ORIGINAL PAPER

FUNCTIONAL UROLOGY

The role of abdominal muscle training in combination with pelvic floor muscle training to treat female urinary incontinence – a pilot 12-week study

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Introduction Current literature is inconclusive as to whether transversus abdominis (TrA) training can provide an additional benefit to pelvic floor muscle (PFM) training in female stress urinary incontinence (SUI). We designed a study to investigate the effect of PFM and TrA training on incontinence parameters.
Material and methods 60 females with SUI were randomised to PFM training alone or PFM plus TrA training. They all attended 12 weekly training sessions by a single physical therapist and completed relevant questionnaires at baseline and study completion.
Results Both interventions reduced the number of incontinence episodes and improved quality of life (QoL) and sexual function. Women on PFM+TrA training reduced the number of used pads per day ($p = 0.007$), improved the QoL ($p = 0.031$) and the sexual lubrication score ($p = 0.04$), and reported better satisfaction rates compared to PFM alone (66.7% versus 43.3%). A subgroup analysis reported that women with pure SUI benefit more from combined PFM+TrA training compared to PFM alone ($p = 0.04$).
Conclusions TrA add-on to PFM training was similar to PFM training alone in the reduction of incontinence episodes but was superior in reducing the number of pads needed, which suggests a beneficial effect on the severity of incontinence.

Key Words: incontinence ‹› stress incontinence ‹› pelvic floor muscle training ‹› transversus abdominis muscle training

INTRODUCTION

Urinary incontinence (UI) is defined as the complaint of involuntary loss of urine during the bladder storage phase, and it is broadly classified as urgency UI (UUI) and stress- or activity-related UI (SUI); the former is associated with urgency while the latter is associated with effort, physical exertion, sneezing, or coughing [1]. About 30% of incontinent women present with mixed incontinence (MUI), which involves complaints of both urgency and SUI [2]. Even though MUI implicates an equal presence of stress and urge components, in daily practice, patients present with the predominant type, and those in whom urgency UI predominates report a higher degree of bother. The characterisation of UI type is fundamental for the management of these patients because UUI or MUI with a predominant urgency component can be treated by pharmacotherapy, while SUI or MUI with a predominant stress component are potential candidates for surgery.

Pelvic floor forms the inferior border of the abdominopelvic cavity, provides support for the pelvic viscera and controls their outlets [3]. Dysfunction of the pelvic floor muscles (PFMs) may lead to struc-

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tural problems such as SUI, faecal incontinence, and pelvic organ prolapse (POP) as well as functional problems such as sensory and emptying abnormalities of the lower urinary tract, defecatory dysfunction, sexual dysfunction, and chronic pain syndromes [3, 4]. A single PFM contraction narrows the levator hiatus area, increases the urethral closure pressure, and lifts the bladder and the rectum [2]. There is strong evidence that pelvic floor muscle training (PFMT) improves the function of the pelvic floor and symptoms of both types of UI, thus it is recommended as the initial treatment approach by all major scientific societies [2]. A Cochrane review compared PFM training to no treatment for SUI and found that women in the PMF training groups were 9 times more likely to report cure (56% vs 6%) [5].

It has been proposed that PFM rehabilitation is incomplete until the abdominal muscles are also rehabilitated [3]. Thus, training of the deep abdominal muscles, in particular the transversus abdominis (TrA), restores tonic PFM activity, especially when the automatic and coordinated function has been lost [3]. To date, however, there is ongoing discussion about the synergistic role of PFM and TrA, but the evidence according to systematic reviews is inconclusive [6, 7]. In asymptomatic women, a defined pattern of abdominal muscle activity in response to voluntary PFM contractions has been recorded [8].

The aim of this study is to compare the clinical effect of PFM and TrA muscle training on incontinence parameters in women with stress or mixed urinary incontinence with a predominant stress component.

MATERIAL AND METHODS

Study design and patient population

This was a randomised study approved by the Institutional Review Board and the local University's Ethics committee, and it was carried out in accordance with the Declaration of Helsinki. The study protocol was registered in the International Standard Randomised Controlled Trial Number registry (ISRCTN14126416).

