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REVIEW ARTICLE

The effect of antenatal pelvic floor muscle training on labor and delivery outcomes: a systematic review with meta-analysis

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Abstract
Introduction and hypothesis Pelvic floor muscle training (PFMT) has been widely used to prevent and treat urinary incontinence; however, the possible effect of antenatal PFMT on labor and delivery is still not clear. The purpose of the study was to investigate the possible effect of antenatal PFMT on labor and delivery.
Methods A systematic review of the scientific literature was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement. Randomized or quasi-randomized controlled studies of an obstetric population who had done antenatal PFMT met the inclusion criteria. Data about labor and delivery outcomes included the first stage of labor, the second stage of labor, episiotomy, instrumental delivery, and perineal laceration. The nine English and four Chinese databases were searched from their inception through November 6, 2014. Fixed or random effects models were selected based on study heterogeneity. The weighted mean differences (WMDs) and odds ratios (ORs) with the corresponding 95 % confidence intervals (CIs) were calculated to assess the association between PFMT and the labor and delivery outcomes.
Results Twelve studies were identified, involving a total of 2,243 women, in which 1,108 were PFMT and 1,135 controls. They indicated that PFMT during pregnancy significantly shortened the first and second stage of labor in the primigravida (WMD = −28.33, 95 % CI: −42.43 to −14.23, I^2= 0.0 % , and WMD = −10.41, 95 % CI: −18.38 to −2.44, I^2= 64.0 % respectively). In the subgroup analysis on the second stage of labor, heterogeneity decreased for subgroups of China and European countries (I^2=0.0 %, P=0.768 and I^2= 0.0 %, P=0.750 respectively), but statistically significant association only existed in the subgroup of China (WMD = −17.42, 95 % CI: −23.41 to −11.43). When evaluating the effect on the rates of episiotomy, instrumental delivery and perineal laceration, the meta-analysis showed that the results were not significant (OR=0.75, 95 % CI: 0.54 to 1.02; OR=0.84, 95 % CI: 0.61 to 1.17 and OR=0.96, 95 % CI: 0.66 to 1.40 respectively).
Conclusions Antenatal PFMT might be effective at shortening the first and second stage of labor in the primigravida. The moderate heterogeneity for the second stage of labor data need further study. Antenatal PFMT may not increase the risk of episiotomy, instrumental delivery, and perineal laceration in the primigravida.

Keywords Delivery · Labor · Meta-analysis · Pelvic floor muscle · Training

Yihui Du and Li Xu contributed equally to this work.

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Introduction

Pregnancy and vaginal delivery may cause weakness of the pelvic floor muscles (PFM) [1], which can lead to the development of urinary incontinence [2]. Since Kegel [3] first proposed pelvic floor muscle training (PFMT) in 1948 as a method of reducing urinary incontinence, this procedure has been widely mentioned and documented in published reports [4–8]. PFMT, as a kind of conservative intervention, was defined as a program of repeated voluntary pelvic floor muscle contractions taught and supervised by a healthcare professional [9]. Many studies have demonstrated that training the PFM during pregnancy can prevent and treat urinary incontinence [10–12]. Therefore, pregnant women are encouraged to do exercises for these muscles. There is, however, scant knowledge about the influence of the PFMT on labor and delivery outcome [13] . A study conducted by Aran T et al. showed that reduced strength of the PFM was associated with an abnormally prolonged first stage of labor, and strong PFM might preclude the descent or rotational movements of the fetal head [14]. Anecdotal evidence suggests that an excessively strong PFM (for example, as a result of horse riding) might obstruct labor and result in perineal trauma, which negates the beneficial effects of antenatal PFMT. Others believe, however, that it produces flexible, well-controlled muscles that can facilitate labor and reduce the need for instrumental delivery [15].

Boyle et al. investigated the effect of antenatal pelvic floor muscle training on urinary and fecal incontinence outcome [9]. In this article, urinary and fecal incontinence were the primary outcome, and labor and delivery outcomes were reported as “other outcomes of interest”, which means Boyle et al. excluded trials from their review that did not measure incontinence outcomes (yet did contain labor and delivery data). The current systematic review is an opportunity to address this lack. Boyle et al. has demonstrated that PFMT in women having their first baby could prevent urinary incontinence in late pregnancy and postpartum [9], but the possible effects of PFMT on labor is still not clear. This study was aimed at undertaking a systematic review of randomized or quasi-randomized controlled trials, to evaluate the available scientific evidence about the effectiveness of isolated pelvic floor muscle programs, without the use of any other kind of device, during pregnancy.

Materials and methods

Literature searches

This systematic review and meta-analysis was conducted using the guidelines set forth in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [16]. In this study, articles published in English as well as those published in Chinese were considered. Articles published in English were identified through PubMed, Elsevier ScienceDirect, Web of Science, Cochrane Library databases, EBSCO (Academic Search Complete and Business Source Complete), Scopus, EMBASE, Cumulative Index to Nursing and Allied Health Literature (CINHAL), and Current Controlled Trials. Those published in Chinese were found through China National Knowledge Infrastructure (CNKI), Database of Chinese Scientific and Technical Periodicals (VIP), Wan Fang database, and the China biology medical literature database (CBM). The nine English and four Chinese databases were searched from their inception through to November 6, 2014. The following keywords were chosen: (“pelvic floor muscle” or “PFM” or “perineal”) and (“training” or “exercise”) and (“antenatal” or “pregnant” or “pregnancy” or “conceive” or “conception”) and (“labor”’ or “delivery”). The subjects of studies were defined as humans, and the languages of articles were limited to English and Chinese because the reviewers are fluent in both of these languages. The reference lists from the selected studies were also checked to identify other studies that could have been missed by the electronic keyword search. Registries of randomized controlled trials were reviewed to identify unpublished studies.

