Ankle positions potentially facilitating greater maximal contraction of pelvic floor muscles: a systematic review and meta-analysis

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Running title: Ankle positions and pelvic floor muscle activity

Abstract

Objectives: To evaluate the effect of ankle positions on pelvic floor muscles in women.

Methods: Multiple databases were searched from inception-July 2017. Study quality was rated using the grading of recommendations, assessment, development, and evaluation system and the 'threats to validity tool'.

Results: Four studies were eligible for inclusion. Meta-analysis revealed significantly greater resting activity of pelvic floor muscles in neutral ankle position (-1.36 [95% CI -2.30, -0.42] *p*=0.004) and induced 15° dorsiflexion (-1.65 [-2.49, -0.81] *p*=0.0001) compared to induced 15° plantar flexion. Significantly greater maximal voluntary contraction of pelvic floor was found in dorsiflexion compared to plantar flexion (-2.28 [-3.96, -0.60] p=0.008). Meta-analyses revealed no significant differences between the neutral ankle position and 15° dorsiflexion for either resting activity (0.30 [-0.75, 1.35] p=0.57) or maximal voluntary contraction (0.97 [-0.77, 2.72] p=0.27).

Conclusion: Pelvic floor muscle-training for women with urinary incontinence could be performed in standing with ankles in a neutral position or dorsiflexion to facilitate greater maximal pelvic floor muscle contraction. As urethral support requires resting contraction of pelvic floor muscles, decreased resting activity in plantar flexion identified in the meta-analysis indicates that high-heel wearers with urinary incontinence might potentially experience more leakage during exertion in a standing position.

Keywords: Ankle positions; pelvic floor muscles; stress urinary incontinence; systematic review.

Introduction

Urinary incontinence is a common condition in women, with a prevalence of 8.5%-38% [1]. The majority of women with urinary incontinence have stress urinary incontinence (SUI) [1]. SUI is controlled by the bladder neck support and sphincteric closure systems [1]. The levator ani muscles (key pelvic floor muscle (PFM)) form a major component of the urethral support system [1]. The levator ani muscles consist of Type 1 striated muscle fibres, which maintain the constant muscle tone necessary to keep the urogenital hiatus closed [1]. In addition, PFMs play an important role in urethral closure at rest and when the intra-abdominal pressure increases during exertion (e.g., sneezing or exercise) [2]. Deconditioning or dysfunction of PFMs commonly leads to urinary incontinence [1]. Studies have shown that PFM activity can be influenced by different body positions (e.g., sitting or standing) [3, 4] and lumbopelvic posture [5]. Significantly higher PFM resting activity is found in standing [4, 5]; however, maximal voluntary contraction (MVC) does not differ between sitting or standing positions [4]. Capson *et al.* [5] found significantly greater PFM resting activity in the hypolordotic posture compared to hyperlordotic posture. They also found significantly greater PFM MVC in the normal standing posture compared to standing with hyper- or hypolordosis [5]. In addition to supporting the abdominal and pelvic viscera, PFMs also contribute to the segmental stability of the lumbar spine and pelvis [6-9]. Thus, it has been postulated that changes in lumbopelvic posture (lumbar lordosis and pelvic tilt/inclination) might create changes in PFM activity [5].

Previous studies have found that different ankle positions (dorsiflexion, neutral and plantar flexion) alter PFM activity in women, but with contradictory results [10-14]. Some studies found significantly greater PFM activity in induced ankle plantar flexion (wedges under heels) compared to ankle neutral and induced dorsiflexion (placing wedges under toes) [12, 14].

However, other studies found greater PFM activity in ankle neutral and induced dorsiflexion as opposed to induced plantar flexion [10, 13]. As ankle positions can influence resting and MVC PFM, it is worth identifying the ankle position facilitating greater maximal contraction to aid PFM training for women with SUI.

Studies of high-heeled gait kinetics report that the shoes force the ankles into plantar flexion in standing and walking [15, 16]. A weight of biomechanical evidence suggests that high-heeled shoes create changes in lumbopelvic posture [17-23]. Given the influence of high-heeled shoes on ankle position and the association between ankle position and PFM activity, investigating the effect of high-heeled shoes on PFM activity is necessary.

The objective of this systematic review is:

(1) to evaluate the effect of ankle position on resting and MVC of PFMs in women, and

(2) to review the literature regarding the impact of high-heeled shoes on PFM activity in women.

Findings of this review will inform clinicians of which ankle position could be used as an adjunct to PFM training for women with SUI.

