold	Hot pack over lower abdomen for 10mins	Pain intensity via VAS	No statistically significant difference in pain intensity between slow Kegels and control Statistically significant reduction in pain intensity in fast Kegels compared to control
Motahari-Tabari 2017 [62,74]	122	Medical students, Iran (Age range not reported)	• 15mins abdominal / pelvic stretching exercises, taught initially, 3x/wk; for 2 cycles	Mefenamic acid 250mg 3x/day	Pain intensity via VAS Pain duration	No statistically significant difference in pain intensity or pain duration
Nasri 2016a [58,76] Nasri 2016b	45	High school pupils, Iran ("Teenagers")	Aerobic group: • 45mins observed "aerobic exercise", 3x/wk; for 8wks Kegel group: • 15 mins Kegel exercises; 6s hold, 3x/day	Usual care - "no exercise", advised no salty / fatty foods, no medications	Pain intensity via VAS Pain duration	No statistically significant reduction in pain intensity / duration between exercise groups Statistically significant reduction in pain intensity / duration compared to control
Ortiz 2015 [63]	192	Uni students, Mexico (18–22yrs)	• Stretches (inc Billig / Kegel), jogging, relaxation led / monitored by instructors; 50mins, 3x/wk; for 3 cycles	Kept in courtyard; "walking, talking and standing"	Pain intensity via VAS	Statistically significant reduction in pain intensity
Patel 2015 [61]	120	Students, India (17–25yrs)	• 6 stretches; 2x/day, 3x/wk for 8wks	Usual care	Pain intensity via VAS	Statistically significant reduction in pain intensity

Study	n	Participants	Intervention(s)	Comparator(s)	Outcome(s)	Results
Rakhshaee 2011 [72]	120	Uni students, Iran (17–23yrs)	• 3 yoga poses / breathing techniques taught by booklet, for 20mins/day, luteal phase (14d) of 2 cycles	Usual care	Pain intensity via 0–3 scale Pain duration	Statistically significant reduction in pain intensity and pain duration
Reyhani 2013 [73]	90	Nursing/midwifery students, Iran (Age range not reported)	• 30mins brisk walking (one training session), 1st 3d of menstruation; for 3 cycles	Usual care	Pain intensity via VAS	Statistically significant reduction in pain intensity
Saleh 2016a [59] Saleh 2016b	150	Women from outpatient clinic, Egypt (Age range not reported)	Stretching group: • 4 stretches, 10mins, 3x/d, 3x/wk; for 8wks Core strengthening group: • 4 core strengthening exercises, 20mins, 4x/wk	Usual care	Pain intensity via VAS Pain duration	Statistically significant reduction in pain intensity / pain duration in both intervention groups when compared to control
Shahr-Jerdy 2012 [69]	179	High school pupils, Iran (15-17ys)	• 6 stretches taught initially, 10mins, 2x/d, 3x/wk; for 8wk	Usual care - exercises taught to controls after study	Pain intensity via VAS Pain duration	Statistically significant reduction in pain intensity and pain duration
Siahpour 2013a [60] Siahpour 2013b	60	Uni students, Iran (20–25yrs)	Aerobic group: • Aerobic dance for 60 mins, 3x/wk; for 8wks Yoga group: • 60 mins yoga, 3x/wk; “trained”	Usual care	Pain intensity via VAS Pain duration	Statistically significant reduction in pain intensity / pain duration between aerobic and yoga groups compared to control
Sutar 2016 [71]	100	Medical students, India (18–22yrs)	• Aerobic dance for 45mins, 3x/wk, for 8wks	Usual care	Pain intensity via VAS	Statistically significant reduction in pain intensity
Yang 2016[65]	140	Nursing students, S Korea (20–23yrs)	• 60mins guided yoga, 1x/wk (poses, sun salutations, relaxation); for 12wks	Usual care - told not to do yoga	Pain intensity via VAS Pain duration	Statistically significant reduction in pain intensity No statistically significant reduction in pain duration
Yonglitthip agon 2017 [70]	34	Uni students, Thailand (18–22yrs)	• 30mins yoga taught by booklet, 2x/wk; for 12wks • Diary / weekly phone calls to check adherence	Usual care	Pain intensity via VAS	Statistically significant reduction in pain intensity

Figure legends

Figure 1 – PRISMA flow diagram.