Eligibility criteria

To be included in this analysis, a study must have met the following inclusion criteria: (1) the study population was a sample of an obstetric population, (2) the training group had done antenatal PFMT, and all types of PFMT programs were considered, including using variations in the ways of teaching PFMT, types of contractions (fast or sustained), and number of contractions, (3) labor and delivery outcomes of interest were the first stage of labor, the second stage of labor, episiotomy, instrumental delivery (vacuum extraction or forceps or both) and perineal laceration, one of which was reported in an article, and (4) original studies which were randomized or quasi-randomized controlled trial design. Studies that used vaginal cones, electrical muscle stimulation, and biofeedback for perineal muscle strengthening were excluded. Titles and abstracts identified by electronic searches were examined independently by two researchers (YH Du and L Xu) on-screen, to select potentially relevant studies. If multiple articles were published from the same randomized or quasi-randomized controlled trail, the study that provided more detailed information was included.

Definition of five labor and delivery outcomes

The first stage of labor was defined as the period from regular uterine contraction to total cervix dilatation. The second stage of labor was the period from total cervix dilatation to the exit of the newborn. Episiotomy is a surgical enlargement of the vaginal orifice by an incision to the perineum during the last part of the second stage of labor or delivery. Women with episiotomy, regardless of the type, such as median episiotomy and mediolateral episiotomy, in the original article, were included in the study group. Instrumental delivery in the meta-analysis included vacuum extraction and forceps delivery.

Women who underwent vacuum extraction or forceps delivery during the labor were regarded as cases, and women with no instrumental delivery were included in the control group. Women with first- or second- or third- or fourth-degree perineal laceration comprised the study group, whereas women with no laceration comprised the control group.

Data extraction and quality assessment

The following items were extracted from each identified study: name of the first author, published journal, year of publication, country, samples, mean age, interventions in training and control groups, beginning and duration of training program, training program and labor and delivery outcomes information about vaginal delivery in the PFMT and control groups. Some articles [15, 17] provided the median and range of the second stage of labor, so simple and elementary inequalities [18] were used to estimate the mean and standard deviation of such trials. The methodological quality of the included trials was evaluated using the risk of bias tool developed for The Cochrane Collaboration [19], and Review Manager 5.1 statistical software was used. The methods of random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias were considered, and each category was deemed at low, high, or unclear risk of bias. Where there was insufficient information to make a clear decision, trials were rated as 'unclear risk'. Data extraction was performed by independent investigators (YH Du and YP Wang) and data entry was cross-checked. Quality evaluation was performed by YH Du and ZP Wang. Any disagreements encountered thereupon were settled through discussion.

Statistical analysis

Five outcomes including the first stage of labor, second stage of labor, episiotomy, instrumental delivery (vacuum extraction or forceps or both), and perineal laceration were reviewed in this systematic review with meta-analysis. to here

The weighted mean differences (WMDs) and odds ratios (ORs) with the corresponding 95 % confidence intervals (CIs) were calculated to assess the association between PFMT and the labor and delivery outcomes. WMD is a standard statistic that measures the absolute difference between the mean values in two groups in a clinical trial. I^2 was calculated using Stata12.0 to assess statistical heterogeneity. I^2 describes the percentage of the variability, in effect estimates what is due to heterogeneity rather than sampling error (chance). A value of greater than 50 % may be considered to be substantial heterogeneity [19]. When trials were statistically homogeneous ($I^2 \leq 50$ %), pooled effects (WMDs) were calculated by use of a fixed-effects model. When trials were statistically heterogeneous ($I^2 \geq 50$ %), estimates of pooled effects (WMDs) were obtained by use of a random effects model [19]. If $I^2 \geq 50$ %, subgroup analysis and sensitivity analysis were conducted to explore the possible sources of between-study heterogeneity. Publication bias was estimated using a funnel plot, and then assessed formally with Begg's test. Stata version 12.0 (Stata Corporation, College Station, TX, USA) statistical software was used for statistical procedures and a significance level of 0.05 was adopted for the tests.