Materials and methods

Study design

This systematic review was developed and reported in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [24]. Our review is registered in the PROSPERO registry (CRD42017072460).

Search strategy

An electronic search was conducted of AMED, CINAHL, EMBASE, Ovid Medline, PubMed, Web of Science and Google Scholar from database inception to July 2017. Reference lists of all included full-text articles were searched for further eligible articles. No additional searches were conducted. Database specific Medical Subject Headings (MeSH) and keywords were used to retrieve studies. As the electronic databases have specific MeSH terms, each was searched independently. The search strategy for Ovid Medline is reported in table 1. One reviewer performed searches in the electronic databases. Included articles were combined into one reference library and duplicated articles were removed. Two reviewers independently performed title, abstract and full-text screening. Discrepancies were resolved by discussion between reviewers. A third reviewer was contacted for unresolved discrepancies.

Insert table 1about here

Eligibility criteria

Articles were included for review if they met the following inclusion criteria: women of all age ranges; evaluating the effect of ankle position (i.e., neutral, bare feet, dorsiflexion, plantar flexion) or high-heeled shoes on PFM activity using surface electromyography (EMG), ultrasound, dynamometry or digital palpation. Conference abstracts, short communications and PhD theses were also included in the review. Conference abstracts and short communications providing mean and standard deviation data were included for meta-analysis but not for methodological quality evaluation. Observational and randomized controlled trials (RCTs) were considered eligible for inclusion in this review. No search restriction was applied regarding the language of publication. Authors were contacted for any incomplete data in the included studies.

Quality assessment and data extraction

Two independent reviewers performed quality assessment of each included study. Quality assessment of included studies was conducted utilizing two tools: 1) the GRADE tool developed to evaluate the quality of observational studies and RCTs, and 2) ‘threats to validity’, which is a generic tool developed to detect threats to internal validity in observational studies [25].

GRADE profiler 3.6 software was used to rate the evidence quality. In the GRADE system, observational studies begin as ‘low quality’. Studies can be upgraded if the pooled analyses show a large effect (+1 large; +2 very large) [26]. Study quality was downgraded for the following reasons:

(1) Risk of bias: limitations in observational studies such as failure to apply eligibility criteria, flaws in the measurement of exposure and outcomes and failure to control confounding factors [27].

(2) Inconsistency: statistical heterogeneity expressed by large chi-squared value ($I^2 > 50\%$) [28].

(3) Indirectness: use of surrogate outcome measures [29].

(4) Imprecision: when the confidence interval does not overlap or is wide [30].

(5) Publication bias: downgraded if studies are industry sponsored. If more than ten studies were available for meta-analysis, we used a funnel plot [31].

The internal validity of a study is rated using nine items in the ‘threats to validity’ tool: selection bias (diagnostic inaccuracy, participant representativeness and sampling); random variation/chance (sample size); detection bias (validity of assessment tools, follow-up period similar for cases and controls, and blinding); attrition bias (lost to follow-up) and reporting bias (investigator/funding bias) [25]. Items are scored as a tick (✓) for no evidence of bias, cross (X) for evidence of bias, question mark (?) for poor reporting or uncertain risk of bias and n/a for not applicable to research design [25]. According to this quality assessment tool, the methodological quality of a study is rated as 'high', 'moderate' or 'low'. Studies scoring ≥ 70% were considered high quality, 40-69% moderate and < 40% considered low quality [25]. The percentages were obtained by dividing the total number of tics by the total number of validity items used by the tool [25].

Two reviewers independently extracted data from each included study utilizing a standardized data extraction form. Discrepancies were resolved by discussion between the two reviewers, and a third reviewer was contacted for any unresolved discrepancies. Data extracted from the studies included: author and year, language and country of publication, study design, participants, assessment tool, heel height in inches/ankle positions and PFM activity data for various ankle positions.

Data analysis

Resting and MVC PFM data were used to obtain a pooled estimate of the difference between ankle positions using Review Manager 5.3. A computer-based algorithm was used to calculate mean and SD from median and interquartile ranges (IQR) (http://vassarstats.net/median_range.html) [32]. Meta-analyses for PFM resting activity and MVC were conducted for the following comparisons: 1) ankle neutral position and plantar flexion, 2) ankle neutral position and dorsiflexion, and 3) dorsiflexion and plantar flexion. All studies included for meta-analysis used the same outcome measure and therefore weighted mean difference was calculated. A fixed-effect model was used for minimal heterogeneity ($I^2 < 50\%$) and a random effects model used for maximum heterogeneity ($I^2 > 50\%$) [33].

