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Yoga and Pilates compared to pelvic floor muscle training for urinary incontinence in elderly women: A randomised controlled pilot trial

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Highlights

- Yoga provides superior benefits for improving incontinence compared with Pilates, as measured by the International Consultation on Incontinence Questionnaire-Short Form.
- Yoga and Pilates are as effective as pelvic floor muscle training for decreasing the severity of stress urinary incontinence.
- The findings of this study demonstrated that the use of yoga and Pilates to strengthen the pelvic floor is applicable and feasible in elderly women.

ABSTRACT

Background and purpose: There is limited evidence from randomized controlled trials (RCTs) regarding the use of yoga and Pilates for the management of urinary incontinence (UI) in women. This study aims to investigate the preliminary effects of using Pilates and yoga to manage UI.

Materials and methods: An assessor-blinded, prospective, three-arm parallel-group randomized controlled pilot trial was conducted in three elderly care centres in Hong Kong. Thirty women aged 60 years or above were included in the study. Study centres were randomly assigned to each of the three interventions (yoga, Pilates and pelvic floor muscle training [PFMT; standard care control]). Study interventions were provided once a week for four weeks, followed by unsupervised CD-guided home exercises for eight weeks. Outcomes included the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF), one-hour pad test, and feasibility measures such as adherence to the intervention programme, recruitment and retention rates and safety. Outcomes were assessed at baseline, 4 and 12 weeks. Statistical analysis was performed using two-way repeated measures analysis of covariance.

Results: All three interventions demonstrated a statistically significant effect on ICIQ-SF scores from baseline to weeks 4 and 12. Significant effects in UI were reported for yoga compared with Pilates (mean: −2.93, 95% CI −5.35, −0.51; p=0.02).

Conclusion: Yoga poses intended to address the pelvic floor and core muscles were found to have superior benefits over Pilates exercises in terms of improved continence measured with the ICIQ-SF.

Keywords: Pelvic floor muscle training, Pilates, randomised controlled trial, urinary incontinence, yoga.

1. Introduction

Urinary incontinence (UI) is a highly prevalent condition among adult women of all ages and greatly influences women's general health, well-being, and quality of life [1, 2]. The prevalence of UI in women aged 70 years or above is reportedly 40% [1]. A review of population-based studies revealed that the prevalence of reported UI ranged from 5% to 70%, with most studies reporting a prevalence of 25% to 45% [1, 3].

Pelvic floor muscle training (PFMT) is regularly adopted as the first-line conservative treatment for UI [2]. PFMT has been demonstrated to improve UI by increasing the strength, endurance, and coordination of the pelvic floor muscles (PFMs) [4, 5]. However, growing evidence has indicated that PFM contraction can be optimised by the co-contraction of core abdominal and other regional muscles (such as the transverse and rectus abdominis and the diaphragm) [5]. These muscles are often neglected during PFMT, despite their importance for optimal pelvic floor activation [5]. Pilates exercises that focus on pelvic stability, mobility, and body alignment [5, 6] are thought to result in significant improvements in PFM strength because most Pilates exercises are performed in conjunction with the contraction of the core abdominal muscles and the diaphragm [5]. Such exercises are crucial because urinary continence, the maintenance of intra-abdominal pressure, and respiratory mechanics are interconnected [5, 7]. However, the effectiveness of Pilates exercise for improving UI is currently inconclusive [8]. A Cochrane review concluded that insufficient evidence was available to confirm the effects of alternative therapies, such as Pilates exercise, for the treatment of UI [8]. Therefore, it was necessary to evaluate the effectiveness of Pilates exercises (that target the core abdominal muscles) to manage UI.

The breathing, relaxation, and muscle control techniques practised during yoga are thought to contribute to the strengthening of the PFMs [9, 10]. The lifting of the pelvic floor that occurs during exhalation is thought to increase the strength and tone of the PFMs [10]. A Cochrane review reported that yoga might, therefore, function as an alternative PFMT method or as a supplement to PFMT [9]. However, insufficient empirical evidence exists regarding the effectiveness of yoga for addressing UI [9]. Given the limited available evidence, the Cochrane review recommended future well-conducted trials to determine the effectiveness of yoga as a primary or adjunct intervention for the treatment of UI in women [9].

Despite reviews [11, 12] reporting positive effects of PFMT for the management of UI, the benefits are often compromised by patient adherence, motivation and commitment to PFMT [2]. Women have expressed increasing interest in using alternative therapies to treat stress UI (SUI) [8, 13, 14]. Yoga and Pilates have been increasingly integrated into rehabilitation programs as alternatives to PFMT because they may provide a more holistic mind-body approach to the management of UI [2].

Given the insufficient evidence for the effectiveness of Pilates and yoga in the treatment of UI, the objective of this study was to (1) investigate the preliminary effects of Pilates and yoga compared to PFMT on improving UI in community-dwelling elderly women and (2) test the feasibility of using Pilates and yoga in a future full-scale randomised controlled trial (RCT). Data from this pilot trial will be used to conduct a power analysis for a future RCT.

2. Materials and methods

2.1. Design

This study was an assessor-blinded, prospective, three-arm, parallel-group randomised controlled pilot trial conducted in Hong Kong from January to December 2019. Ethics approval was obtained from the human subjects ethics sub-committee of the Hong Kong Polytechnic University (reference number: HSEARS20190509001) before data collection. This trial was prospectively registered in the Australian New Zealand Clinical Trials Registry (registration number: ACTRN12619000784112). Trial registration was completed before the enrolment of the first participant.