*PRISMA flow diagram demonstrating flow of studies through identification process and eligibility screening *See Appendix C for further details*

Figure 2 – Risk of Bias Summary

Summary of Risk of Bias of included studies

Figure 3 – Pain intensity meta-analysis

Random effects meta-analysis of pain intensity via VAS in cm

Figure 4 – Pain duration meta-analysis

Random effects meta-analysis of pain duration in hours

Figure 5 - GRADE evidence profile

Evidence profile for pain intensity and pain duration

Appendix A – Search strategies

Medline / Medline in Process searched 05/24/17:

1 exp Dysmenorrhea/ 3600
2 dysmenorrh*.ti,ab. 4950
3 (menstrua* adj2 pain).ti,ab. 720
4 (menstrua* adj2 cramp).ti,ab. 7
5 (period* adj2 pain*).ti,ab. 1372
6 1 or 2 or 3 or 4 or 5 7684
7 exp Exercise/ or exp Exercise Therapy/ 184201
8 exp Physical Exertion/ or exp Physical Fitness/ 79696
9 exp running/ or exp swimming/ or exp walking/ 81381
10 exp tai ji/ or exp yoga/ 2941
11 exp dancing/ or exp gardening/ or exp sports/ 162811
12 exercis*.ti,ab. 245761
13 "physical activit*".ti,ab. 82503
14 sport*.ti,ab. 57350
15 stretch*.ti,ab. 62854
16 fitness.ti,ab. 55378
17 jog*.ti,ab. 2026
18 running.ti,ab. 49262
19 swim*.ti,ab. 32718
20 (cycl* adj2 train*).ti,ab. 2065
21 walk*.ti,ab. 93124
22 yoga.ti,ab. 3190
23 "tai ji".ti,ab. 25
24 "tai chi".ti,ab. 1249
25 pilates.ti,ab. 304
26 "physical training".ti,ab. 5245
27 "resistance training".ti,ab. 5278
28 (athlete* adj2 train*).ti,ab. 4489
29 "weight training".ti,ab. 914
30 isometric*.ti,ab. 30361
31 danc*.ti,ab. 5670
32 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 731463
33 6 and 32 312
34 randomized controlled trial.pt. 462560
35 controlled clinical trial.pt. 94063
36 randomized controlled trial.sh. 462560
37 random allocation.sh. 92576
38 double blind method.sh. 147085

39 single-blind method.sh. 24526
40 34 or 35 or 36 or 37 or 38 or 39 645852
41 (animals not human).sh. 6109803
42 40 not 41 571840
43 clinical trial.pt. 521341
44 exp clinical trial/ 803438
45 (clin$ adj25 trial$).ti,ab. 368228
46 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab. 161643
47 placebos.sh. 34931
48 placebo$.ti,ab. 192528
49 research design.sh. 96076
50 43 or 44 or 45 or 46 or 47 or 48 or 491211208
51 50 not 41 1110374
52 51 not 42 562047
53 comparative study.sh.1809971
54 exp evaluation studies/ 232296
55 follow up studies.sh. 586124
56 prospective studies.sh. 456986
57 (control$ or 31thlete3131ve$ or volunteer$).ti,ab. 3751440
58 53 or 54 or 55 or 56 or 57 5717430
59 58 not 41 4252943
60 59 not (42 or 52) 3578680
61 42 or 52 or 60 4712567
62 33 and 61 136

EMBASE searched 05/24/17:

1 exp Dysmenorrhea/ 9975
2 dysmenorrh*.ti,ab. 6530
3 (menstrua* adj2 pain).ti,ab. 993
4 (menstrua* adj2 cramp).ti,ab. 11
5 (period* adj2 pain*).ti,ab. 2026
6 1 or 2 or 3 or 4 or 5 13542
7 exp Exercise/ or exp Physical Activity/ 539709
8 exp Sport/ or exp Fitness/ 159023
9 exp dynamic exercise/ or exp isotonic exercise/ or exp anaerobic exercise/ or exp static exercise/ or exp aerobic exercise/ or exp isokinetic exercise/ 16049
10 exp stretching exercise/ or exp aquatic exercise/ or exp isometric exercise/ 5696
11 exp stretching/ or exp muscle stretching/ or exp muscle training/ or exp resistance training/ or exp pelvic floor muscle training/ 29219
12 exp running/ or exp swimming/ or exp walking/ 123921
13 exp jogging/ or exp pilates/2023