Patients were recruited from the Female Urology outpatients clinics of the Urology Department and from the Urogynaecology outpatient clinics of the Obstetrics and Gynaecology Department of a public teaching hospital. Women ≥18 years old who presented with at least a 3-month history of SUI or MUI with a predominant stress component and had at least 7 incontinence episodes per week, as recorded in a bladder diary, were recruited. The enrolled women should have a positive cough stress test (CST) and a grade 3 or 4 PFM contraction based on the PERFECT Assessment Scheme [9]. Those with daytime frequency (>8 micturition episodes per day) or nocturia (>1 voidings per night) were excluded. Additional exclusion criteria were neurogenic lower urinary tract dysfunction (LUTD), and LUTD resulting from systemic diseases such as diabetes mellitus, chronic kidney disease, or reported history of any type of continence surgery. Pregnancy was also considered an exclusion factor.

Eligible patients signed a written informed consent form and were randomised to receive either PFM training plus TrA training (Group A) or PFM training alone (Group B) in a 1:1 allocation ratio. The randomisation process was performed on a single sequence of random assignments using SPSS 19.0 software (IBM Corp, Armonk, NY, USA). Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes to prevent undermining the random allocation sequence when assigning participants into treatment groups. The study protocol included weekly training sessions by a single physical therapist for 12 weeks. The detailed training sessions of both groups are presented in Table 1.

Clinical Assessment

All subjects underwent routine assessment with a detailed urological, medical, and gynaecological history, clinical examination with CST in lithotomy and/or upright position, vaginal assessment of the PFMs with the PERFECT assessment scheme, uroflowmetry, and ultrasonographic assessment of post-void residual. Eligible patients completed a 3-day bladder diary at baseline and at study completion. In addition, they completed the Kings Health Questionnaire (KHQ), the Patient Global impression of Improvement (PGI-I), the quality-of-life score, and the Female Sexual Function Index (FSFI) both at baseline and at study completion.

Study endpoints and parameters

The primary endpoint was the change in the number of incontinence episodes from baseline to end of the study (at week 12), as reported in the 3-day bladder diary. The secondary endpoints included changes in KHQ, PGI-I, QoL, and FSFI scores, and changes in the vaginal assessment of pelvic floor muscles using the PERFECT assessment scheme. A subgroup analysis of the primary outcome was performed between women with pure SUI versus MUI.

Statistics

Study power calculation was based on the results of our previously published randomised study [10].

Accepting a mean of 14 ±6 incontinence episodes per week for baseline, to achieve statistical significance for the primary outcome (change in the number of incontinence episodes by 50% from baseline to end-of-study) with at least 80% power, 95% confidence interval and effect size 1, and an estimated 30% drop-out rate, 32 women were needed for recruitment in each study arm.
Descriptive statistical analysis was carried out for all the study data. Continuous variables were summarized with the use of descriptive measures (mean, SD, range). An ANCOVA was used to adjust for pretreatment differences. All statistical tests were two-sided and were carried out at a 0.05 significance level. The analysis was done using SPSS 19.0 software (IBM Corp, Armonk, NY, USA).

RESULTS

A total of 85 women were recruited, but only 72 fulfilled the inclusion criteria and were randomised to Group A and Group B on a 1:1 basis. Sixty women completed the study (Group A: 30, Group B: 30) (Figure 1). The main reasons for the drop-out rate (7%) were the inability to attend the sessions (N = 4) or to perform the exercises independently (N = 3), as well as consent withdrawal (N = 2), or other (N = 3). The baseline characteristics of the final study sample are presented in Table 2.
At baseline, both groups were comparable for incontinence episodes per day (2.73 vs 3.53) as were recorded in the 3-day bladder diary. At 12 weeks, the incontinence episodes were evenly reduced in both groups (-1.76 vs -2.03, p = 0.278). However, group A patients significantly reduced the number of pads used per day compared to group B (-1.27 vs -1.09 pads/day, p = 0.007). In multiple linear regression models, the improvement in both groups was strongly correlated with the severity of incontinence prior to intervention, as measured by the number of incontinence episodes.
Prior to intervention, 83.3% of group A patients and 76.7% of group B patients reported being unsatisfied or disappointed as a consequence of urine incontinence. After intervention, a significantly larger proportion of group A patients (66.7%) as opposed to group B patients (43.3%) reported that they were satisfied with the outcome. Four women (13.3%) from group A and 7 women from group B (23.3%) reported being neither satisfied nor unhappy. These