2.2. Participants, therapists, and centres

Women were included in the trial if they (1) were aged 60 or above, (2) had stress or mixed UI and (3) obtained at least 6 out of 21 in the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF). Women were excluded if they (1) had pure urgency incontinence, (2) were experiencing UI caused by neurological conditions (such as Parkinson's disease, multiple sclerosis, spinal cord injury, Alzheimer's disease, etc.), (3) had cognitive impairment (obtaining a score of less than 23 in the Mini-Mental State Examination [MMSE] scale), (4) had pelvic organ prolapse (stage 3 or 4 in the Pelvic Organ Prolapse Quantification System), urethral and/or vesical fistula, urinary tract infection or haematuria, (5) were currently receiving treatment for pelvic cancer, (6) were bedridden or (7) were participating in other research related to UI.

Potential participants were recruited from three elderly care centres (Kwai Fong Light and Love Home, the Sik Yuen Ho Chak Neighbourhood Centre for Senior Citizens and Ma On Shan Neighbourhood Elderly Centre) in Hong Kong. A certified yoga trainer with 500 hours of yoga training provided the yoga intervention. A Pilates trainer with over 10 years of experience provided

Pilates training. PFMT was provided by a perineal rehabilitation therapist (trained at the Herman and Wallace Pelvic Rehabilitation Institute, USA) with over five years of experience.

2.3. Randomisation and blinding

Study centres were randomly assigned to each of the three interventions (yoga, Pilates and PFMT). The simultaneous randomisation technique (the complete sampling frame was created, and centres were randomised prior to enrollment of participants) [15] was employed to randomise centres to interventions. Given the nature of the interventions, participants and therapists could not be blinded to study interventions. However, the assessment of the study outcomes was blinded. Data analysis was also blinded by assigning a group code (group A, B and C) to each of the three groups. The group code was revealed upon completion of the analyses.

2.4. Procedure

Women who volunteered to participate in the study were invited to their respective centres for a face-to-face visit for eligibility screening. During their visit, they provided written informed consent and completed a self-reported questionnaire containing demographic details, general medical information, the MMSE and the ICIQ-SF. Eligible women who provided written consent completed a one-hour pad test with a stress test. The one-hour pad test with stress will be referred to as the one-hour pad test hereafter. The ICIQ-SF scores and one-hour pad test were used to establish baseline data.

2.5. Intervention

Women underwent supervised sessions (yoga, Pilates or PFMT [standard care control]) once a week for four weeks, followed by unsupervised, CD-guided home exercises for eight weeks. Yoga, Pilates and PFMT training were provided through group-based exercises. Women in the yoga group performed the Virabhadrasana and Parsvakonasana poses (squeezing the heels toward the midline, which creates a lifting sensation in the PFMs) [10] in addition to the hatha

yoga style, which included eight postures: Tadasana, Utkatasana, Trikonasana, Malasana, Viparita Karani Variation, Salamba Setu Bandhasana, Supta Baddha Konasana and Savasana [16, 17]. An image of women performing a yoga pose is presented in Fig. 1. A description of the yoga poses (including descriptions of how long each yoga pose was held and how each pose might influence the pelvic floor) is summarised in Table A.1 (Appendix). Women in the Pilates group performed Pilates exercises targeting the pelvic floor and core muscles (transverse abdominis and multifidus) [6]. The Pilates exercises women performed included Pilates breathing, knee sways, heel slides, pelvic clock, coccyx curl, pelvic lift, roll down, leg springs, circles, single leg stretch, scissors, spinal stretch, and swan prep [2, 6]. An image of women performing a Pilates exercise is presented in Fig. 2. A description of the Pilates exercises (including a description of the number of repetitions for Pilates exercises and how the Pilates exercises were progressed) is summarised in Table A.1. Women in the PFMT group performed the following exercises in antigravity positions (lying on their sides, supine, or prone or kneeling on all fours) and progressed to against-gravity positions (sitting and standing): (1) contract the urethra; (2) control the bowel action (or the passage of wind); and (3) contract the urethral orifice, control the bowel action, and draw the vagina upwards. Eight contractions were performed for each of these pelvic floor exercises (i.e., 24 contractions in total each session). Each contraction was held for five to six seconds, followed by relaxation for 10 seconds.

At the end of the four-week supervised training period, all participants received a CD that contained videos, a booklet with photos and instructions for their respective intervention training sessions, and an adherence diary to assess adherence to unsupervised home exercise. Participants in the Pilates and yoga groups were required to perform unsupervised home exercises five times a week for eight weeks, each session lasting 30 to 45 minutes. Women in the PFMT group were

instructed to perform unsupervised home exercises three times a day [18], five days a week, for eight weeks. The intensity and duration of PFMT during the unsupervised home exercise were the same as described for supervised training. The exercise parameters for PFMT were based on the National Institute for Health and Care Excellence (NICE) guidelines for PFMT [18]. Weekly telephone calls were made to each participant to optimise their adherence to home exercise.

2.6. Outcome measures

Assessments of the outcomes were completed at baseline, four weeks and 12 weeks. The self-reported ICIQ-SF and one-hour pad test were used to assess the outcome of the treatment. The ICIQ-SF is a self-reported questionnaire that measures the frequency and amount of urine leakage and the overall impact of UI. The ICIQ-SF is scored out of 21, with higher scores indicating greater severity. The ICIQ-SF is reported to have adequate validity ($r = 0.93$) [19]. The translated Chinese version of the questionnaire used in the present study is reported to have adequate internal consistency (Cronbach's alpha = 0.71–0.96) and reliability (kappa = 0.72–0.93) [20]. The one-hour pad test was used to quantify the severity of urine leakage [21, 22]. A review by the working group of the International Continence Society Urodynamic Committee recommended the use of a one-hour pad test, as it is an easy and inexpensive objective method of quantifying urine loss, although it may have some limitations [21]. The review reported that pad tests should be supplemented with other assessment instruments, such as questionnaires [21, 22]. For the one-hour pad test, all participants were instructed to empty their bladder before wearing the pads ('Tena Discreet Pants'), after which they drank 500 ml of water. The women then performed a set of activities (as reported in a previous study) [21] for 30 minutes: walking, climbing up and down one flight of stairs, standing up from sitting (10 times), coughing vigorously (10 times), bending to pick up an object from the floor (5 times) and washing their

hands for one minute in running water [21]. The weight of the pad was then measured with a high-precision electronic balance to determine the amount of leakage. The feasibility measures assessed adherence to the intervention programme, recruitment and retention rates and safety.