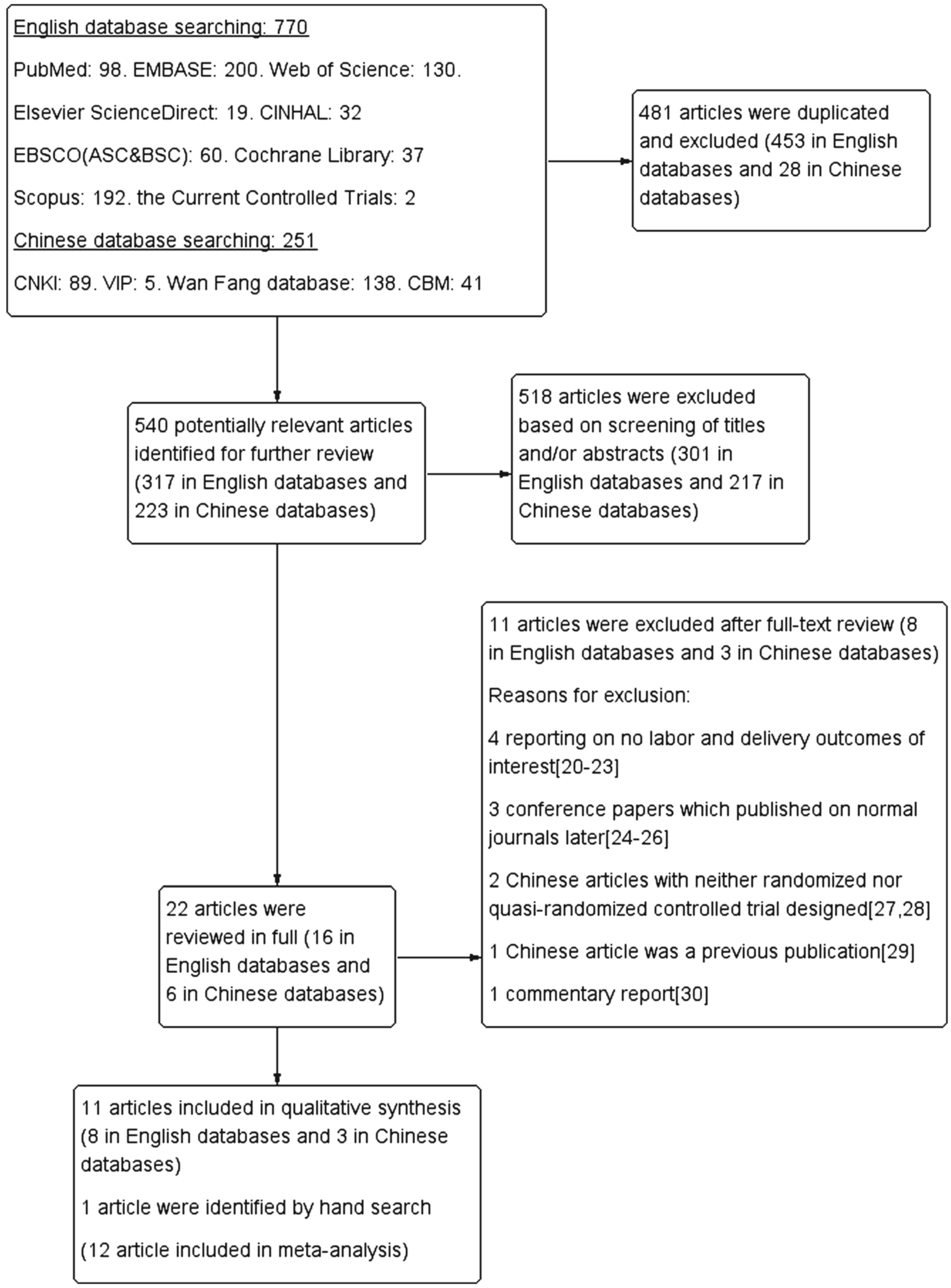
Results

Characteristics of eligible studies

The primary search carried out on the labor and delivery outcomes after antenatal PFMT generated 1,021 potentially relevant articles (770 in English databases and 251 in Chinese databases) in the English and Chinese databases. No unpublished studies were identified from the registries of randomized controlled trials. The articles that were excluded comprised 481 articles (453 in English databases and 28 in Chinese databases) which were found to be duplicated among databases; 514 articles (301 in English databases and 213 in Chinese databases) were also excluded based on the screening of titles or abstracts or both, and 11 articles (eight in English databases and three in Chinese databases) were excluded after a full-text review. The 11 articles excluded had four reporting on no labor and delivery outcomes of interest [20–23], three conference papers which published in normal journals later (the data in articles published in normal journals were extracted) [24–26], two Chinese articles with neither randomized nor quasi-randomized controlled trial design [27, 28], one Chinese article for duplicate publication [29] and one commentary report [30]. One article was identified by hand search. Ultimately 12 studies (eight in English databases and four in Chinese databases) [2, 12, 15, 17, 31–38] (11 were randomized controlled trial design and one [31] was quasi-randomized controlled trial design) were included, involving a total of 2,243 women, in whom 1,108 were PFMT and 1,135 controls. The inclusion of these 12 studies is shown in Fig. 1. Of the 12 articles, three studies [32–34] that all were trials conducted in China provided data for the first stage of labor, seven studies [2, 15, 17, 32–35] for the second stage of labor, seven studies [2, 12, 17, 34–37] for episiotomy, seven studies [2, 12, 15, 17, 31, 35, 38] for instrumental delivery (vacuum extraction or forceps or both), and six studies [2, 12, 34–37] for perineal laceration.

The results of the methodological quality of the studies are presented in Table 1, Figs. 1 and 2 (supplementary material), which show a summary of the risk of bias for all the trials included in the review. Two trials conducted by Nielsen [17]

Fig. 1 Selection of studies for inclusion in meta-analysis



and Ya Li [31] were noted as having a high risk of selection bias. The former was because the primiparas were not randomly allocated to a training or control group, and the latter was because of no description of allocation concealment. It was not considered feasible, in any of the included trials, to blind the treatment provider or participants to group allocation, and so all 12 trials were at high risk of performance bias; the difficulty of blinding exercise-based interventions is a common problem. The risk of bias assessment in Table 1 shows the possible risk of bias other than performance bias in each trial.

The general characteristics of the studies included in this systematic review are shown in Table 1. Five out of 12 trials were conducted in China, six trials in Europe and one trial in Latin America. The age of the participants was described in a number of ways. In ten trials, age was reported comparable at baseline in the comparison groups, and it was not clear if it was comparable in two trials [17, 38].

The characteristics about PFMT are shown in Table 2. The participants in all trials were primigravida or nulliparous women carrying their first baby. Seven out of 12 trials clearly stated that they had selected women carrying a singleton fetus.