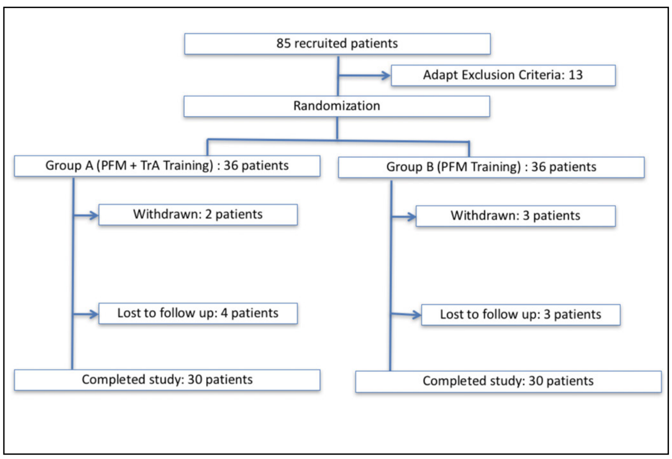

Figure 1. *Flow chart.*

Table 1. *Description of the 12 weekly training sessions*

Session	Group A	Group B
1st session	Re-training diaphragmatic breathing	Awareness of the PFMs. Isolation contraction – relaxation of the PFMs
2nd session	Training TrA from (quadruped, hook lying – supine, prone) positions by using Pressure Biofeedback	Activation PFMs with diaphragmatic breathing (supine position).
3rd session	Awareness of PFM. Isolation contraction – relaxation of the PFMs	Activation PFMs with diaphragmatic breathing (supine, sitting position).
4th session	Co-activation TrA – PFMs with diaphragmatic breathing (supine – sitting – standing position).	Activation PFMs with diaphragmatic breathing (supine, sitting and standing position).
5th session	Functional exercises of TrA and PFMs combined with loading by other muscle groups.	PFM coordination training during coughing, sneezing, laughing, and nose blowing.
6th session	TrA and PFM coordination training during coughing, sneezing, laughing, and nose blowing.	Activation PFMs during a change of position (sitting to standing position).
7th session	Functional exercises of TrA and PFM combined with loading in supine and sitting positions.	Activation PFMs during lifting of a heavy object.
8th session	Functional exercises of TrA and PFM combined with loading by other muscle groups in standing position.	Training PFM with slow and fast contractions in different planes.
9th session	Functional exercises of lumbopelvic control combined with loading in supine and sitting positions.	Training PFM with slow and fast contractions in standing position
10th session	Functional exercises of lumbopelvic control combined with loading in standing position.	PFM coordination training in all positions.
11th & 12th session	Functional exercises combined with co- activation of TrA and PFMs adapted to the patient's personal daily requirements.	Training of daily activities with correct use of PFM.

PFM – pelvic floor muscles; TrA – transversus abdominis

differences were reflected in the quality-of-life questionnaire score, in which a more significant improvement in group A was evident (-2.27 vs -1.73, p = 0.031) (Table 3).
Every domain of KHQ was improved after intervention in both groups. The incontinence impact domain, the personal relations domain, the emotions domain, and the symptom severity scale domain were improved to a great extent in both groups (-23.3 vs -18.9, -18.3 vs -6.11, -31.48 vs -16.67, and -24.67 vs -21.34, respectively) (Table 3).
The total FSFI post-intervention changes were comparable between the 2 groups (+3.48 vs +1.6, p = 0.393). Among the different parameters, only the lubrication subscale was significantly improved in group A compared to group B (+0.83 vs -0.03, p = 0.04) Table 2).
At baseline, the mean score of PFM strength using the PERFECT assessment was 3.0 for both groups. After intervention, group A significantly improved the PFM strength compared to pretreatment values (+0.66, p <0.001) and 95%CI: 0.66 (0.48 to 0.84). In contrast, group B improvement was not significant (+0.04, p = 0.313) and 95%CI: 0.04 (0.02 to 0.11). The post-intervention intergroup comparison revealed a superiority of group A (+0.62, p <0.001), CI95%: 0.62 (0.42 to 0.82).
A subgroup analysis was conducted to identify the benefit of PFM plus TrA training in women with

Table 2. Baseline characteristics.