2.7. Statistical analysis

A sample size calculation is suggested for pilot/feasibility studies testing a null hypothesis [23]. A sample size of 10–20 individuals per group is considered sufficient for pilot studies to estimate variance for power calculation for a larger trial [24]. It is recommended that the sample size for pilot studies is guided by the time and cost constraints [24]. Based on the available funds and timeframe, a sample size of 30 (10 in each group) was used.

Statistical analysis was performed using the IBM SPSS Software (v.25) on an intention-to-treat basis. Missing values were replaced using group means. Statistical significance was established as $P \leq 0.05$. Within-group differences were evaluated using multiple paired t-tests with Bonferroni correction. Two-way repeated-measures analysis of covariance (ANCOVA)/factorial ANCOVA with 'time' as a repeated factor and number of births as a covariate was used to determine the interaction effect between groups. Preliminary checks were conducted before running the analysis to ensure there was no violation of assumptions for running a two-way ANCOVA [25].

3. Results

Participants were recruited over three months, from June to August 2019. The follow-up assessment was completed in December 2019. Following randomisation of centres to interventions, Kwai Fong Light and Love Home was assigned to PFMT, Sik Yuen Ho Chak Neighbourhood Centre for Senior Citizens to yoga and Ma On Shan Neighbourhood Elderly Centre to Pilates.

Forty-three women volunteered to be in the study; thirteen women were excluded, as they did not meet the inclusion criteria. The remaining 30 women were included in the study. Participant flow through the study process is summarised in Fig. 3. At 12 weeks, one woman was lost to follow-up in the Pilates group because she relocated to Mainland China and; one woman from the yoga group dropped out of the study as she had to undergo surgery (an appendectomy).

The baseline characteristics of the participants are presented in Table 1. All participants (n = 28) were married Chinese women who had SUI. The mean age of the study participants was 74.57 (SD 6.42) years, and the average number of births was 2.86 (SD 1.27). The randomised groups were comparable at baseline. There were no significant differences in baseline characteristics between groups.

3.1. Effects of intervention

The descriptive statistics from the ICIQ-SF and one-hour pad test are presented in Table 2. Within-group differences from baseline to weeks four and 12 and from week four to week 12 are presented in Table 3. Between-group differences (time by group interaction using two-way ANCOVA) are reported in Table 4. Graphical summaries showing the group means for the ICIQ-SF is presented in Fig. 4, and the one-hour pad test results are presented in Fig. 5. The mean ICIQ-SF scores in all three groups decreased progressively from baseline to week four and week 12. The within-group analysis of ICIQ-SF scores demonstrated a statistically significant effect of all three interventions from baseline to week four ($p < 0.01$) and 12 ($p < 0.01$) and from week four to week 12 ($p < 0.05$). The between-group analysis of ICIQ-SF scores revealed a non-significant effect (of time by group interaction) of yoga and Pilates compared to PFMT ($p > 0.05$). However, yoga was significantly more effective than Pilates ($p = 0.02$) in improving

continence measured with the ICIQ-SF. Effect size ranged from small to medium (0.22) measured by the ICIQ-SF.

Mean grams of urine lost (one-hour pad test) decreased progressively from baseline to week four and week 12 in all three groups (Table 2). The within-group analysis demonstrated a statistically significant decrease in urine leakage (in grams, measured with the one-hour pad test) from baseline to week four ($p > 0.01$) in the yoga and PFMT groups but not in the Pilates group ($p > 0.05$). However, the decrease in urine leakage from baseline to week 12 was statistically significant in all three groups ($p < 0.01$). The between-group analysis of the one-hour pad test data identified a non-significant effect (of time by group interaction) of yoga and Pilates compared to PFMT and of yoga compared to Pilates ($p > 0.05$). The size of the effect was small (0.04) for the one-hour pad test.

3.2. Feasibility measures

The required number of participants was recruited over two months. The overall adherence of the three groups to the supervised sessions was 100%, and adherence of the three groups to the unsupervised home exercise sessions was 90%. The retention rate was 93%, and no adverse events were reported.

3.3 Sample size for the future RCT

We used G*Power 3.1.9.2 to estimate the sample size for the future RCT [26]. The sample size was calculated for ANCOVA, for a three-group comparison study, to capture fixed effects, main effects and interactions. Using estimates of change in ICIQ-SF ($\boldsymbol{d} = 0.22$), the sample size required to detect differences in ICIQ-SF with at least 80% power at the 5% level of significance

is 165 (55 per group). Assuming a 15% drop out rate, 189 participants (63 per group) would be required.

4. Discussion

The study aimed to investigate the preliminary effects and feasibility of using Pilates and yoga compared to PFMT for improving UI in community-dwelling elderly women. All three interventions demonstrated a statistically significant effect on ICIQ-SF scores from baseline to weeks 4 and 12. However, the between-group analysis of ICIQ-SF scores and one-hour pad test revealed a non-significant effect of yoga and Pilates compared to PFMT. Yoga was significantly more effective than Pilates in improving continence measured with the ICIQ-SF, but not on urine leakage, measured with the one-hour pad test. The lack of significance between groups might have been due to the relatively small size of the study [35]. Although significant results were reported for yoga compared to Pilates, the confidence interval (CI) surrounding the effect was wide (−5.35, −0.51), perhaps a result of the sample size. Increasing the sample size decreases the width of the CI because it decreases the standard error [35]. This justifies the need for conducting an adequately powered RCT.