Results

Flow of studies through the review

The searches identified 25 potentially relevant articles; of which nine were screened at the abstract stage, and seven were eligible for full-text screening. Of the seven articles, four (three full-text and one conference abstract) were eligible for inclusion. The flow of studies through the review is summarized in Figure 1. All three full-text articles and one conference abstract were observational studies. No RCTs were identified in the search.

Insert figure 1 about here

Characteristics of individual studies

A summary of the included studies is presented in table 2. In total, data from 230 women were included in the meta-analysis. All included studies were published in English. Two studies were conducted in Taiwan, one in Egypt and one in Italy. Of the four included studies, two [12, 14] reported mean and SD, one reported mean and IQR [11] and one study reported median and IQR [13]. The mean age of women in the included studies ranged from 26 to 72 years. Three of the four studies used EMG with a vaginal probe, and one study used a surface electrode with EMG to evaluate the bioelectrical PFM activity. No study evaluating the effect of high-heeled shoes on PFM activity was identified in the searches.

One included study [13] evaluated the effect of eight ankle positions (active dorsiflexion and plantar flexion, passive ankle dorsiflexion and plantar flexion using 2.5 cm and 4.5 cm wooden blocks under the toes and heels, respectively and active ankle dorsiflexion and plantar flexion with arms held above the shoulders) on PFM activity in women without incontinence. One study [12] evaluated the effect of three ankle positions (neutral ankle position, passive ankle dorsiflexion and plantar flexion using an adjustable platform set at 15° under the toes and heels, respectively) on PFM activity in women with SUI. One study [14] evaluated the effect of ankle position combined with pelvic tilt (neutral ankle position with normal pelvic tilt, anterior pelvic tilt created by ankle dorsiflexion and posterior pelvic tilt created by ankle plantar flexion) on PFM activity in women with SUI. One study [11] of women with SUI evaluated the PFM activity in seven ankle positions: horizontal standing and standing with ankles in dorsi- and plantar flexion at 5°, 10° and 15°.

Insert table 2 about here

Quality

The summary of findings generated by the GRADE profiler software is presented in table 3. The GRADE quality of evidence for comparisons ranged from 'low' to "moderate'. The methodological quality of included studies is presented in table 4. Of the three full-text studies, two were of moderate methodological quality and one of low quality. The items, diagnostic inaccuracy, participant representativeness, validity of assessment tool and reporting bias were reported in all three studies. No reporting bias was identified in any of the included studies.

Insert table 3 about here

Insert table 4 about here

Effects of ankle position on PFM activity

Resting activity

The methodological quality of the three studies contributing resting PFM activity data ranged from low to moderate. The pooled analysis showed significantly greater resting PFM activity in ankle neutral position compared to ankle plantar flexion (-1.36 [95% CI -2.30, -0.42] $p = 0.004$; $n = 168$) (Figure 2); the GRADE evidence for this comparison was low. The meta-analysis revealed significantly greater PFM resting activity in ankle dorsiflexion compared to ankle plantar flexion (-1.65 [-2.49, -0.81] $p = 0.0001$; $n = 168$) (Figure 3). The GRADE evidence for this comparison was also low. There was no significant difference in resting PFM activity between ankle neutral position and dorsiflexion (0.30 [-0.75, 1.35] $p = 0.57$; $n = 168$) (Figure 4). The GRADE evidence was judged to be moderate for this comparison.

Insert figure 2 about here

Insert figure 3 about here

Insert figure 4 about here

MVC of PFMs

Data pooled from four studies [11-14] revealed significantly greater PFM MVC in ankle dorsiflexion compared to plantar flexion (-2.28 [95% CI -3.96, -0.60] $p = 0.008$; $n = 230$) (Figure 5). However, there was no significant MVC difference in ankle neutral position compared to dorsiflexion (0.97 [-0.77, 2.72] $p = 0.27$; $n = 230$) (Figure 6). The GRADE evidence for both of these comparisons was moderate, and the methodological quality of studies contributing data for these comparisons ranged from low to moderate.

Insert figure 5 about here

Insert figure 6 about here

Sensitivity analysis

A sensitivity analysis was performed by removing two studies: one study [11] that provided mean and IQR and one that provided median and IQR [13]. The sensitivity analysis did not alter the results obtained for any comparisons of either resting or MVC. Resting activity: ankle neutral vs. plantar flexion ($p = 0.002$); dorsiflexion vs. plantar flexion ($p = 0.003$); and ankle neutral vs. dorsiflexion ($p = 0.95$). MVC: dorsiflexion vs. plantar flexion ($p = 0.006$); and ankle neutral vs. dorsiflexion ($p = 0.26$).