14 exp tai ji/ or exp yoga/ 7329
15 exp dancing/ or exp gardening/ or exp sports/ 133605
16 exercis*.ti,ab. 316216
17 “physical activit*”.ti,ab. 108960
18 sport*.ti,ab. 75241
19 stretch*.ti,ab. 66632
20 fitness.ti,ab. 61859
21 jog*.ti,ab. 2419
22 running.ti,ab. 59265
23 swim*.ti,ab. 38714
24 (cycl* adj2 train*).ti,ab. 2321
25 walk*.ti,ab. 124213
26 yoga.ti,ab. 4466
27 “tai ji”.ti,ab. 49
28 “tai chi”.ti,ab. 1729
29 pilates.ti,ab. 449
30 “physical training”.ti,ab. 6938
31 “resistance training”.ti,ab. 6242
32 (32thlete* adj2 train*).ti,ab. 5243
33 “weight training”.ti,ab. 997
34 isometric*.ti,ab. 34963
35 danc*.ti,ab. 7125
36 exp health care quality/ 2478747
37 random:.tw. 1190652
38 clinical trial:.mp. 1442523
39 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 1005054
40 36 or 37 or 38 4188607
41 6 and 39 and 40 243

PsycINFO searched 05/24/17:

1 exp Dysmenorrhea/ 190
2 dysmenorrh*.ti,ab. 304
3 (menstrua* adj2 pain).ti,ab. 122
4 (menstrua* adj2 cramp).ti,ab. 1
5 (period* adj2 pain*).ti,ab. 229
6 1 or 2 or 3 or 4 or 5 617
7 exp Exercise/ or exp Aerobic Exercise/ 22140
8 exp Physical Fitness/ or exp Physical activity/ 35122
9 exp running/ or exp swimming/ or exp walking/ 7599
10 exp yoga/ 1407

11 exp dancing/ or exp dance therapy/ 938
12 exp sports/ or exp athletic training/ 22874
13 exercis*.ti,ab. 52521
14 “physical activit*”.ti,ab. 26010
15 sport*.ti,ab. 27171
16 stretch*.ti,ab. 4142
17 fitness.ti,ab. 12800
18 jog*.ti,ab. 417
19 running.ti,ab. 12473
20 swim*.ti,ab. 8017
21 (cycl* adj2 train*).ti,ab. 217
22 walk.ti,ab. 6195
23 yoga.ti,ab. 2052
24 “tai ji”.ti,ab. 5
25 “tai chi”.ti,ab. 443
26 pilates.ti,ab. 55
27 “physical training”.ti,ab. 520
28 “resistance training”.ti,ab. 484
29 (33thlete* adj2 train*).ti,ab. 797
30 “weight training”.ti,ab. 178
31 isometric*.ti,ab. 1865
32 danc*.ti,ab. 6309
33 (control: or random*.tw. or exp treatment/ 1218890
34 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 150179
35 6 and 33 and 34 23

CINAHL searched 05/24/17:

1 MH exercise OR MH exercise therapy OR MH physical exertion OR MH physical fitness OR MH locomotion OR MH exercise movement techniques OR MH recreation 48,339S14
2 AB dysmenorrh* OR AB “menstrual cramp*” OR AB “menstrual pain” OR AB “period pain” OR AB “painful periods” OR AB “painful menstrua*” 858
3 TI dysmenorrh* OR TI “menstrual cramp*” OR TI “menstrual pain” OR TI “period pain” OR TI “painful periods” OR TI “painful menstrua*” 573
4 KW dysmenorrh* OR KW “menstrual cramp*” OR KW “menstrual pain” OR KW “period pain” OR KW “painful periods” OR KW “painful menstrua*” 15,172
5 2 OR 3 OR 4 1,147
6 AB “physical activit*” OR AB 33thlete33* OR AB (stretch* or isometric) OR AB (fitness or sport*) OR AB “physical training” OR AB “weight training”