The results of the current study cannot be compared to previous studies of similar interventions because of the differences in the population (types of UI) [16], control conditions [16, 27] and outcome measures [2, 6]. Previous studies of the effects of yoga and Pilates included women with urge [27], urge-predominant stress [16] or mixed UI [2] and utilised subjective measures such as bladder diaries to record incontinence frequency [16], UI episodes [27] or PFM strength [6]. The control conditions of those studies were wait-list control [16], PFMT (augmented with biofeedback, vaginal manipulation and neuromuscular education) [2, 6] or mindfulness-based stress reduction [27]. The current study included only women with stress UI, used a control group

that performed PFMT alone (without any adjunct therapies such as biofeedback), and determined outcomes using both subjective (ICIQ-SF) and objective measures (one-hour pad test). A literature search identified no minimal clinically important difference values for the one-hour pad test in women with SUI. However, a clinically meaningful change in ICIQ-SF scores is defined as a four-point reduction from baseline for women undergoing non-surgical treatments for UI [28]. The mean reduction in ICIQ-SF scores in all three groups reported in the current study from baseline to week 12 (Table 2) is well above the threshold of four points. A mean change of 9.9 points (Table 2) in ICIQ-SF scores reported by the PFMT group at week 12 is noteworthy. However, these results must be considered with caution because this study is underpowered, with only a small number of participants in each group.

The most commonly used perineal test for the objective assessment of urine loss is the one-hour pad test recommended by the International Continence Society [29] and the 24-hour pad test [30]. The current study utilised the one-hour pad test because it is easy to use, inexpensive, has a short duration and increases participant compliance [31]. However, the one-hour pad test is criticised for inadequate test-retest reliability [32] and conflicting correlation results with reported symptoms [30]. The 24-hour pad test is reportedly a reliable test with good test-retest reliability [33]. Additionally, the 24-hour pad test correlates better with symptoms of UI [34], is more suitable for elderly women who have a physical disability that prevents them from performing some of the exercises for the one-hour test, and is more representative of the women's day-to-day experiences [30]. Therefore, the 24-hour pad test will be used instead of the one-hour pad test in our future study. In addition, for our future RCT, we will establish a minimum baseline value for the 24-hour pad test, which was not performed in the current study. For the 24-hour pad test, a pad weight gain of 4 to 20 grams indicates mild incontinence, 21 to 74 grams indicates moderate incontinence, and

>75 grams indicates severe incontinence [21]. Therefore, for the future RCT, women with mild to moderate UI, as indicated by a baseline pad weight gain of 4 to 74 grams, will be considered for inclusion in the study [21]. The current study did not include any objective tools for the measurement of PFM strength. We plan to use objective tools, such as the modified Oxford scale, to monitor and quantify PFM strength in response to intervention in our future RCT.

4.1. Strengths and limitations

The current study is the first to compare the effectiveness of yoga, Pilates and PFMT for improving UI in community-dwelling elderly women. The primary strengths of the study are the rigorous methodological procedures, use of an objective measure (one-hour pad test) to quantify intervention effectiveness and low attrition rate. Reporting bias due to the no-treatment control condition was eliminated in the current study by including an active control group. The study's main limitation is the small sample size; our study was not sufficiently powered to make inferences about the effectiveness of the interventions. Furthermore, randomisation was done at the level of the centres/interventions rather than with all recruited participants, which might potentially cause bias at baseline. The relatively short follow-up period may also fail to reflect the long-term carryover effects.

5. Conclusion

Preliminary results show evidence of positive changes in UI following yoga, Pilates and PFMT interventions. The results demonstrated that yoga is superior to Pilates in terms of improved continence measured with the ICIQ-SF. The current study provides preliminary evidence to support the feasibility and effectiveness of yoga and Pilates compared to PFMT for improving UI

in community-dwelling elderly women. The effectiveness of interventions will be studied further in a future, adequately powered, randomised controlled trial.

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Table 1
Demographics and baseline characteristics of study participants

Characteristics	**Groups**		
	Yoga (*n* = 10)	**Pilates (*n* = 10)**	**Standard care control (PFMT) (*n* = 10)**
Mean age	74.2	73	76.2
(*SD, range*)	(5.37, 67-81)	(8.52, 62-87)	(5.37, 68-86)
Ethnicity, *n* (%)			
Chinese	10 (100)	8 (100)	10 (100)
Non-Chinese	0 (0)	0 (0)	0 (0)
Marital status, *n* (%)			
Married	10 (100)	8 (100)	10 (100)
Never married	0 (0)	0 (0)	0 (0)
Number of births, *n* (%)			
0	0 (0)	1 (12.5)	0 (0)
1	1 (10)	0 (0)	1 (10)
2	2 (20)	3 (37.5)	3 (30)
3	4 (40)	3 (37.5)	2 (20)
4	2 (20)	0 (0)	3 (30)
5	1 (10)	1 (12.5)	1 (10)
Education level, *n* (%)			
Not been to school	1 (10)	2 (25)	2 (20)
Primary	5 (50)	5 (62.5)	7 (70)
Secondary	4 (40)	1 (12.5)	1 (10)
Types of UI, *n* (%)			
Stress UI	10 (100)	10 (100)	10 (100)

PFMT: Pelvic Floor Muscle Training; SD: Standard Deviation; UI: Urinary Incontinence

