Research Article

Effectiveness and predictive factors of pelvic floor muscle training in female urinary incontinence: A retrospective cohort study

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Abstract

Background: Factors predictive of the efficacy of pelvic floor muscle training (PFMT) in stress urinary incontinence (SUI) or mixed urinary incontinence (MUI) are poorly defined. Identifying these factors is crucial for guiding treatment decisions, determining training repetitions, and predicting PFMT outcomes. **Objective:** This study aimed to identify clinical factors predictive of PFMT outcomes in women with primary SUI. **Methods:** We retrospectively reviewed data from 188 consecutive women with either SUI ($n = 90$) or MUI ($n = 98$) with a primary stress component. All participants underwent a 3-month PFMT program. Predictive factors for 50% improvement and complete cure of incontinence were assessed through urogynecological history/examination, medical history, digital pelvic floor muscle (PFM) evaluation ($n = 87$), and 3-day bladder diaries. Logistic regression analyses were conducted for the overall group and separately for the SUI and MUI subpopulations. **Results:** At 3 months, 10% of SUI patients and 11.2% of MUI patients achieved complete SUI cure, while 35.7% of MUI patients were free from urge urinary incontinence (UUI). A complete cure of SUI was correlated with a negative or mildly positive results of stress test ($p = 0.014$). For MUI patients, complete UUI cure was linked to initial digital PFM evaluation results ($p = 0.003$) and negative ($p = 0.005$) or mildly positive findings of stress tests ($p = 0.003$). The absence of prior surgery and digital evaluation predicted a 50% improvement in MUI ($p = 0.021$ and $p = 0.026$, respectively). Endurance improvement was related independently with >50% improvement in MUI patients (odds ratio = 3.794, $p = 0.019$). **Conclusion:** Negative or mildly positive stress tests and digital PFM evaluation predict better outcomes with PFMT. Further prospective studies are needed to validate these findings.

Keywords: Mixed urinary incontinence, Pelvic floor muscle training, Predictive factors, Stress urinary incontinence, Urinary incontinence

1. INTRODUCTION

Urinary incontinence (UI) is a highly prevalent condition in women, with substantial physical, psychological, and socioeconomic consequences [1]. Approximately 33% of adult women suffer from UI, though prevalence rates vary widely, ranging from 5% to 70%, depending on factors such as age [2,3]. Remarkably, the Study of Women's Health Across the Nation study, which encompassed 1,339 American women with UI, found that 61% of women did not seek medical help for their condition, indicating a significant gap in treatment-seeking behavior [4].

UI management typically includes conservative measures, pharmacological treatments, and surgical interventions. Pelvic floor muscle training (PFMT) is emerging as a primary therapeutic approach, aiming to improve the strength, endurance, and relaxation of pelvic floor muscles (PFM) to prevent the progression of UI [5-9]. PFMT has

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proven effective in reducing symptoms of both stress urinary incontinence (SUI) and mixed urinary incontinence (MUI) by enhancing voluntary PFM contraction and maintaining muscle tone. These events help prevent bladder neck descent during physical exertion [6]. Furthermore, substantial evidence supports the role of PFMT in treating urgency urinary incontinence (UUI), as it helps inhibit detrusor muscle contractions and increases PFM and urethral sphincter tone through urethra-bladder reflexes [6].

Despite the established benefits of PFMT, few studies have identified the predictive factors that influence its efficacy [10,11]. A recent systematic review of 15 randomized control trials showed that PFMT mitigated incontinence severity but failed to identify factors predictive of treatment success, highlighting a gap in the literature [12]. Although UI is prevalent in older women with various comorbidities, our study focused on women aged 52.2 ± 10 years, with only 19.7% having a history of gynecological surgery. The aim of this study was to retrospectively assess the efficacy of PFMT in women with stress and/or mixed UI and to identify clinical predictive factors affecting the outcomes of PFMT in this population.

2. MATERIALS AND METHODS

2.1. Participants

This study was a single-center, retrospective analysis of a 3-month PMFT program for women with UI, conducted between April 2022 and March 2023. This study protocol was approved by the Scientific Committee of "Papageorgiou" General Hospital, Thessaloniki (registration number 341st/21.04.2021), and it compiled with the Declaration of Helsinki.