Discussion

PFM training is the first line treatment for SUI in women [10]. Training PFMs facilitates an automatic and unconscious contraction of the PFMs, increasing the urethral closure pressure during rest and exertion [34]. Identifying the optimal ankle position to enhance MVC is crucial for training PFMs in women with SUI. As a result of contradictory evidence, the optimal ankle position for greater resting and maximal PFM contraction in women is not known. To date, no systematic review has evaluated the effect of ankle position on PFM activity in women. The effect of high-heeled shoes (which align ankles in plantar flexion) on PFM activity has also not been evaluated. Therefore, we analysed the effect of ankle position on PFM activity in women.

The pooled analyses revealed a significantly greater resting activity for PFMs in neutral ankle position and 15° dorsiflexion compared to 15° plantar flexion. The PFMs and endopelvic fascia work in unison to maintain continence and provide urethral support [1]. The activity of PFMs at rest ensures that the support function (urethral support system) is normal [35]. The constant PFM tone maintains the rigidity of the supportive layer under the urethra [1]. When the rigidity of the supportive layer is reduced, there is less resistance to deformation under increased intra-abdominal pressure. This loss of rigidity increases the possibility of SUI due to the inefficient closure of the urethral lumen [1]. Based on the findings herein, we hypothesize that high-heel wearers with SUI may experience more leakage during exertion in a standing position due to the decreased stiffness of the supportive urethral layer. Further investigation is required to confirm this due to the small sample size, methodological quality and limited number of studies included for meta-analysis.

The meta-analysis revealed that 15° ankle dorsiflexion facilitates greater MVC of PFMs than 15° plantar flexion in women with SUI. There was no significant difference in MVC between the neutral ankle position and 15° dorsiflexion. Conservative management of SUI is primarily based on perineal re-education, which is used to increase the strength and endurance of the PFMs and striated urethral sphincter [2]. PFM-strengthening involves achieving a greater MVC [36]. Based on the results of this review, we suggest that PFM training in women with SUI should be performed with ankles in a neutral position or 15° dorsiflexion. Women with SUI could be discouraged from wearing high-heeled shoes due to the effect of ankle plantar flexion on MVC.

The proposed mechanism of how ankle positions might affect PFM activity is related to the anterior and posterior pelvic tilts induced by dorsiflexion and plantar flexion respectively [5, 12, 14]. Anterior pelvic tilt created by dorsiflexion is postulated to increase the pelvic outlet, move ischial tuberosities apart and the sacrum and coccyx in an anterior and inferior direction, resulting in the closure of the sub-urethral vaginal wall, urethra, and bladder neck, and elevating the urethral support [12]. In addition, dorsiflexion induced changes at the pelvis, sacrum and coccyx causes the attachments of the pubococcygeus muscle move closer, resulting in a shortening of the muscle fibres. These distortions are thought to increase the contractility of the PFM muscles [4, 14].

Various methods such as surface perineometry, digital palpation, ultrasound, magnetic resonance imaging and EMG have been used to record PFM activity. Of these, digital palpation and perineometry are regarded as the ‘gold standards’ for the assessment of PFM contraction

[37, 38]. However, digital palpation has the disadvantages of subjective bias and low repeatability [37, 39], while perineometry is limited by interference from intra-abdominal pressure [37, 40]. Despite limitations in detection and electrical noise that affects the signal, surface EMG is one of the modalities used to investigate PFM function in real time [4, 41]. All of the studies included herein used surface EMG to measure PFM activity. Three of the four included studies used surface EMG with a vaginal probe, and one study used only surface electrodes. It is worth noting that PFM EMG via vaginal probe has high intra-rater reliability (ICC 0.78-0.99) for resting and MVC of PFMs and re-test reliability (ICC 0.38-0.96) for MVC of PFMs in women [42].

Strengths and limitations

This study is the first systematic review and meta-analysis evaluating the effect of ankle position on PFM activity in women. Rigorous screening procedures were carried out to identify potentially relevant articles. In addition, the grey literature (unpublished studies such as abstract proceedings) was searched to eliminate publication bias. Our systematic review does have some limitations which should be considered when interpreting the findings. Only four studies were included for the review and the meta-analyses were conducted among three-to four studies, therefore these results need to be considered with caution. Despite the comprehensive search strategy and rigorous procedures carried out to minimize potential biases and ensure high methodological quality for this review, synthesis of the evidence proved difficult. The GRADE and methodological quality of individual studies ranged from low to moderate, and studies included in this review were of small size or inadequately powered.