	Group A (N = 30)	Group B (N = 30)
Age, Mean (±SD)	46.5 (6.2)	51.4 (11.0)
BMI, Mean (±SD)	25.7 (4.5)	27.2(4.4)
Pregnancies, Mean (±SD)	2.2 (1.0)	1.80 (0.76)
Vaginal deliveries, Mean (±SD)	2.07 (1.1)	1.63 (0.9)
No delivery, N (%)	2 (6.7%)	4 (13.3%)
1 delivery, N (%)	3 (10%)	7 (23.3%)
2 deliveries, N (%)	19 (63.3%)	16 (53.3%)
≥3 deliveries, N (%)	6 (20%)	3 (10%)
Pure stress urinary incontinence, N (%)	23 (54.8%)	19 (45.2%)
Mixed urinary incontinence, N (%)	7 (38.9%)	11 (61.1%)

BMI – body mass index; N – number of patients; SD – standard deviation

Table 3. *Quality of life score, King's Health Questionnaire, and Female Sexual Function Index results per treatment group*

	Group A (N = 30)		Group B (N = 30)		
	Before Intervention	After Intervention	Before Intervention	After Intervention	P (post-intervention intergroup comparison)
Quality of life score, mean (SD)	4.37 (1.03)	2.1 (0.92)	4.3 (0.99)	2.57 (0.62)	p = 0.031
KHQ (King's Health Questionnaire)					
General Heath Perception	28.3 (26.1)	20.0 (16.6)	27.5 (20.1)	27.5 (17.8)	p = 0.161
Incontinence impact	62.22 (31.24)	38.89 (29.14)	65.55 (28.34)	46.67 (27.12)	p = 0.568
Role Limitations	39.4 (29.52)	20.55 (23.4)	43.33 (30.5)	22.22 (27.1)	p = 0.919
Physical Limitations	42.77 (28.25)	23.33 (20.81)	43.33 (27.19)	16.67 (20.99)	p = 0.107
Social Limitations	26.66 (29.23)	17.22 (18.3)	27.96 (23.86)	18.88 (12.17)	p = 0.847
Personal relationships	20.55 (27.57)	2.22 (7.24)	15.55 (20.96)	9.44 (20.84)	p = 0.065
Emotions	44.07 (35.8)	12.6 (16.7)	31.1 (26.5)	14.4(17.5)	p = 0.187
Sleep/Energy	15.5 (22.7)	3.89 (11.31)	18.3 (24.9)	6.11 (10.25)	p = 0.564
Severity Measures	42.44 (22.32)	17.78 (14.9)	45.11 (20.24)	23.77 (15.23)	p = 0.134
FSFI (Female Sexual Function Index)					
Desire	3.56 (1.2)	3.81 (0.95)	3.65 (1.14)	3.9 (1.22)	p = 0.718
Arousal	4.04 (1.64)	4.71 (1.3)	3.72 (1.71)	4.05 (1.45)	p = 0.160
Lubrication	4.29 (1.62)	5.12 (1.22)	4.65 (1.8)	4.62 (1.61)	p = 0.040
Orgasm	3.99 (1.7)	4.66 (1.42)	4.32 (1.82)	4.64 (1.5)	p = 0.796
Satisfaction	4.74 (1.7)	5.19 (1.24)	4.65 (1.7)	5.13 (1.36)	p = 0.615
Pain	4.66 (1.78)	5.26 (1.34)	4.69 (2.1)	4.95 (1.87)	p = 0.518
Total score	25.27 (8.6)	28.75 (6.57)	25.69 (8.78)	27.28 (8.13)	p = 0.393

N – number of patients

pure SUI over women with MUI. Both subgroups showed significant improvement in the number of incontinence episodes per 24 h. In patients with pure SUI, the training of PFM and TrA was associated with greater improvement compared to PFM training alone (-0.56, p = 0.04) (Figure 2, Table 4).