Table 2
The mean scores of ICIQ-SF and one-hour pad test

Outcome	Groups								
	Yoga			Pilates			Standard care control (PFMT)		
	Baseline	Week 4	Week 12	Baseline	Week 4	Week 12	Baseline	Week 4	Week 12
ICIQ-SF									
Mean	10.8	7.5	2.44	14.38	7.75	5.75	13.5	7	3.6
(SD)	(3.55)	(3.31)	(2.99)	(3.96)	(3.28)	(3.54)	(4.12)	(3.83)	(2.84)
Range	6-17	2-12	0-8	7-20	5-15	0-11	8-20	0-13	0-9
One-hour pad test (in grams)									
Mean	4.6	1.5	0.56	3.88	1.88	0.13	4.3	0.9	0.1
(SD)	(3.06)	(2.32)	(0.83)	(1.81)	(3.72)	(0.35)	(2.26)	(1.60)	(0.32)
Range	1-9	0-6	0-2	1-6	0-11	0-1	1-7	0-5	0-1

ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; PFMT: Pelvic Floor Muscle Training; SD: Standard Deviation

Table 3

Within-group comparisons of changes over time in ICIQ-SF and one-hour pad test outcomes in yoga, Pilates and standard care control groups

Groups	Time of Comparison	ICIQ-SF (*p*-value)	One-hour pad test (*p*-value)
Yoga	Baseline to Week 4	0.010*	0.008*
	Week 4 to Week 12	0.001*	0.186
	Baseline to Week 12	0.001*	0.002*
Pilates	Baseline to Week 4	0.004*	0.240
	Week 4 to Week 12	0.029*	0.231
	Baseline to Week 12	0.003*	0.001*
Standard care control (PFMT)	Baseline to Week 4	0.001*	0.005*
	Week 4 to Week 12	0.013*	0.137
	Baseline to Week 12	0.001*	0.001*

ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; PFMT: Pelvic Floor Muscle Training

*$p < 0.05$ was considered statistically significant.

Table 4

Between-group differences over time in ICIQ-SF and one-hour pad test outcomes

Groups for comparison	**Outcome Measures**					
	ICIQ-SF			**One-hour pad test**		
	Mean, SD (95% CI)	*SE*	*p-value*	*Mean, SD (95% CI)*	*SE*	*p-value*
Yoga vs standard care control (PFMT)	-1.09, 4.78 (-3.37, 1.18)	1.10	0.330	0.46, 2.39 (-0.67, 1.59)	0.55	0.406
	1.83, 5.17 (-0.62, 4.29)	1.19	0.136	0.45, 2.56 (-0.77, 1.67)	0.59	0.453
Pilates vs standard care control (PFMT)	-2.93, 4.96 (-5.35, -0.51)	1.17	0.020*	0.01, 2.45 (-1.18, 1.21)	0.58	0.984
Yoga vs Pilates						

CI: Confidence Interval; ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; PFMT: Pelvic Floor Muscle Training; SE: Standard Error; SD: Standard Deviation

*$p < 0.05$ was considered statistically significant.

Fig. 1. Women in the yoga group performing the Salamba Setu Bandhasana pose.

Fig. 2. Women in the Pilates group performing the coccyx curl.

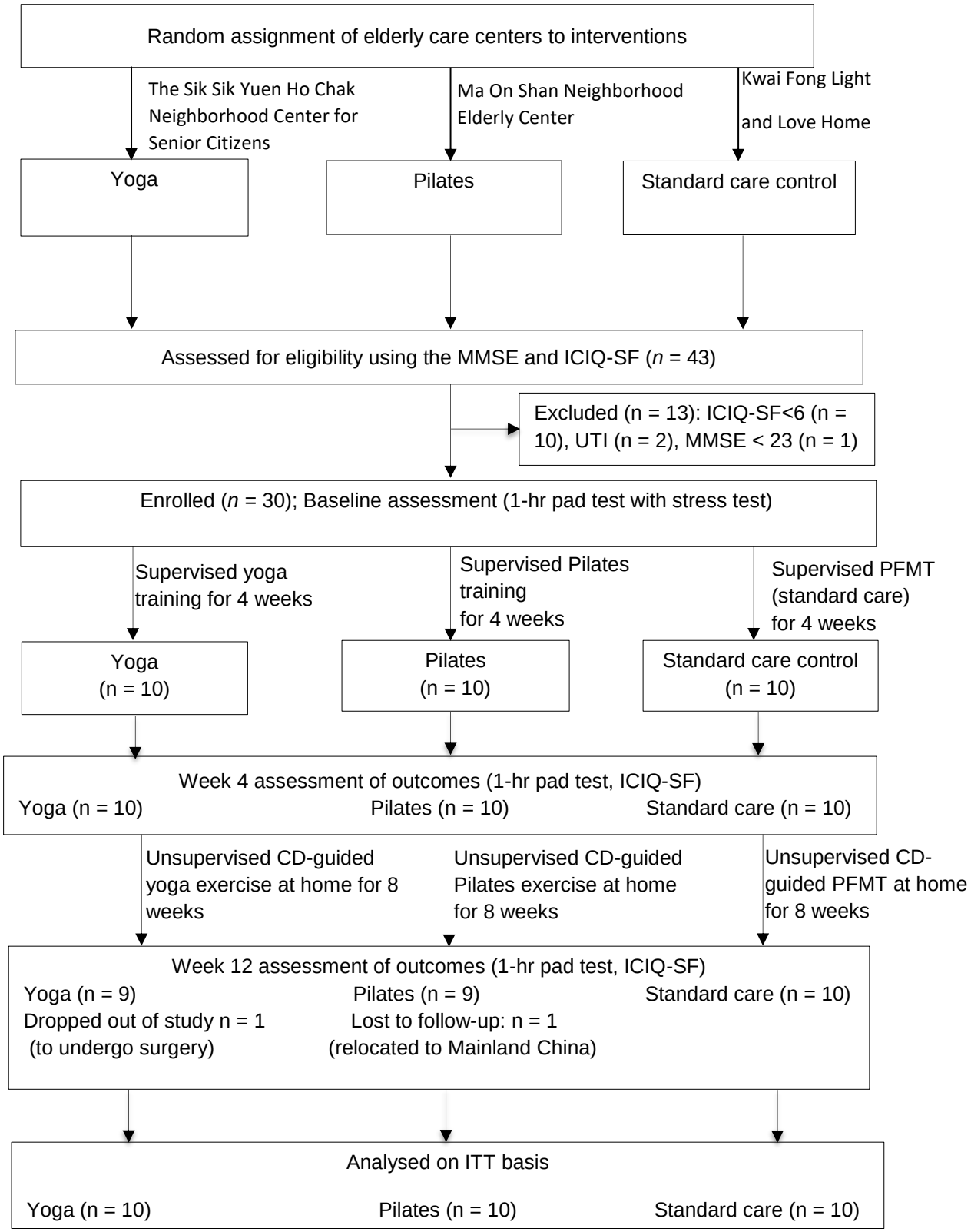
Random assignment of elderly care centers to interventions
The Sik Sik Yuen Ho Chak Neighborhood Center for Senior Citizens
Ma On Shan Neighborhood Elderly Center
Kwai Fong Light and Love Home
Yoga
Pilates
Standard care control
Assessed for eligibility using the MMSE and ICIQ-SF (n = 43)
Excluded (n = 13): ICIQ-SF<6 (n = 10), UTI (n = 2), MMSE < 23 (n = 1)
Enrolled (n = 30); Baseline assessment (1-hr pad test with stress test)
Supervised yoga training for 4 weeks
Supervised Pilates training for 4 weeks
Supervised PFMT (standard care) for 4 weeks
Yoga (n = 10)
Pilates (n = 10)
Standard care control (n = 10)
Week 4 assessment of outcomes (1-hr pad test, ICIQ-SF)
Yoga (n = 10)
Pilates (n = 10)
Standard care (n = 10)
Unsupervised CD-guided yoga exercise at home for 8 weeks
Unsupervised CD-guided Pilates exercise at home for 8 weeks
Unsupervised CD-guided PFMT at home for 8 weeks
Week 12 assessment of outcomes (1-hr pad test, ICIQ-SF)
Yoga (n = 9)
Dropped out of study n = 1 (to undergo surgery)
Pilates (n = 9)
Lost to follow-up: n = 1 (relocated to Mainland China)
Standard care (n = 10)
Analysed on ITT basis
Yoga (n = 10)
Pilates (n = 10)
Standard care (n = 10)