Implications for clinical practice

Integration of the SUI control system

Women with SUI are required to strengthen their PFMs and to know when to contract them to prevent urinary leakage [1]. It has been shown that women with SUI could eliminate urinary leakage by simply learning to time a PFM contraction to occur during a cough or sneeze [1, 43, 44]. Thus, teaching proper PFM timing is crucial [1]. Given that the neutral ankle position could facilitate a greater maximal PFM contraction than plantar flexion, women with SUI should be advised to wear flat shoes instead of high-heels. Due to the effect of gravity and pressure on the musculofascial structures near the pelvic organs, it is common for urine leaks to occur in standing [4]. Thus, women with SUI should be cautioned about body posture [4] and ankle positions assumed during exercise and daily activities.

There is some preliminary evidence from four studies of low-moderate GRADE quality that PFM MVC is significantly greater in induced ankle dorsiflexion than induced plantar flexion. The meta-analysis showed no significant differences between the neutral ankle position and 15° dorsiflexion for either resting activity or MVC. These findings suggest that PFM training for women with SUI should be performed in standing either with ankles in a neutral position or dorsiflexion (with wedges under the toes) to enhance the MVC of PFMs.

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Table 1: Search terms and search strategy for Ovid Medline

Subject areas (Combined with "AND')	Search terms used (combined with "OR')
High-heels	High-heel*.*mp*; high-heeled shoe*. *mp*; positive heel. *mp*; negative heel.*mp*; wedge heel.*mp*; platform heel.*mp*; stiletto.*mp*; positive inclination.*mp*; negative inclination.*mp*; wedges.*mp*; shoes/.
Ankle positions	Ankle/; Neutral.*mp*; dorsiflexion.*mp*; plantar flexion.*mp*; bare feet.*mp*; horizontal standing.*mp*.
Pelvic floor muscle activity	Pelvic floor/; pelvic floor muscle*.*mp*; pelvic floor muscle activity; PFM*.*mp*; resting contraction.*mp*; maximal voluntary contraction.*mp*.

Note: mp: Keyword; /: Medical Subject Heading; *: Truncation

Table 2: Characteristics of included studies

Author and date	**Language and Country of publication**	**Study design**	**Participants**	**Assessment tool**	**Heel height/ankle position**	**Mean (SD) resting and MVC of PFMs**
Chen et al [12]	English Taiwan	Observation	Women with SUI N=39 Age: 38 to 72 years Parity: Mean 3.2 (range 1-8)	EMG biofeedback using intravaginal probe with surface EMG electrodes	Ankle neutral, standing with ankles in DF (with platform set at 15° under the toes), and PF (with adjustable platform set at 15° under the heels)	Resting AN: 6.9 (3.2) DF: 6.9 (2.7) PF: 5.5 (2.1) MVC AN: 15.1 (5.5) DF: 16.1 (4.8) PF: 13.9 (5.0)
Cerruto et al [11]	English Italy	Observation	Women with SUI N=15 Age: 29 to 49 years Parity: Mean and range are not reported	EMG biofeedback using surface EMG electrodes	Ankle neutral, standing with ankles dorsiflexed and plantar flexed at 15°	Resting AN: 32 (8.8) DF: 58 (18.5) PF: 40 (11.8) MVC AN: 278.5 (225.6) DF: 233.5 (122.6) PF: 316 (147.7)
Chen et al [13]	English Taiwan	Observation	Continent women N=31 Age: 26 to 60 years Parity: Mean and range are not reported	EMG biofeedback using intravaginal probe with surface EMG electrodes	Ankle neutral, standing with ankles in DF (with wooden blocks of 2.5 cm under toes), and PF (with wooden blocks of 2.5 cm under heels)	MVC AN: 16.7 (7.6-37.5) DF: 18.0 (7.8-37.6) PF: 16.4 (5.8-40.9)

El-Shamy et al [14]	English Egypt	Observation	Women with SUI N=30 Age: 40 to 50 years Parity: Parity: Mean and range are not reported	Urodynamic device (EMG) using intravaginal probe with surface electrodes	Ankle neutral with normal pelvic tilt, standing with anterior pelvic tilt and ankles in DF (with an adjustable platform set at 15° under the toes), and standing with posterior pelvic tilt and ankles in PF (with an adjustable platform set at 15° under the heels)	Resting AN: 8.9 (3.8) DF: 9.0 (3.2) PF: 7.2 (2.0) MVC AN: 19.7 (6.6) DF: 20.9 (5.8) PF: 18.0 (6.0)