Table 1 General characteristics of the studies included in this meta-analysis

First author	Year	Country	Age	No.	No. of vaginal delivery	First stage of labor (min) mean±SD	Second stage of labor (min) mean±SD	No. of episiotomy	No. of instrumental delivery	No. of perineal laceration (I°/II°/III°/IV°)	Risk of bias assessment*
Nielsen CA	1988	Denmark	18–37	TG: 38 CG: 39	34 36	none [b]	37±20 39±20	22 26	7 5	none [b]	no description of allocation concealment
Salvesen KA	2004	Norway	TG: 28.0±5.3 CG: 26.9±3.9	TG: 148 CG: 153	111 113	none [b]	different definition[a]	56 72	15 19	7 9	no evidence of bias
Agur W	2008	UK	TG: 27 CG: 29	TG: 139 CG: 129	109 105	none [b]	89.82±33.5 89.64±37.67	none [b]	24 26	none [b]	no evidence of bias
Zhou YH	2009	China	TG: 29.74±4.42 CG: 27.77±3.40	TG: 63 CG: 70	22 30	970.0±24.8 994.7±36.3	59.64±27.66 75.70±16.65	none [b]	none [b]	none [b]	no evidence of bias
Li Y	2010	China	none [b]	TG: 52 CG: 69	32 37	none [b]	none [b]	none [b]	1 2	none [b]	no description of random sequence generation
Gaier L	2010	Italy	TG: 25.68±4.22 CG: 26.79±3.72	TG: 65 CG: 62	none [b]	none [b]	none [b]	2 6	none [b]	1 3	no evidence of bias
Mason L	2010	England	28.6 (18.4-48.2)	TG: 140 CG: 142	101 107	none [b]	none [b]	39 34		45 48	no evidence of bias
Po-Chun Ko	2011	Taiwan. China	TG: 31.66±3.42 CG: 31.29±3.78	TG: 150 CG: 150	102 107	none [b]	none [b]	99 104	6 7	10 10	no evidence of bias
Dias LAR	2011	Brazil	TG: 23.1±5.1 CG: 23.7±4.8	TG: 21 CG: 21	16 11	none [b]	21.8±17.6 41.1±53.5	8 5	3 4	5 2	no evidence of bias
Fritel X	2012	France	28.2 (17–41) 28.3 (17–40)	TG: 141 CG: 145	none [b]	none [b]	none [b]	none [b]	29 35	none [b]	no evidence of bias
Wang X	2014	China	TG: 27.31±2.94 CG: 26.58±3.04	TG: 51 CG: 55	35 28	453.0±156.0 520.2±136.2	36.0±18.0 49.8±31.8	24 26	none [b]	4 2	no evidence of bias
Huang JT	2014	China	TG: 26.73±4.5 CG: 26.88±4.59	TG: 100 CG: 100	78 53	436.8±64.2 469.8±92.4	36±11.4 55.2±27.6	none [b]	none [b]	none [b]	no evidence of bias

TG: training group; CG: control group

a: the article provided different definition of the second stage of labor

b: the article offered no corresponding data

*:The risk of bias assessment did not include performance bias

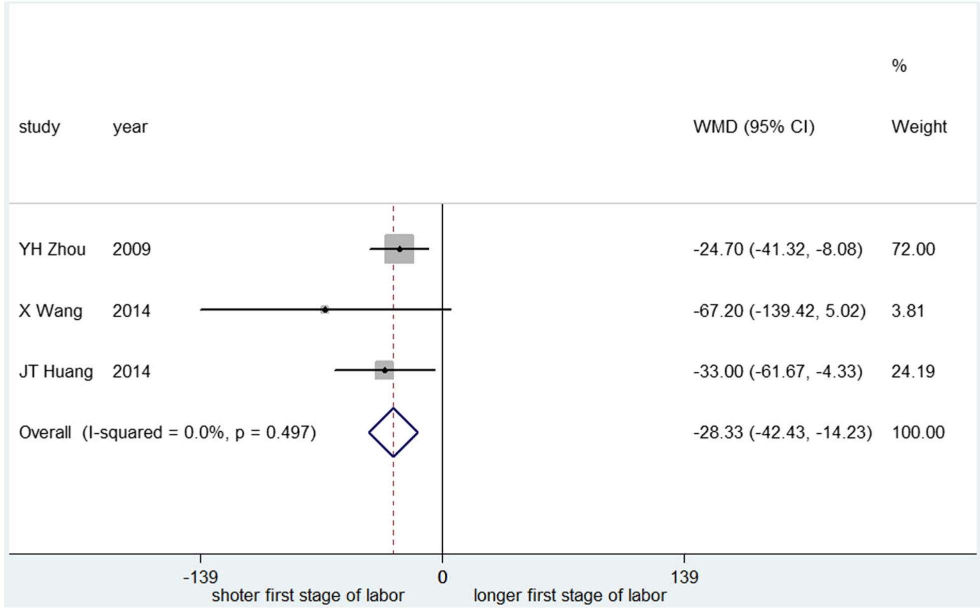


Fig. 2 Forest plots of random effects meta-analysis for the association between PFMT during pregnancy and the first stage of labor (three studies included). *WMD*, weighted mean difference. *CI* indicates confidence interval

Three trials excluded twin pregnancy from the analysis. Two trials did not provide relevant information about this. The characteristics of PFMT varied among trials. One study [31] initiated the exercise program from the 28th gestational week until delivery. In three trials [2, 15, 35], the participants began training from the 20th gestational week. The duration of training varied from 8 weeks to 20 weeks. Four trials reported that the method of intervention delivered was in class or course or session, and in three trials the participants were instructed individually. The other five did not provide enough information to make the method of intervention clear. Eleven out of 12 trials stated clearly that PFMT was supervised by a physiotherapist or health education nurse. Four trials [15, 32, 33, 35] indicated that participants' compliance was monitored using diaries or a recording form. The PFMT program in the trials differed from each other. The frequency of contraction ranged from one to 12, and the duration of holding per contraction from 3 to 10 s. Three trials [12, 15, 35] ensured that all women included in the study were able to perform a correct PFM contraction before training.