Fig. 3. Participant flow through the study.

ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; ITT: Intention To Treat; MMSE: Mini-Mental State Examination; PFMT: Pelvic Floor Muscle Training; UTI: Urinary Tract Infection.

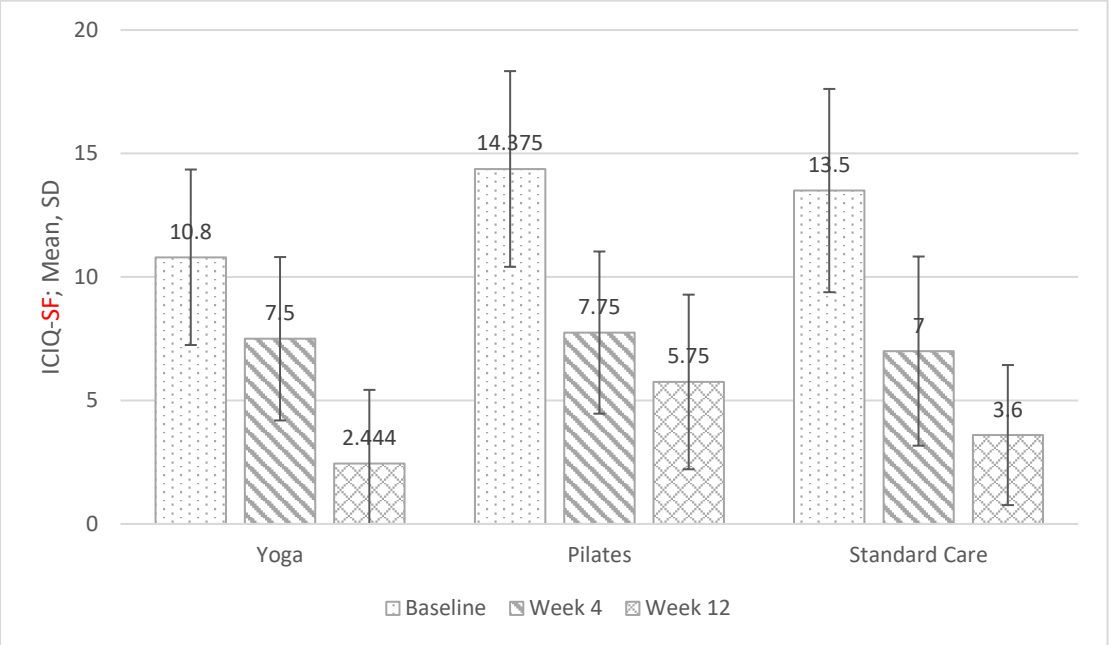

Fig. 4. Mean ICIQ-SF scores of yoga, Pilates and standard care control groups at the three assessment time points.

ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; SD: Standard Deviation.