Abbreviations: AN: Ankle Neutral position; DF: Dorsiflexion; EMG: ElectoMyoGraphy; MVC: Maximal Voluntary Contraction; PF: Plantar Flexion; SUI: Stress Urinary Incontinence

Table 3: Summary of findings (GRADE)

Resting PFM activity						
Outcomes	**Illustrative comparative risks* (95% CI)**		**Relative effect (95% CI)**	**No of Participants (studies)**	**Quality of the evidence (GRADE)**	**Comments**
	Assumed risk	Corresponding risk				
	plantar flexion	**Resting PFM activity: ankle neutral**				
Resting PFM activity: neutral Vs plantar flexion		The mean resting PFM activity: neutral vs plantar flexion in the intervention groups was **1.51 lower** (2.46 to 0.57 lower)		138 (2 studies)	⊕⊕⊝⊝ **low**[a,b,c]	
Resting PFM activity: dorsiflexion Vs. plantar flexion		The mean resting PFM activity: dorsiflexion vs. plantar flexion in the intervention groups was **1.55 lower** (2.4 to 0.71 lower)		138 (2 studies)	⊕⊕⊝⊝ **low**[a,b,c]	
Resting PFM activity: ankle neutral Vs. dorsiflexion		The mean resting PFM activity: ankle neutral vs. dorsiflexion in the intervention groups was **0.04 higher** (1.02 lower to 1.09 higher)		138 (2 studies)	⊕⊕⊕⊝ **moderate**[a,b,d]	

[a] Eligibility criteria specified; adequate follow-up (therefore not downgraded)
[b] $I^2 = 0\%$ (therefore not downgraded)
[c] Wide CI (therefore downgraded)
[d] Narrow CI (therefore not downgraded)

Maximal voluntary contraction of PFMs

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	plantar flexion	**MVC of PFMs: dorsiflexion**				
MVC of PFMs: dorsiflexion Vs. plantar flexion		The mean MVC of PFMs: dorsiflexion vs. plantar flexion in the intervention groups was **2.28 lower** (3.9 to 0.60 lower)		230 (4 studies)	⊕⊕⊕⊝ **moderate**[a,b,c]	
MVC of PFMs: ankle neutral Vs dorsiflexion		The mean MVC of PFMs: ankle neutral vs dorsiflexion in the intervention groups was **0.97 higher** (0.77 lower to 2.72 higher)		230 (4 studies)	⊕⊕⊕⊝ **moderate**[a,b,c]	

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[a] Eligibility criteria specified; adequate follow-up (therefore not downgraded)
[b] I^2 = 0% (therefore not downgraded)
[c] Wide CI (therefore downgraded)

Abbreviations: CI: Confidence interval; MVC: Maximal Voluntary Contraction; PFM: Pelvic Floor Muscle

Table 4: Methodological quality of included studies

Threats to validity	Chen et al [12]	Chen et al [13]	El-Shamy et al [14]
Selection bias (diagnostic inaccuracy)	✓	✓	✓
Selection bias (participant representativeness)	✓	✓	✓
Selection bias (sampling)	X	X	X
Random variation/chance (sample size)	X	X	X
Detection bias (validity of assessment tool)	✓	✓	✓
Detection bias (follow-up)	n/a	n/a	n/a
Detection bias (blinding)	n/a	n/a	n/a
Attrition bias (loss to follow-up)	✓	✓	?
Reporting bias (investigator or funding bias)	✓	✓	✓
Quality rating	Moderate (55%)	Moderate (55%)	Low (44%)

✓: No evidence of bias; X: Evidence of bias; ?: Poor reporting or uncertain risk of bias; n/a: Not applicable to research design