OR AB “resistance training” OR AB (jog* or running or swim* or walk* or danc*) OR AB (yoga or “tai ji” or “tai chi” or pilates) 131,871
7 TI “physical activit*” OR TI 34thlete34* OR TI (stretch* or isometric) OR TI (fitness or sport*) OR TI “physical training” OR TI “weight training” OR TI “resistance training” OR TI (jog* or running or swim* or walk* or danc*) OR TI (yoga or “tai ji” or “tai chi” or pilates) 97,173
8 KW “physical activity” OR KW exercise 35
9 6 OR 7 OR 8 182,705
10 1 OR 9 202,476
11 MH dysmenorrhea 1,025
12 5 OR 11 1,566
13 10 AND 12 95
14 Limiters – Clinical Queries: Therapy – High Sensitivity 46

SPORTDiscus searched 05/24/17:

1 AB dysmenorrh* OR AB “menstrual cramp*” OR AB “menstrual pain” OR AB “period pain” OR AB “painful periods” OR AB “painful menstrua*” 157
2 TI dysmenorrh* OR TI “menstrual cramp*” OR TI “menstrual pain” OR TI “period pain” OR TI “painful periods” OR TI “painful menstrua*” 60
3 KW dysmenorrhea OR KW dysmenorrhoea 35
4 1 OR 2 OR 3 190
5 AB “physical activit*” OR AB 34thlete34* OR AB (stretch* or isometric) OR AB (fitness or sport*) OR AB “physical training” OR AB “weight training” OR AB “resistance training” OR AB (jog* or running or swim* or walk* or danc*) OR AB (yoga or “tai ji” or “tai chi” or pilates) 420,655
6 TI “physical activit*” OR TI 34thlete34* OR TI (stretch* or isometric) OR TI (fitness or sport*) OR TI “physical training” OR TI “weight training” OR TI “resistance training” OR TI (jog* or running or swim* or walk* or danc*) OR TI (yoga or “tai ji” or “tai chi” or pilates) 272,594
7 KW “physical activity” OR KW exercise 20,595
8 5 OR 6 OR 7 556,573
9 4 AND 8 53

AMED searched 05/24/17:

1 AB dysmenorrh* OR AB “menstrual cramp*” OR AB “menstrual pain” OR AB “period pain” OR AB “painful periods” OR AB “painful menstrua*” 120
2 TI dysmenorrh* OR TI “menstrual cramp*” OR TI “menstrual pain” OR TI “period pain” OR TI “painful periods” OR TI “painful menstrua*” 130
3 KW dysmenorrhea OR KW dysmenorrhoea 116
4 1 OR 2 OR 3 195

5 AB “physical activit*” OR AB 35thlete35* OR AB (stretch* or isometric) OR AB (fitness or sport*) OR AB “physical training” OR AB “weight training” OR AB “resistance training” OR AB (jog* or running or swim* or walk* or danc*) OR AB (yoga or “tai ji” or “tai chi” or pilates) 24,404
6 TI “physical activit*” OR TI 35thlete35* OR TI (stretch* or isometric) OR TI (fitness or sport*) OR TI “physical training” OR TI “weight training” OR TI “resistance training” OR TI (jog* or running or swim* or walk* or danc*) OR TI (yoga or “tai ji” or “tai chi” or pilates) 19,137
7 KW “physical activity” OR KW exercise 15,600
8 5 OR 6 OR 7 36,091
9 4 AND 8 7

Cochrane searched 05/24/17:

1 “dysmenorrhea”:ti,ab,kw (Word variations have been searched) 1188
2 MeSH descriptor: [Dysmenorrhea] explode all trees 465
3 “menstrual cramps”:ti,ab,kw 27
4 “period pains”:ti,ab,kw 4
5 “painful menstruation”:ti,ab,kw 17
6 “menstrual pain”:ti,ab,kw 174
7 1 or 2 or 3 or 4 or 5 or 6 1235
8 MeSH descriptor: [Exercise] explode all trees 18710
9 MeSH descriptor: [Exercise Therapy] explode all trees 10374
10 MeSH descriptor: [Physical Exertion] explode all trees 3389
11 MeSH descriptor: [Physical Fitness] explode all trees 2648
12 MeSH descriptor: [Running] explode all trees 1599
13 MeSH descriptor: [Swimming] explode all trees 407
14 MeSH descriptor: [Walking] explode all trees 3482
15 MeSH descriptor: [Sports] explode all trees 12907
16 MeSH descriptor: [Yoga] explode all trees 513
17 MeSH descriptor: [Tai Ji] explode all trees 343
18 MeSH descriptor: [Dancing] explode all trees 128
19 “35thlete35*”:ti,ab,kw 57524
20 “physical activit*”:ti,ab,kw 13568
21 sport*:ti,ab,kw 4824
22 stretch*:ti,ab,kw 2968
23 fitness:ti,ab,kw 6049
24 jog*:ti,ab,kw 318
25 running:ti,ab,kw 3623
26 swim*:ti,ab,kw 813
27 “cycl* train*”:ti,ab,kw 129
28 walk*:ti,ab,kw 14632
29 yoga:ti,ab,kw 1449
30 “tai chi”:ti,ab,kw 666

31 “tai ji”:ti,ab,kw 355
32 pilates:ti,ab,kw 187
33 “physical training”:ti,ab,kw 1083
34 “resistance training”:ti,ab,kw 4765
35 “weight training”:ti,ab,kw 310
36 isometric:ti,ab,kw 3299
37 danc*:ti,ab,kw 488
38 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 81187
39 7 and 38 40

Web of Science searched 05/24/17:

1 TS=(dysmenorrh*) 3,781
2 TS=(“menstrual cramp*”) 72
3 TS=(menstru* NEAR/1 pain*) 634
4 TS=(period$ NEAR/1 pain*) 811
5 4 OR 3 OR 2 OR 1 4,861
6 TS=(“physical activit*”) 120,487
7 TS=(36thlete36*) 346,079
8 TS=(sport*) 103,132
9 TS=(stretch*) 145,828
10 TS=(fitness) 104,942
11 TS=(jog*) 3,483
12 TS=(running) 408,116
13 TS=(swim*) 52,369
14 TS=(cycl* NEAR/2 train*) 3,333
15 TS=(walk*) 171,784
16 TS=(yoga) 3,304
17 TS=(“tai ji”) 61
18 TS=(“tai chi”) 1,945
19 TS=(pilates) 341
20 TS=(“physical training”) 5,087
21 TS=(“resistance training”) 6,810
22 TS=(36thlete* NEAR/2 train*) 5,548
23 TS=(“weight training”) 1,330
24 TS=(isometric*) 35,686
25 TS=(danc*) 15,569
26 25 OR 24 OR 23 OR 22 OR 21 OR 20 OR 19 OR 18 OR 17 OR 16 OR 15 OR 14 OR 13 OR 12 OR 11 OR 10 OR 9 OR 8 OR 7 OR 6 1,340,672
27 26 AND 5 231

PEDro searched 05/24/17:

1	dysmenorrh* AND exercise*	17
2	dysmenorrh* AND physical activit*	3
3	dysmenorrh* AND yoga	6
4	dysmenorrh* AND stretch*	28

Clinicaltrials.gov searched 05/24/17:

Condition: dysmenorrhoea OR “menstrual cramps” OR “menstrual pain” OR “period pain” OR “painful periods” OR “painful menstruation”
Intervention: “physical activity” OR exercise OR sport OR stretch OR fitness OR “physical training” OR “resistance training” OR “weight training” OR jogging OR running OR walking OR swimming OR yoga OR “tai chi” OR pilates (searches both tai ji and tai chi)
13

WHO ICTRP searched 05/24/17:

Condition: dysmenorrhea OR dysmenorrhoea OR menstrual cramps OR menstrual pain OR period pain OR painful periods OR painful menstruation
Intervention: physical activity OR exercise OR sport OR stretch OR fitness OR physical training OR resistance training OR weight training OR jogging OR running OR walking OR swimming OR yoga OR tai chi OR pilates
11

OpenGrey searched 05/24/17:

Dysmenorrhea	1
Dysmenorrhoea	6
Menstrual + exercise	11
Menstrual + sport	3
Menstrual + yoga	0
Menstrual + physical activity	0

Google searched 05/24/17:

Google was searched using the terms “dysmenorrhea” and “exercise”; all returns up to page 15 were reviewed at which point no new returns were being identified. This was repeated with the alternative spelling “dysmenorrhoea”.
The Menstruation Research website was also searched in greater detail (menstruationresearch.org)

Appendix B - Database search returns

Database	Interface	Dates	Returns
MEDLINE and MEDLINE In Process	Ovid	1946 – 05/24/17	136
EMBASE	Ovid	1974 – 05/24/17	243
PsycINFO	Ovid	1806 – 05/24/17	23
Cochrane Database of Systematic Reviews (CDSR)	Cochrane Library	N/A	40 total*
Cochrane Central Register of Controlled Trials (CENTRAL)	Cochrane Library	1966 – 05/24/17	
CINAHL	EBSCO	1937 – 05/24/17	46
SPORTDiscus	EBSCO	1980 – 05/24/17	53
AMED (Allied and Complimentary Medicine Database)	EBSCO	1995 – 05/24/17	7
PEDro	NeuRA	1929 – 05/14/17	41
Science Citation Index	Web of Science	1964- 05/24/17	231 total*
Conference Proceedings Citation Index	Web of Science	1990 – 05/24/17	
Social Sciences Citation Index	Web of Science	1900 – 05/24/17	
Conference Proceedings Citation Index – Social Sciences and Humanities	Web of Science	1990 – 05/24/17	
Clinicaltrials.gov	National Institute of Health	To 05/24/17	13
WHO ICTRP	WHO	To 05/24/17	11
OpenGrey	SIGLE	1993 – 05/24/17	21
Google	Google	N/A	42 new
Citation searching	N/A	N/A	1 new

SCI/CPCI/SSCI/SS-CPCI and CDSR/CENTRAL were searched simultaneously; there is therefore no individual return numbers for these databases.

Appendix C – Excluded studies with reasons for exclusion

A reference list of excluded studies can be obtained from the study authors

Study	**Reason for exclusion**
Abbaspour 2006	No inclusion / exclusion criteria reported, no reply from authors
ACTRN12613001195741	Registered trial and feasibility study, contacted authors who have completed trial and are in process of publishing, however unwilling to share any of data
Anonymous 1945	Letter
Anonymous 1960	Letter
Anonymous 1993	Review
Arora 2014	No inclusion / exclusion criteria reported, no reply from authors
Azima 2015a	Two arm trial which is also reported as 3 arm trial - see Azima 2015b below
Azima 2015b	No inclusion / exclusion criteria in either of papers reporting trial, protocol contains some inclusion / exclusion criteria but does not specify regarding secondary dysmenorrhoea, irregular menstruation or hormonal contraception
Chaudhuri 2013	Some participants were athletes, also some had irregular periods (from correspondence with author)
Chien 2013	Non-randomized controlled trial
Dehghanzadeh 2014	Before and after trial
DeWitt 1981	Asked women about hormonal contraception but did not specify whether these women were excluded
El Refaye 2007	Thesis, no online abstract, unable to obtain full text through inter-library loans, no contact details for authors
Gamit 2014	Physical activity intervention for four weeks only
Golub 1960	Non-randomized controlled trial
Golub 1963	Before and after trial
Halder 2012	Non-randomized controlled trial
Haman1945	Before and after trial
Harris 1955	Before and after trial
Heidarianpour 2016	Menstrual characteristics, dysmenorrhoea considered but did not exclude secondary dysmenorrhoea
Huang 2007	No inclusion / exclusion criteria reported, unable to find contact details for authors
Hubbell 1949	Non-randomized controlled trial
IRCT2013071013940N1	Registered trial, results published in Behbahani 2016
IRCT2016103119024N2	Registered trial, unable to find published paper, contacted authors and no reply; probably still ongoing as only registered in 2016
ISRCTN75567759	Registered trial and published protocol, mixed-methods study with no randomization
Jahromi 2008	Before and after trial