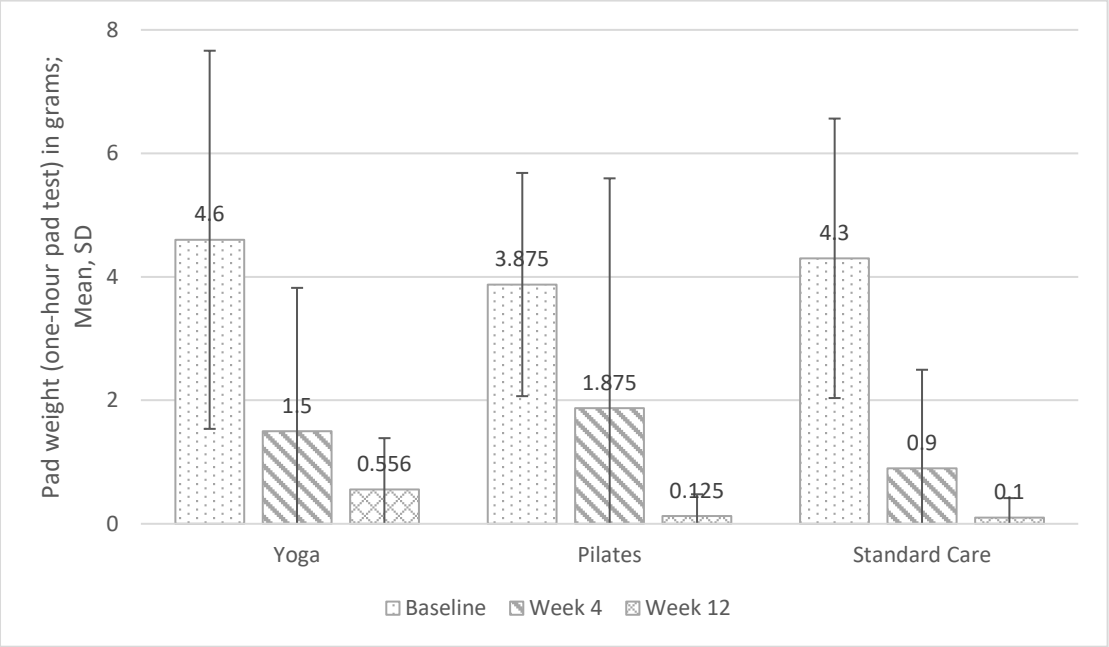

Fig. 5. Mean one-hour pad test (urine leakage in grams) scores of yoga, Pilates and standard care control groups at the three assessment time-points.

SD: Standard Deviation.

Details of yoga poses and Pilates exercise

Yoga poses	
Pose	*Description*
Tadasana (mountain pose)	Tadasana is the basis for several standing asanas. Tadasana is performed standing with the big toes touching. The toes are lifted, fanned out, and dropped back down. The anterior thigh muscles are engaged to move the kneecaps upwards. The thighs are then rotated inwards by placing a block between the thighs. The block is squeezed with the legs and rolled backwards slightly to feel the engagement and rotation of the thighs. Relaxed breathing is performed during this pose.[1] The Tadasana pose is maintained for 30 seconds to 1 minute, with easy breathing. Tadasana is progressed by removing the block and performing the thigh action as if the block were still between the thighs.
Virabhadrasana II (warrior pose)	The Virabhadrasana pose strengthens the core (transverse abdominis and multifidus) and pelvic floor muscles.[2] The core and pelvic floor muscles work in conjunction with the spinal extensors and flexors to maintain the torso in the upright position. From the Tadasana pose, the feet are spread wide, and the right foot is turned out so that the toes are pointing away from the body, while the left foot is turned slightly in. The knee is bent over the left ankle, bringing the left thigh parallel to the floor. The right leg is straightened, and the right heel is pressed down into the floor. The arms are raised parallel to the floor, with palms facing down. The Virabhadrasana II pose is held for 30 seconds to 1 minute and then repeated on the other side for the same duration.[3] Virabhadrasana II is progressed by turning the palms and inner elbow creases to face the ceiling while drawing the shoulder blades backwards.
Parsvakonasana (extended sides angle pose)	The Parsvakonasana pose works the core abdominal muscles (transverse abdominis). The Parsvakonasana pose was modified for the elderly by performing the pose on a chair. Sitting on a chair, the right leg is swung 90 degrees to the right, allowing the chair to support the right sitting bone and the back of the thigh. The left leg is then extended slightly ahead of the right leg. On an inhalation, the arms are lifted up and out to the sides, parallel to the floor. On an exhalation, the right elbow is bent, and the forearm is placed firmly on the thigh. The left arm is then lifted above the head. The Parsvakonasana pose is maintained for 6 to 8 breaths and then progressed to 12 to 24 breaths.[4]
Utkatasana (chair pose)	Going in and out of chair pose works the pelvic floor. In Utkatasana, the knees are held hip-width apart, the knees are bent, and the arms are lifted above the head (in line with the ears), reaching the fingertips to the ceiling to lengthen the torso.[5] Elderly women were encouraged to perform this pose with a yoga block held between the thighs and to maintain the neck neutral, rather than lifting the chin. The Utkatasana is held for 15 to 20 breaths. The Utkatasana pose is progressed by reducing the distance between the feet.
Trikonasana (triangle pose)	The Trikonasana pose works the core abdominal muscles. Trikonasana involves standing with the feet one foot-length apart with the knees straight. The right foot is turned completely to the outside, and the left foot is turned < 45 degrees to the inside. The arms are lifted and spread