Antenatal PFMT and the first stage of labor

The relationship between antenatal PFMT and the first stage of labor compared with the controls is shown in Fig. 2. Three articles were included in this meta-analysis. The fixed-effect model was chosen, according to the heterogeneity (I^2=0.0 %, P=0.497), to evaluate the pooled weighted mean difference (WMD). The result shows that antenatal PFMT significantly shortens the first stage of labor (WMD = −28.33, 95 % CI: −42.43 to −14.23), which means the first stage of labor in the PFMT group reduced by 28.33 minutes on average compared with the controls.

Antenatal PFMT and the second stage of labor

The relationship between antenatal PFMT and the second stage of labor compared with the controls is shown in Fig. 3. One study [2] was excluded from analysis because it had a different definition for the second stage of labor; therefore, six articles were included when reviewing. The random-effect model was chosen, according to the heterogeneity (I^2=64.0 %, P=0.016), to evaluate the pooled WMD. The result shows that antenatal PFMT significantly shortens the second stage of labor (WMD = −10.41, 95 % CI: −18.38 to −2.44), which means the second stage of labor in the PFMT group diminished by 10.41 minutes on average compared with the controls.

Subgroup analysis and sensitivity analysis

There was moderate heterogeneity (I^2=64.0 %) observed among six studies in the above mentioned random-effect model. To explore the source of heterogeneity, firstly we divided the six studies into subgroups by countries (China versus European countries versus Brazil) and the risk of bias assessment result. Subsequently, given the comparability of age of participants, body mass index (BMI) before pregnancy, gestational weeks, and baby birth weight in PFMT and control groups described in the included trials, which possibly influences the association between antenatal PFMT and the second stage of labor and leads to heterogeneity, we also conducted subgroup analyses by whether they were comparable in two groups described in the included trials. The result is shown in Table 3. In the results, heterogeneity decreased for subgroups of China and European countries (I^2=0.0 %, P=0.768 and I^2=0.0 %, P=0.750 respectively), including 246 (44.17 %)

Table 2 Characteristics about PFMT of the studies included in this meta-analysis

First author	Participants	Beginning of training (GW)	Duration of training	Interventions	PFMT program
Nielsen CA	normal healthy primiparae	33th	until delivery	PFMT: were instructed in training the pelvic floor. Control: these instructions were not given to the control.	50 brief, maximal contractions morning and evening (max. ten per min)
Salvesen KA	healthy nulliparous women	20th	16 weeks	PFMT: trained with a physiotherapist for 60 minutes once per week. Control: were not discouraged from doing pelvic floor muscle exercises on their own.	perform near maximal PFM contractions, and to hold the contractions 6–8 s. At the end of each contraction, add 3–4 fast contractions with an about 6 s resting period.
Agur W	primigravidae with antenatal bladder neck mobility	20th	until delivery	PFMT: supervised PFMT with a physiotherapist. Compliance was monitored using diaries. Control: usual verbal advice on PFMT from their midwives.	three repetitions of eight contractions each held for 6 s with 2 min rest between repetitions. These were repeated twice daily. At 34 weeks gestation, the number of contractions per repetition was increased to 12.
Zhou YH	nulliparous women aged 18 or older carrying a singleton pregnancy	16–30th	not less than 8 weeks	PFMT: were instructed in PFMT with a physiotherapist. Compliance was monitored using a recording form. Control: usual care, no PFMT instructions.	two repetitions of one contraction held for 5–10 s with 5–10 s rest between contractions and five fast contractions. These were repeated three times daily with each 10–15 min.
Li Y	healthy primigravida with a singleton fetus	28th	until delivery	All subjects participated in a PFMT course. The PFMT group was individually instructed by a health education nurse, and was followed up by telephone. The control group underwent no individual instructions.	contractions held for 3–5 s. Contract when inspiring and relax when expiring. These were repeated two to three times daily every 15–20 min.
Gaier L	healthy nulliparous women	not reported	12 weeks	PFMT: 12-week PFMT program during pregnancy, supervised by a physiotherapist and a mid-wife. Control: routine care and PFMT customary instruction at intake visit.	not reported
Mason L	nulliparous with a singleton pregnancy and no previous stress incontinence.	11–14th	not reported	PFMT: 45-minute physiotherapy class once a month for 4 months. Control: usual care and instruction in PFME.	8-12 maximal pelvic floor muscle contractions held for 6–8 s repeated twice per day. At the end of each contraction, three or four fast contractions were performed.
Ko Po-Chun	nulliparous women, at 16 to 24 gestational weeks	24th	12 weeks	PFMT: individually instructed by a physical therapist about pelvic floor anatomy and how to contract the pelvic floor muscles correctly before exercise. Compliance was monitored using diaries. Control: regular prenatal care and the customary written postpartum instructions that did not include PFMF.	three repetitions of eight contractions each held for 6 s, with 2 min rest between repetitions. These were repeated twice daily at home, with additional training in groups once a week for 45 min by a physical therapist.
Dias LAR	nulliparous healthy pregnant women carrying a single fetus aged between 18–36 years old	20th	16 weeks	PFMT: individual sessions of PFMT supervised by two experienced women's health physical therapists for 30 minutes on a weekly basis. Control: usual Brazilian care; instructions regarding PFMT are not part of prenatal care routine.	four sets of ten contractions sustained for 6–8 s with an interval of 6 s between each contraction. Three additional fast contractions (1 s) were per-formed at the end of the ten repetitions. A 30-s rest interval was defined between each set.