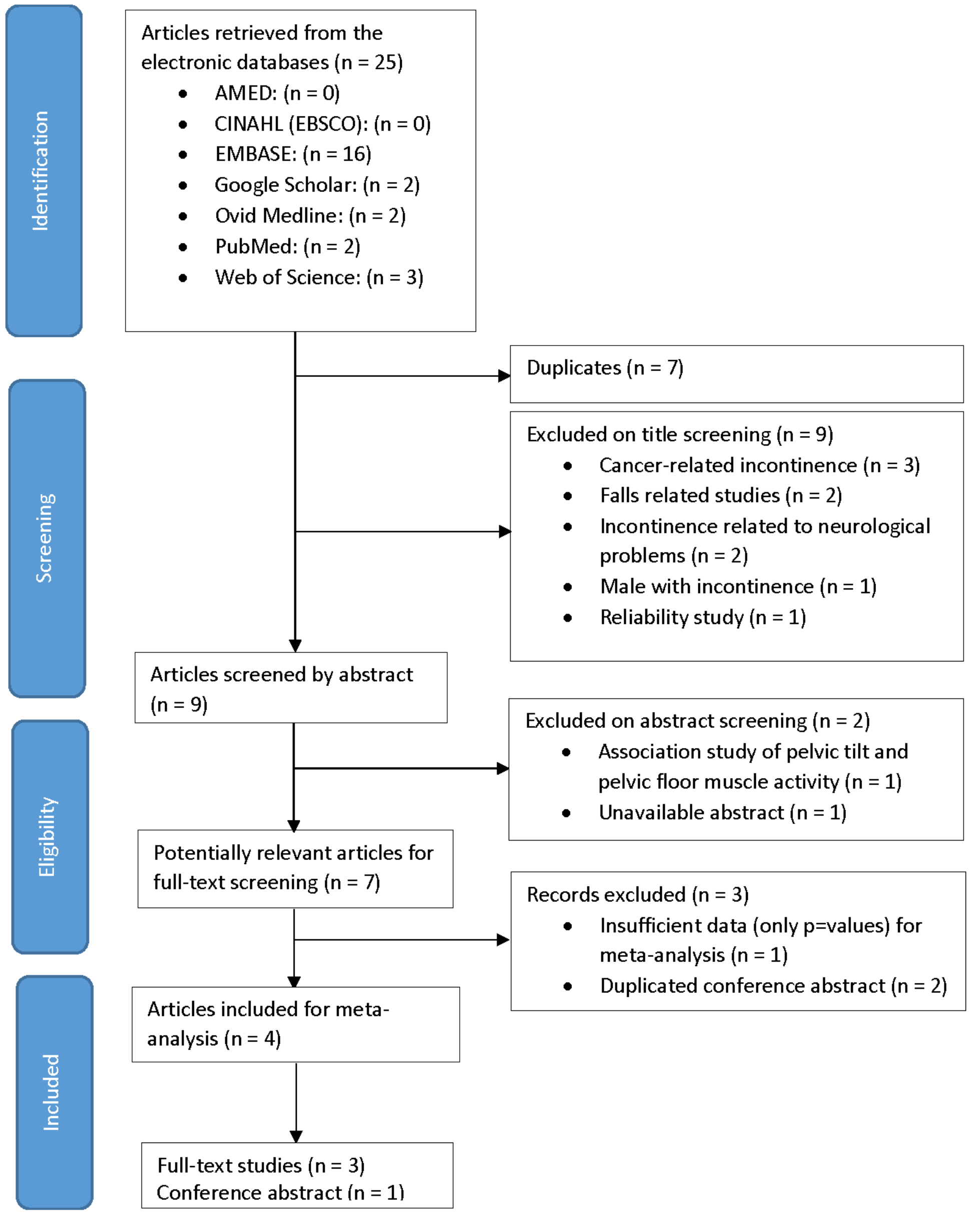

Figure 1. Flow of studies through the review

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Cerruto et al [11]	40	11.8	15	32	8.8	15	1.6%	8.00 [0.55, 15.45]
Chen et al [12]	5.5	2.1	39	6.9	3.2	39	61.1%	-1.40 [-2.60, -0.20]
El-Shamy et al [14]	7.2	2	30	8.9	3.8	30	37.3%	-1.70 [-3.24, -0.16]
Total (95% CI)			**84**			**84**	**100.0%**	**-1.36 [-2.30, -0.42]**

Heterogeneity: Chi² = 6.26, df = 2 (P = 0.04); I² = 68%
Test for overall effect: Z = 2.84 (P = 0.004)

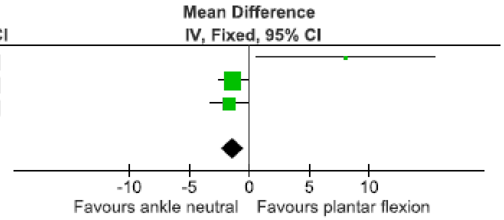

Figure 2: Resting activity of pelvic floor muscle: ankle neutral Vs. plantar flexion

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Cerruto et al [11]	40	11.8	15	58	18.5	15	0.6%	-18.00 [-29.10, -6.90]
Chen et al [12]	5.5	2.1	39	6.9	2.7	39	60.9%	-1.40 [-2.47, -0.33]
El-Shamy et al [14]	7.2	2	30	9	3.2	30	38.5%	-1.80 [-3.15, -0.45]
Total (95% CI)			**84**			**84**	**100.0%**	**-1.65 [-2.49, -0.81]**