	out to the sides with palms facing down. The torso is extended forward over the right leg. The left fingers are then placed on the ground beside the right big toe. The right arm is extended vertically toward the ceiling, and the spine and trunk are gently twisted (clockwise). Finally, the head is turned to the right to gaze at the right thumb. A steady breathing pattern should be maintained.[6] The trikonasana pose is maintained for 30 seconds to 1 minute. The Trikonasana pose was modified for elderly women; they could place the top hand against a wall and the bottom hand on a yoga block. This pose was maintained for 30 seconds to 1 minute. The Trikonasana pose could be progressed by moving away from the wall or by removing the yoga block.
Malasana (garland pose)	Malasana pose opens the pelvic floor and facilitates pelvic health. Malasana is a squatting pose with feet (hip-width apart), heels lifted off the floor, pressing the elbows into the knees and holding the palms together in a prayer position.[1] Elderly women performed this pose with their backs supported by a wall and their feet on the ground. Malasana is maintained for 30 seconds to 1 minute. The Malasana pose (for the elderly) is progressed by moving slightly away from the wall or lifting the heels farther away from the floor.
Viparita Karani Variation (legs up the wall pose)	Viparita Karani Variation works the core abdominal muscles (transverse abdominis). Viparita Karani Variation includes lying with the back on the ground and the buttocks against a wall and legs hip-width apart, extending up the wall. The right leg is then bent and brought towards the chest (relaxed breathing) and held for three breaths. The right leg is straightened and placed back against the wall. The motion is then repeated for the left leg.[7,8] Elderly women performed the Viparita Karani Variation pose by supporting the legs on a chair. The Viparita Karani Variation pose can be held for up to 5 minutes. The Viparita Karani Variation pose is progressed by increasing the time duration from 5 minutes to 10 minutes.
Salamba Setu Bandhasana (bridge pose)	The Salamba Setu Bandhasana pose facilitates pelvic motions, widens the pelvic girdle and stretches the abdominal region. Salamba Setu Bandhasana pose involves lying on the back with the knees bent and hands by the side of the body. The back and hips are lifted from the ground.[7,8] The Salamba Setu Bandhasana pose is performed for 30 seconds to one minute.
Variation of Supta Baddha Konasana (reclining bound angle pose)	The Variation of Supta Baddha Konasana has the following benefits: (1) it stimulates the abdominal organs (ovaries, bladder, and kidneys) and (2) stretches the inner thighs and groin. The Supta Baddha Konasana pose is performed by lying on the back with knees bent and the soles of the feet together on the floor (with blanket supports under the outer thighs if needed). Elderly women performed this pose with blanket support under the outer thighs.[7,8] To start, the Variation of Supta Baddha Konasana is held for 1 minute and is gradually extended to 5 minutes.
Savasana (corpse pose)	Savasana is intended to rejuvenate the body, mind, and spirit. To perform Savasana, women lie on their backs, with their legs spread as wide as the yoga mat, arms relaxed to the side, and eyes closed. The whole body is relaxed with an awareness of the chest and abdomen

	rising and falling with each breath. Savasana is held for 5–10 minutes at the end of asana practice.[6]
Pilates*	
Pilates breathing	Inhaling (breathing in) through the nose, expanding the ribs laterally, exhaling through the mouth, closing/moving the rib cage down and in. Pilates breathing is performed for 10 minutes.
Knee sways	Lying on the back with the knees bent and spine in a neutral position. Using the abdominals (and keeping the pelvis still), the knees are swayed from side to side (keeping knees together). Repeated five times.
Heel slides	Lying on the back with the knees bent, shoulders relaxed, and spine in a neutral position. Inhaling and sliding the leg away (keeping the heel in line with the ischial tuberosities [bones that press into the ground while sitting]). Exhaling and bending the knee to the starting position. Repeated five times for each leg.
Pelvic clock	Lying on the back with knees bent and feet flat on the floor. Hands placed on the belly, inhaling as the pelvis is tilted towards the 6 o'clock position and exhaling as the pelvis is tilted towards the 12 o'clock position. Repeated five times.
Coccyx curl	Lying on the back with knees bent and feet flat on the floor (hip-distance apart) and arms down by the side of the body. A deep inhalation is followed by exhalation; during exhalation, the navel is pulled toward the spine while gently squeezing the buttock muscles and flattening the lower back onto the mat. Repeated five times.
Pelvic lift	Lying on the back with knees bent, feet flat on the floor, the pelvis and buttocks are slowly raised off the floor as high as possible. The position is held for 10 counts and repeated five times.
Pelvic rocks	Lying on the back with knees bent and feet on the floor. During inhalation, the pelvis is rocked towards the tailbone, and during exhalation, the pelvis is rocked towards the belly button. Repeated five times.
Roll down	Standing with the back against a wall, with the feet 6 to 10 inches away from the wall, and arms at the side of the body. Abdominals are tucked in, and relaxed inhalation is performed. While exhaling, the head is flexed, and the spine is slowly rolled down and away from the wall (vertebrae by vertebrae). Repeated five times.
Leg circles	Lying on the back, unilateral perpendicular leg circles are performed in clockwise and anti-clockwise directions while maintaining a stable pelvis. Repeated five times.
Single leg stretch	Lying on the back with the knees bent and shins parallel to the floor. The right leg is brought to the chest, and the head and shoulders are lifted off the mat. The left leg is extended and maintained at a 45-degree angle. Elbows are lifted, and inhalation is performed. Then, exhalation and legs are switched. Repeated five times.
Scissors	Lying on the back with a slight natural curve under the low back and feet hip-width apart. Relaxed inhalation followed by exhalation; during exhalation, the pelvic floor and deep core are engaged to maintain a stable pelvis. This motion is followed by floating one leg to the tabletop position. Inhale and return the foot to the floor. Repeated five times for each leg.

Spinal stretch	Sitting up tall on the floor with legs straight and spread a little wider than the width of the hips. The feet are flexed during inhalation, followed by bending the neck and head forward with arms extended in front and shoulders relaxed while exhaling. Repeated three times.
Swan prep	Lying on the mat face down, with the arms close to the body, elbows bent, and hands under the shoulders. The belly button is lifted away from the mat, inhaling and lengthening the spine while pressing the forearms and hands into the mat. Exhale while returning the torso to the mat. Repeated five times.

*Pilates exercises were progressed by increasing the number of repetitions from 5 to 15.

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