We retrospectively reviewed data from 188 consecutive women with either SUI or MUI with a primary stress component. All participants were on a standardized 3-month PFMT program administered by a specialized physiotherapist. All participants were recruited from the female urology outpatient clinics of a public teaching hospital. The inclusion criteria were: (i) at least 18 years of age, (ii) a diagnosis of SUI or MUI by a functional urologist, and (iii) strict adherence to the 3-month standardized PFMT program. The exclusion criteria comprised: (i) symptoms of UUI only, (ii) stage III or IV prolapse (prolapse >1 cm below the hymen during straining), (iii) prior incontinence or prolapse surgery, (iv) inability to contract PFM, (v) pregnancy or recent delivery (within the past 6 months), and (vi) a history of neurological disease.

2.2. Study design and PFMT program

All participants were evaluated at baseline and monthly for symptom severity throughout the 3-month PMFT program [13]. The initial evaluation included an interview to collect data on the patients' demographics, medical history, and clinical examinations.

The following variables were recorded: (i) demographic characteristics (age and somatometric values), (ii) urogynecological history (gynecological surgeries, number and type of deliveries, menopausal status, type and severity of incontinence, presence of frequency, nocturia and prolapse, (iii) medical history of comorbidities, concomitant medications, other surgeries, (iv) digital evaluation of the PFM, and (v) 3-day bladder diaries. In addition, we analyzed baseline urodynamic data from women originally referred for preoperative evaluation who later opted for PFMT. The stress test was classified as mildly positive if urine loss was absorbed by one pad, moderately positive if absorbed by two to three pads, and severely positive if more than three pads were needed. The digital evaluation involved digital palpation during maximal voluntary contraction and assessed PFM strength, endurance, number of repetitions, and number of fast contractions. Women were instructed to perform maximal pelvic floor contractions for 5 s, with 10-s rests in between. The best result from three trials was used for data analysis. Muscle endurance was measured by the duration of continuous contraction until the participant could no longer maintain it.

The PFMT protocol used in our clinic has been previously described and was administered by a single physiotherapist [13]. Each woman attended a 1-h supervised session, including education on pelvic floor anatomy and a demonstration of the PFMT program. Participants were instructed to perform three sets of fast contractions and 3–4 sets of slow contractions daily, in lying, sitting, and standing positions (10 repetitions per set). During monthly follow-up visits, the program was adjusted according to the patients' progress in endurance and/or strength. Those who progressed well were instructed to increase the number of repetitions by 1–3 sets for fast contractions and one set for slow contractions and extend their endurance time by 2 s. In addition, they were advised to incorporate pelvic floor exercises into daily activities involving physical exertion. Women with moderate or minimal progress were instructed to continue with the same number of sets as initially prescribed. Strict adherence to the program was ensured through telephonic reminders of follow-up visits. In case of delays, follow-up visits were rescheduled and program parameters (including digital evaluation using the Oxford Grading Scale, number of repetitions, and muscle strength) were adjusted accordingly [14].

2.3. Outcomes

2.3.1. Primary outcome

The primary outcome was to identify predictive factors for at least 50% improvement or complete cure of incontinence. The efficacy of PFMT was assessed by evaluating changes in

the number of pads used and the results of the stress test at the end of the study period, compared to baseline measurements.

2.3.2. Secondary outcomes

Secondary outcomes included the effect of PFMT on bladder diary parameters (such as the frequency of micturition and nocturia), constipation, and changes in the PFM parameters. PFM parameters were assessed using the Oxford Grading Scale for digital evaluation results, as well as the number of exercise repetitions, fast contraction repetitions, and muscle strength [14].

2.3.3. Statistical analysis

Numerical variables were presented as mean±standard deviation or as median (25–75% quartiles) when skewed. Categorical variables were expressed as frequencies and percentages. Paired *t*-test (parametric) and U-test (non-parametric tests) were used for comparisons before and after PMFT sessions. In addition, parametric and non-parametric tests were conducted to compare bladder diary parameters and urodynamic characteristics before and after PMFT sessions.

Predictive factors for at least 50% improvement or complete cure of incontinence, as indicated by the number of pads used, were investigated in the total study group and separately for the SUI and MUI subpopulations using univariate and multivariate logistic regression analyses. Factors evaluated included age, Body mass index, type of incontinence, number of deliveries, the onset of menopause, history of prolapse and constipation, medication, surgical history, the birth of overweight neonates, severity of leakage on stress test, and the use of digital palpation.