Kang 2009	Thesis, unable to obtain full text through inter-library loans, no contact details for authors
Kanwal 2016	Physical activity intervention for one month only
Kashef 2014	Physical activity intervention for four weeks only
Khare 2016	Physical activity interevention for three weeks only
Kaur 2014	Unclear whether secondary causes excluded. No contact details for authors. Mentions randomization in abstract but in text participants are "taken at random"
Kumar 2013	No inclusion / exclusion criteria reported, unable to find contact details for authors
Locke 1999	Review
Locke 1999	Review
Lundquist 1947	Non-randomized controlled trial
Mahishale 2013	Physical activity intervention for one menstrual cycle only
Mahvash 2012	Unclear whether those on hormonal contraception or with irregular periods were excluded as no inclusion / exclusion criteria were given. No contact details found
Mathur 1986	Non-randomized controlled trial
Monika 2012	Hormonal contraception specifically provided to the groups
Motesharee 2013	Hormonal contraception / irregular periods not excluded
Nag 2013	No inclusion / exclusion criteria reported, unable to find contact details for authors. Unclear whether athletes included (although have excluded those already practicing yoga), whether those on hormonal contraception or with irregular periods were excluded.
Pazoki 2013	Pre-menstrual symptoms; dysmenorrhoea considered but did not exclude secondary dysmenorrhoea
Pazoki 2016	Pre-menstrual symptoms; dysmenorrhoea considered but did not exclude secondary dysmenorrhoea
Rani 2013	Hormone profiles assessed as outcome
Roozbahani 2015	Did not exclude secondary dysmenorrhoea
Rezvani 2013	Unclear whether women using hormonal contraception were excluded, no reply from authors
Rong 2013	Unclear whether athletes or women using hormonal contraception were excluded, unable to find contact details for authors
Shah 2016	No inclusion / exclusion criteria, no reply from authors
Steege 1993	Pre-menstrual symptoms; dysmenorrhoea considered but did not exclude secondary dysmenorrhoea
Thomas 2010	Physical activity intervention for 3 weeks only
Vaziri 2015	Menstrual symptoms assessed as outcome, unable to extract data about pain
Wilt 1976	Not specified whether those with secondary cause excluded, unable to obtain information from authors as no contact details
Yeknami 2015	No inclusion / exclusion criteria, no reply from authors

Appendix D – Risk of Bias Assessment

	Risk of Bias	**Justification**
Random sequence generation	*Low / High / Unclear*	
Allocation concealment	*Low / High / Unclear*	
Blinding to study group / study purpose	*Low / High / Unclear*	Studies were considered at high risk of bias if they reported that no blinding was done, or blinding was not reported but the comparator group received no intervention.
Blinding of outcome assessment	*Low / High / Unclear*	
Incomplete outcome data	*Low / High / Unclear*	
Selective outcome reporting	*Low / High / Unclear*	
Other bias (observer bias, recall bias, contamination, co-interventions, Hawthorne effect)	*Low / High / Unclear*	Studies were considered at high risk of bias if one of these biases was present. If none of these biases were adequately described studies were considered at unclear risk of bias Interviewer bias - high risk if outcomes assessed during interview Recall bias – high risk if outcomes assessed more than one day after the end of menstruation Contamination – high risk if participants were from schools / colleges / individual courses unless cluster randomized Co-interventions – high risk if there was a co-intervention or physical activity was performed in a group Hawthorne effect – high risk if physical activity was performed in a group or closely monitored setting

Appendix E - Reasons For Exclusion From Meta-Analysis

	Pain intensity	**Pain duration**	**Absenteeism**
Aboushady 2016	Only reported for intervention group	Included	Not reported
Behbahani 2016	Pain intensity reported via McGill questionnaire	Not reported	Not reported
Kaur 2013	Included	Not reported	Not reported
Motahari-Tabari 2017	Included	Included	No measure of variance given
Nasri 2016	Included	Included	Not reported
Ortiz 2015	Included, derived from graph	Not reported	Not reported
Patel 2015	Included	Not reported	Not reported
Rakhshaee 2011	VAS reported as 0 to 3 categorical scale	Included in cluster randomised meta-analysis	Not reported
Reyhani 2013	Included	Not reported	Not reported
Saleh 2016	Included	Included	Not reported
Shahr-Jerdy 2012	Cluster randomised; no other clusters to combine with	Included in cluster randomised meta-analysis	Not repeated
Siahpour 2013	Included	Included	Not reported
Sutar 2016	No measure of variance given	Not reported	Not reported
Yang 2016	Included	Included	Not reported
Yonglitthipagon 2017	Included	Not reported	Not reported