DISCUSSION

The results of this study provide high-level evidence that PFM plus TrA training is similar to PFM training alone in the reduction of stress-urinary incontinence episodes; however, the combination of PFM plus TrA training is associated with significant improvement in quality of life and reduced number of pads used per day. In women suffering from pure SUI, TrA add-on training to PFM training was superior to PFM training alone.

Pelvic floor muscle training is the key conservative measure to improve functional and morphological parameters of the pelvic floor. During a single PFM contraction, the following effects are evident: the narrowing of the levator hiatus area, an increase of the urethral closing pressure, and the lifting of the bladder and rectum [11]. Performing a rapid, strong, and well-timed PFM contraction prevents urethral descent and subsequent urine leak during increases of intra-abdominal pressure, while intense training reinforces the structural support of pelvic organs and enhances the hypertrophy and stiffness of connective tissues [12]. In addition, PFM training improves urgency urinary incontinence episodes

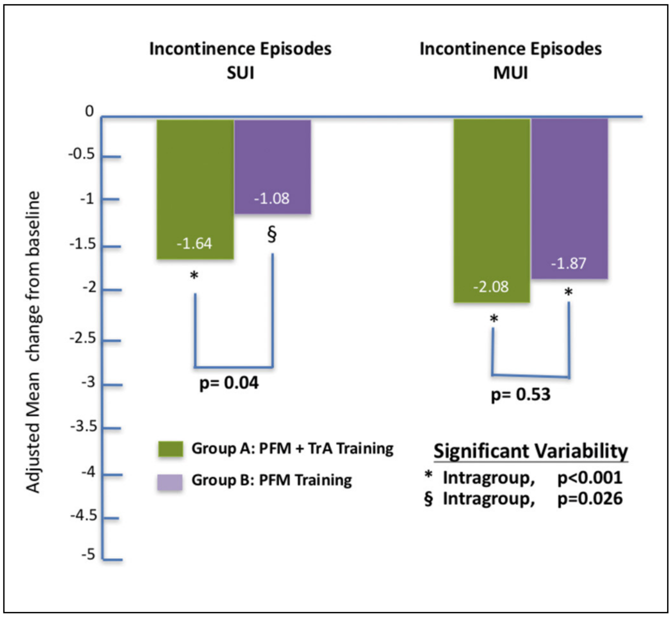

Figure 2. *Improvement in the number of incontinence episodes per 24 h.*

Table 4: Results for the subgroup analysis to identify the benefit of pelvic floor muscle plus transversus abdominis training in women with pure stress urinary incontinence

	Group A (N = 30)		Group B (N = 30)	
	SUI Subgroup (N = 23)	MUI Subgroup (N = 7)	SUI Subgroup (N = 19)	MUI Subgroup (N = 11)
Change in the number of incontinence episodes per 24 hours from baseline, mean (SD)	-1.64 (1.49)*	-2.08 (2.68)*	-1.08 (1.41)**	-1.87 (1.76)*
95% Confidence Interval	0.78 to 2.38	0.96 to 3.21	0.13 to 1.98	0.76 to 2.98

MUI – mixed urinary incontinence; PFM – pelvic floor muscle training; SD – standard deviation; SUI – stress urinary incontinence; TrA – transversus abdominis
*: p < 0.001, **: p = 0.026

because the strong PFM contraction can inhibit detrusor contraction in addition to occlusion of the urethra and thus prevents urine leakage [13]. The clinical efficacy of PFMT in women with SUI has been documented in a Cochrane review that compared PFMT with no treatment or with inactive controls and reported that intervention groups were 8 times more likely to report improvement or cure [5].