Table 2 (continued)

First author	Participants	Beginning of training (GW)	Duration of training	Interventions	PFMT program
Fritel X	nulliparous women carrying an uncomplicated singleton pregnancy with or without UI.	21–32th	12 weeks	PFMT: eight standardised pelvic floor muscle training sessions were conducted between the 6th and 8th month of pregnancy supervised by a trained midwife or physiotherapist and took 20 to 30 minutes each. Control: written instructions about how perform pelvic floor contractions.	not reported
Wang X	nulliparous women carrying a singleton pregnancy	16–32th	not reported	All subjects participated in a PFMT course instructed by one full-time health education nurse. The PFMT group was given a one-on-one consultation and followed up by telephone, and they were encouraged to persistently practice PFMT at home. The control group underwent no telephone follow-up after completion of the course.	two contractions held for not less than 3 s, and then five fast contractions with 2 min rest between repetitions. These were repeated 2–3 times daily every 10–15 min.
Huang JT	nulliparous women carrying a singleton pregnancy	13–27th	not reported	PFMT: individually instructed by a health education nurse and was followed up by telephone. Compliance was monitored using a recording form. Control: usual care, no PFMT instructions	contract when inspiring and relax when expiring. These were repeated 3–5 times daily every 3–5 min.

GW: gestational week

Chinese and 284 (50.99 %) European participants respectively, but statistically significant association only existed in the Chinese subgroup (WMD = −17.42, 95 % CI: −23.41 to −11.43). Only one out of six trials was regarded as having a high risk of selection bias. In the subgroup of five trials with no evidence of bias, heterogeneity did not decrease (I^2=60.2 %, P=0.040). Most trials (five out of six trials) stated that they had comparable age of participants in two groups. Moderate heterogeneity was still observed in the subgroup of five trials that age of participants was comparable (I^2=60.2 %, P=0.040). The result of the subgroup analysis showed that the second stage of labor was shorter in antenatal PFMT than in control group (WMD = −12.62, 95 % CI: −17.64 to −7.61). In the two subgroups of comparable and incomparable BMI before pregnancy, the pooled results were both statistically significant (WMD = −8.09, 95 % CI: −14.61 to −1.57 and WMD = −12.11, 95 % CI: −18.13 to −6.09). In the subgroup of three trials in which gestational weeks were comparable and three trials in which baby birth weight was comparable in two groups, no heterogeneity was observed (I^2=0.0 %, P=0.920 and I^2=0.0 %, P=0.942 respectively), and antenatal PFMT still significantly shortens the second stage of labor (WMD = −18.40, 95 % CI: −24.98 to −11.82 and WMD = −15.27, 95 % CI: −24.18 to −6.35 respectively). The result of sensitivity analysis indicated that when the trial rated as high risk of selection bias [17] was removed, the pooled effect did not change essentially (WMD = −12.55, 95 % CI: −21.36 to −3.75).

Antenatal PFMT and risk of episiotomy

The relationship between antenatal PFMT and the risk of episiotomy compared with the controls is shown in Fig. 4a. A fixed-effect model was used because there was no significant heterogeneity between the seven studies (I^2=36.5 %, P= 0.150). The overall result showed that the association between antenatal PFMT and the risk of episiotomy is not statistically significant (OR=0.75, 95 % CI: 0.54 to 1.02).

Antenatal PFMT and risk of instrumental delivery (vacuum extraction or forceps or both)

The relationship between antenatal PFMT and the risk of instrumental delivery compared with the controls is shown in Fig. 4b. There was no significant heterogeneity between the seven studies (I^2=0.0 %, P=0.932), hence a fixed-effect model was used. The pooled result shows that the association between antenatal PFMT and the risk of instrumental

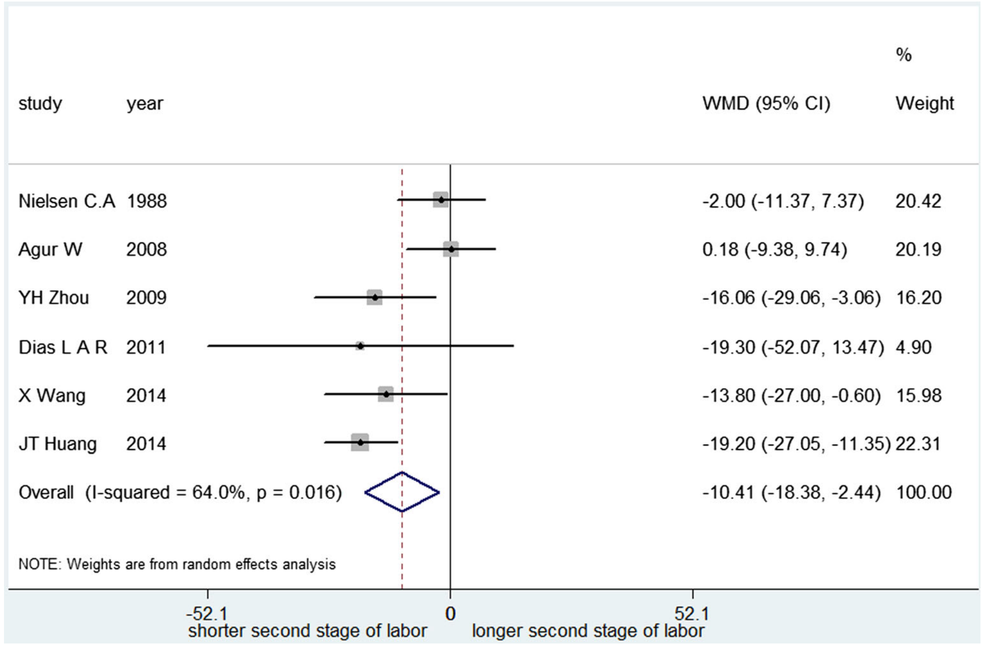


Fig. 3 Forest plots of random effects meta-analysis for the association between PFMT during pregnancy and the second stage of labor (six studies included). *WMD*, weighted mean difference. *CI* indicates confidence interval

delivery is not statistically significant (OR=0.84, 95 % CI: 0.61 to 1.17).