Heterogeneity: Chi² = 8.58, df = 2 (P = 0.01); I² = 77%
Test for overall effect: Z = 3.86 (P = 0.0001)

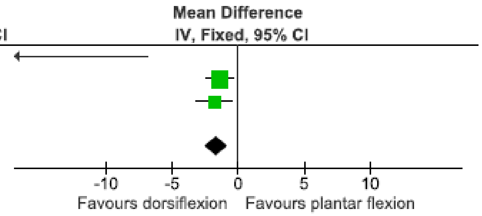

Figure 3: Resting activity of pelvic floor muscles: dorsiflexion Vs. plantar flexion

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Cerruto et al [11]	58	18.5	15	32	8.8	15	1.0%	26.00 [15.63, 36.37]
Chen et al [12]	6.9	2.7	39	6.9	3.2	39	64.0%	0.00 [-1.31, 1.31]
El-Shamy et al [14]	9	3.2	30	8.9	3.8	30	35.0%	0.10 [-1.68, 1.88]
Total (95% CI)			**84**			**84**	**100.0%**	**0.30 [-0.75, 1.35]**

Heterogeneity: $Chi^2 = 23.86$, $df = 2$ ($P < 0.00001$); $I^2 = 92\%$

Test for overall effect: $Z = 0.56$ ($P = 0.57$)

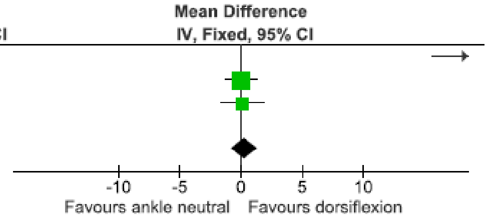

Figure 4: Resting activity of pelvic floor muscle: ankle neutral Vs. dorsiflexion

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Cerruto et al [11]	316	147.7	15	233.5	122.6	15	0.0%	82.50 [-14.64, 179.64]
Chen et al [12]	13.9	5	39	16.1	4.8	39	59.6%	-2.20 [-4.38, -0.02]
Chen et al [13]	21.2	10.6	31	22.1	12.1	31	8.8%	-0.90 [-6.56, 4.76]
El-Shamy et al [14]	18	6	30	20.9	5.8	30	31.6%	-2.90 [-5.89, 0.09]
Total (95% CI)			**115**			**115**	**100.0%**	**-2.28 [-3.96, -0.60]**

Heterogeneity: Chi² = 3.33, df = 3 (P = 0.34); I² = 10%

Test for overall effect: Z = 2.66 (P = 0.008)

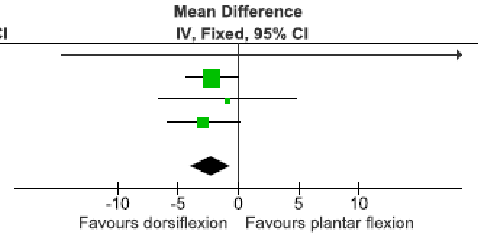

Figure 5: Maximal voluntary contraction of pelvic floor muscle: ankle dorsiflexion Vs. plantar flexion

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Cerruto et al [11]	233.5	122.6	15	278.5	225.6	15	0.0%	-45.00 [-174.94, 84.94]
Chen et al [12]	16.1	4.8	39	15.1	5.5	39	58.1%	1.00 [-1.29, 3.29]
Chen et al [13]	22.1	12.1	31	19.6	8.7	31	11.1%	2.50 [-2.75, 7.75]
El-Shamy et al [14]	20.1	5.8	30	19.7	6.6	30	30.8%	0.40 [-2.74, 3.54]
Total (95% CI)			**115**			**115**	**100.0%**	**0.97 [-0.77, 2.72]**

Heterogeneity: $Chi^2 = 0.93$, $df = 3$ ($P = 0.82$); $I^2 = 0\%$

Test for overall effect: $Z = 1.09$ ($P = 0.27$)

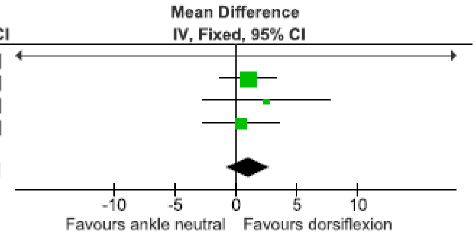

Figure 6: Maximal voluntary contraction of pelvic floor muscle: ankle neutral position Vs. dorsiflexion