The interrelationship between TrA and the pelvic floor is not yet well understood. It has been demonstrated that during a PFM contraction, there is a transient increase in intra-abdominal pressure [14]. The authors concluded a synergistic action of these muscle groups because EMG monitoring could not verify relaxation of the abdominal muscles during the contraction of PFMs. Thus, activation of abdominal muscles might contribute to the continence mechanism. An electrophysiologic study has shown that during voluntary PFM contractions TrA is activated to 47.4% of maximal voluntary electrical activity [8]. There are data showing similar increases in urethral pressure during PFM exercise and TrA exercise [15]. The co-activation of PFMs during TrA contraction has been demonstrated also by ultrasound and MRI studies [16, 17]. This synergistic action is not evident in every woman, but activation of the PFMs during TrA contraction is less effective as compared to a direct PFM contraction [17, 18]. Makadoro and Miaki examined the association of TrA with early post-partum continence and reported that the muscle thickness was significantly smaller in incontinent subjects when compared to controls [19]. It has been argued that excessive activity of abdominal muscles is associated with greater intra-abdominal pressure, and it carries the theoretical risk of pelvic floor dysfunction due to pelvic floor descent [16].

There is conflicting evidence for the beneficial use of TrA training added to PFM training in women with incontinence. A systematic review failed to draw a conclusion about the effect of added TrA training to PFM training due to lack of robust evidence [6]. A small RCT randomised 30 obese women with mild SUI to PFM or TrA training for 12 weeks and assessed the effect on vaginal pressure, leak point pressure, and waist-hip ratio [20]. The latter was superior in this patient group. A single-blind RCT randomised 57 incontinent women to PFM alone and PFMT plus TrA training and followed them up for 7 years, concluding that there is no additional benefit of TrA training in the long term [15]. Kucukkaya et al. reported more significant improvement with combined PFM+TrA training as opposed to PFM training alone in the rate of negative stress test (93.7% vs 53.1%, $p < 0.001$) and in increasing PFM activity ($p < 0.05$) [21]. Dumoulin et al. randomised 62 women with SUI to PFM training plus electrical stimulation (ES), PFM training plus ES plus TrA training, and control, and reported that the cure rate (<2 gr on pad test) was similar between the intervention groups (70% and 74%) and significantly different from the control group [22]. A 4-D ultrasonographic study compared the constriction of levator hiatus during PFM or TrA contraction [23]. The investigators reported that changes in levator hiatus ultrasonographic parameters (levator hiatus area, transverse diameter, antero-posterior diameter, and muscle length shortening) during TrA contraction were weak compared to PFM contraction, with the latter being more effective. A cross-sectional study of 40 nulliparous professional female athletes reported that incontinent females had greater PFM strength compared to continent athletes ($p = 0.02$), suggesting that urinary incontinence in this population is not due to PFM weakness; however, no difference in abdominal muscle function was observed between groups [24].

Among the strengths of our study was the randomisation protocol, the close supervision of patients by the physical therapist, and the homogenous sample. The main limitations were the small sample size (although the study was adequately powered), the short follow-up, and the lack of pad test to quantify incontinence. An additional limitation is the lack of electrical activity of TrA monitoring by EMG to verify TrA activation during PFM contraction and similarly the activity of PFM during TrA contraction, but this could add to a future investigation.

CONCLUSIONS

Our results show that at 12 weeks of follow-up TrA added to PFM training is as effective as PFM training alone in the reduction of leakage episodes, but it is superior in reducing the number of pads needed, which suggests a beneficial effect on the severity of incontinence, which is reflected in significant improvement in quality of life. In patients with pure SUI, TrA added to PFM training was superior to PFM training alone in improving incontinence episodes. Due to the small study sample, the results need to be confirmed in larger longitudinal studies.

CLINICAL TRIAL REGISTRATION

International Standard Randomised Controlled Trial Number registry (ISRCTN14126416).

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS OF APPROVAL STATEMENT

The study was approved by the Institutional Review Board of Papageorgiou General Hospital (approval number 136/11.12.2009) and the local University's Ethics Committee (General Assembly of the Medical School of Aristotle University of Thessaloniki approval number A12899/24-7-2008)

PATIENT CONSENT STATEMENT

All patients signed a written informed consent form

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