Antenatal PFMT and risk of perineal laceration

The relationship between PFMT during pregnancy and the risk of perineal laceration compared with the controls is shown in Fig. 4c. A fixed-effect model was used to pool the OR because there was no significant heterogeneity between six studies examining antenatal PFMT and risk of perineal laceration (I^2=0.0 %, P=0.825). The result of the meta-analysis shows that the association between antenatal PFMT and the risk of perineal laceration is not statistically significant (OR=0.96, 95 % CI: 0.66 to 1.40).

Table 3 Results of subgroup analyses on association between PFMT during pregnancy and the second stage of labor (6 studies included)

Subgroup	Number of studies	WMD	95 % CI	I^2	P for heterogeneity
Countries					
China	3	−17.42*	−23.41, −11.43	0.0 %	0.768
European countries	2	−0.93	−7.63, 5.76	0.0 %	0.750
Brazil	1	−19.30	−52.07, 13.47	–	–
No evidence of bias					
Yes	5	−12.55*	−21.36, −3.75	60.2 %	0.040
No	1	−2.00	−11.37, 7.37	-	-
Comparable age of participants					
Yes	5	−12.62*	−17.64, −7.61	60.2 %	0.040
No	1	−2.00	−11.37, 7.37	-	-
Comparable BMI before pregnancy					
Yes	4	−8.09*	−14.61, −1.57	45.3 %	0.140
No	2	−12.11*	−18.13, −6.09	86.8 %	0.006
Comparable gestational weeks					
Yes	3	−18.40*	−24.98, −11.82	0.0 %	0.920
No	3	−3.56	−5.93, 2.41	33.4 %	0.223
Comparable baby birth weight					
Yes	3	−15.27*	−24.18, −6.35	0.0 %	0.942
No	3	−8.62*	−13.72, −3.53	83.5 %	0.002

*means the pooled WMD was statistically significant

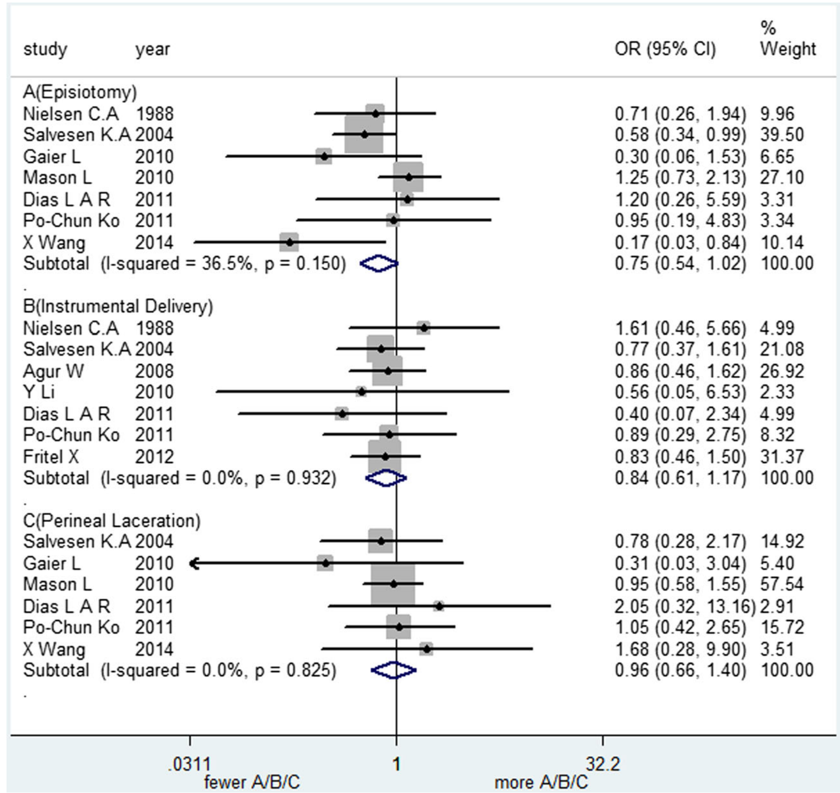


Fig. 4 Forest plots of fixed effects meta-analysis for the association between PFMT during pregnancy and the risk of episiotomy (seven studies included), instrumental delivery (seven studies included) or perineal laceration (six studies included). *CI* indicates confidence interval. *OR*, odds ratio. *A*: episiotomy. *B*: instrumental delivery. *C*: perineal laceration

Publication bias evaluation

Begg's funnel plot and Egger's test were performed to assess the publication bias of literatures. No significant publication bias was detected by Begg's test for the first stage of labor (P= 0.117), the second stage of labor (P= 0.573), episiotomy (P= 0.806), instrumental delivery (P= 1.000), and perineal laceration (P=0.308). The shape of the funnel plot to assess publication bias was roughly symmetrical (data not shown).

Discussion

This systematic review and meta-analysis investigated the relationship between antenatal PFMT and five labor and delivery outcomes. The first stage of labor, the second stage of labor, episiotomy, instrumental delivery (vacuum extraction or forceps or both), and perineal laceration were regarded as the primary outcomes of interest. It included 12 trials with a total of 2,243 women. The participants in all 12 trials were primigravida or nulliparous women carrying their first baby. Ten out of 12 trials analyzed the data of primigravida carrying a singleton fetus. Overall, the results of this study suggest that PFMT applied in pregnancy may be effective at shortening the duration of the first stage of labor by 28.33 min and the second stage of labor by 10.41 min on average in the primigravida. Carrying out antenatal PFMT, therefore, may have a protective effect against the prolonged second stage of labor, which might indicate an important clinical significance. This novel finding gives some reassurance to the primigravida. The results also showed that there was no abundant evidence of an association between antenatal PFMT and risk of episiotomy, instrumental delivery and perineal laceration compared with the control group in the primigravida, which was consistent with the results of a cohort study [39] conducted by Kari Bø including 18,865 primiparous women. For the primiparous women, this is important because it shows that antenatal PFMT does not negatively affect birth.

PFM consist of urethral sphincter, levator ani muscle, anal sphincter, and other muscles, which support the pelvic organs like a hammock to keep them stable. Pregnancy and vaginal delivery may cause weakness of the pelvic floor muscles [1]. The mechanism between PFMT in gestation and the reduced first and second stage of labor is not completely clear. Generally, regular PFMT has been shown to increase PFM strength [10]. Antenatal PFMT results in improved muscle control and strong flexible muscles [2], which may contribute to the descent or rotational movements of the fetal head. Thus, antenatal PFMT shortens the first and second stage of labor. It may also help the primigravida to form a positive attitude towards childbirth, which is conducive to spontaneous labor.

The moderate heterogeneity among the six trials that reported the second stage of labor when evaluating the antenatal PFMT and the second stage of labor cannot be ignored. In the subgroup analysis on the second stage of labor by country, a statistically significant association was presented in the trials conducted in China which was not observed in trials conducted in European countries. This result should be interpreted with caution. On one hand, three trials conducted in China whose participants only accounted for 44.17 % (246 out of 557) reported the second stage of labor. On the other hand, the trials conducted in Europe were likely to involve a wide range of ethnicities, so not all the women included in the European trials were Caucasian. Dietz demonstrated that nulliparous Asian women were shown to have significantly less pelvic organ mobility than Caucasian women both antepartum as well as 2–5 months after childbirth [40]. Yang et al. showed that there was a significantly thicker average pubovisceral muscle in nulliparous Chinese than Caucasian women [41]. Van der Walt.et al. indicated that black women had stronger PFM than white and mixed-race women [42]. Hoyte et al. showed that levator ani volume was significantly greater in African-American versus white American nulliparous women [43]. Whether ethnic or racial differences influence the effect of antenatal PFMT on the second stage of labor needs further study. The subgroup analysis by risk of bias assessment result where age of participants was comparable indicated that there were other potential factors qhich could be the source of heterogeneity. In the two subgroups of comparable gestational weeks and comparable baby birth weight in two groups, no heterogeneity was observed, and antenatal PFMT still significantly shortens the second stage of labor, which further demonstrated the beneficial effect of antenatal PFMT. Our subgroup analysis also suggested that whether BMI before pregnancy and baby birth weight were comparable or not in two groups, the association between antenatal PFMT and second stage of labor did not change. That is, even obese pregnant women or woman who conceived a large baby can benefit from PFMT. Although subgroup analysis were conducted to explore the source of heterogeneity, the intervention variability in included trials, such as the method of delivery of intervention, duration of training, number of contractions recommended, duration of hold per contraction, the participants' compliance to the prescribed programme, and whether a correct contraction was confirmed prior to training should be noticed.

This meta-analysis had several strengths. This study included prospective randomized or quasi-randomized controlled trials to determine the association of antenatal PFMT and labor and delivery outcomes over time. Studies that used vaginal cones, electrical muscle stimulation, and biofeedback for perineal muscle strengthening were excluded, to guarantee that the intervention method in all included studies was conservative voluntary pelvic floor muscle contractions, thus decreasing the large variation among studies. This review has implications for clinical practice. It has been suggested that pregnant women who do PFMT during pregnancy can benefit from this procedure which shortens the first and second stage of labor. However, the potential limitations of this meta-analysis should be considered as well. First, this meta-analysis only included English and Chinese language articles; eligible articles in other languages were not included in this analysis, which may have influenced the pooled estimated value. Second, all data about the first stage of labor were from Chinese trials in the present analysis, so the effect of antenatal PFMT on the first stage of labor in other ethnic groups cannot be recognized. More than half of the selected articles did not report the first stage of labor, which could affect the accuracy of the outcome. Third, the rate of episiotomy is affected by the rate of instrumentation and vice versa; the meta-analysis could not control for those interactions. Fourth, the procedures of PFMT varied among the included studies with regard to frequency, intensity, and duration, which may be a reason leading to the moderate heterogeneity when evaluating the association between PFMT during pregnancy and the second stage of labor. Fifth, intervention variability in PFMT program potentially influenced the intervention outcome. Future studies need to be designed more strictly to control potential influencing factors and to have large enough trials to investigate the effect of intervention variability on labor and delivery outcomes. Finally, all trials included in this review selected participants having their first baby, so we cannot investigate the effect of antenatal PFMT on pregnant women carrying a second or subsequent baby, which is an important clinical question.

Future studies on this subject area are needed for a number of reasons, to increase the sample size and better delineate exclusion criteria for samples, to eliminate other risk factors for labor outcome, to carefully analyze the influence of PFMT on childbirth, to explore the underlying mechanisms and elucidate the causal pathways that link PFMT and labor and delivery outcomes. In addition, studies that focus on antenatal PFMT in pregnant women regardless of parity need to be conducted.

Conclusions

Antenatal PFMT might be effective at shortening the first and second stage of labor in the primigravida. That the first and second stage of labor was shortened by about 28 min and 10 min on average may indicate an important clinical significance. The source of moderate heterogeneity observed in studies including the second stage of labor data needs further study. Antenatal PFMT does not increase the risk of episiotomy, instrumental delivery, and perineal laceration in the primigravida.

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