Statistical analysis was carried out using IBM SPSS Statistics for Windows, version 24.0 (IBM Corp, USA).

3. RESULTS

3.1. Patient characteristics

A total of 188 women were included in the study cohort. Of these, 90 women (47.9%) suffered from SUI, while the remaining 98 women (52.1%) had MUI with primary stress component. The mean age of the women was 52.2 ± 10 years, and the median BMI was 27.6 kg/m^2. The median number of deliveries was 2 (interquartile range (IQR) = 1). Fifty-seven women (32.9%) had delivered overweight neonates. Most participants (64.9%; 122 women) were postmenopausal, and 19.7% (37 women) had a history of gynecological surgery. Forty-two women (22.3%) were additionally prescribed medication for incontinence. Of these, 13.8% (26 women) received anticholinergics, 4.3% (eight women) duloxetine, and 2.1% (four women) mirabegron. In addition, 2.1% (four women) were prescribed combined pharmacotherapy, which included a combination of an anticholinergic with an α-blocker in two women and duloxetine with an anticholinergic in another two. Patient characteristics, along with medical and urogynecological history, are presented in Table 1.

3.2. Primary outcomes

3.2.1. Effect of PFMT on UI

Bladder diary parameters and urodynamic findings of included patients are presented in Table 2.

3.2.2. Effect of PFMT on pad usage

At baseline, women were using a median of three pads daily (IQR = 2). Of the participants, 73 women (38.8%) reported only slight leakage, 95 women (50.5%) experienced moderate leakage, and 20 women (10.6%) reported severe urine leakage. After PMFT, the median number of pads used decreased to 1 (IQR = 1; $p < 0.001$). A reduction of more than 50% in the number of pads used was observed in 107 women (56.9%) overall, with 60% of women in the SUI subgroup and 54.1% in the MUI subgroups showing this improvement.

3.2.3. Effect of PFMT based on stress test results

At baseline, 43.1% of the participants (81 women) had a negative stress test. Among the 107 women (56.9%) with a positive stress test, 26.1% (28 women) had a mildly positive

Table 1. Medical and urogynecological history of the 188 women included in the study

Urogynecological history	Values
Deliveries	2 (1)
Overweight neonates	
Yes	57 (32.9)
No	116 (67.1)
Post-menopause	
No	66 (35.1)
Yes	122 (64.9)
Gynecological surgery	
No	84 (44.7)
Yes	104 (55.3)
Prolapse	
No	84 (44.7)
Yes	104 (55.3)
Medication for incontinence	
No	146 (77.7)
Yes	42 (22.3)
Anticholinergics	26 (13.8)
Duloxetine	8 (4.3)
Mirabegron	4 (2.1)
Combination[a]	4 (2.1)

Notes: [a]Anticholinergic plus α-blocker in two women and duloxetine plus anticholinergic in another two patients. All parameters are presented as numbers (percentage), except for "deliveries," which is expressed as median (interquartile range).

test (drops of urine), 20.2% (22 women) had a moderately positive test, and 10.6% (11 women) had a severely positive test. At the end of the study, 88.8% of women had a negative stress test, 10.1% had a mildly positive test, and 1.1% had a severely positive test (all $p < 0.001$ compared to baseline).

3.2.4. Effect of PFMT based on type of incontinence

In the MUI subgroup, 51% of women reported daily episodes of UUI, 26.5% experienced weekly episodes, and 22.4% reported monthly episode s. Among the MUI women, 52% had only light leakage, 39.8% experienced moderate leakage, and 8.2% had severe leakage. Both the frequency and severity of UUI improved significantly after PFMT ($p < 0.001$). At the end of the study, 20 women (10.6% of the entire study cohort, including 10% of the SUI subgroup and 11.2% of the MUI subgroup) were free from SUI symptoms, while 35 women (35.7%) in the MUI subgroup were cured of their UUI symptoms ($P < 0.001$).

3.3. Predictive factors for PFMT success

Univariate analysis of women with SUI revealed a statistically significant correlation ($p = 0.014$) between a negative or mildly positive stress test and complete relief from UUI. However, this correlation was not statistically significant in multivariate analysis. In contrast, univariate analysis of women with MUI showed that an initial digital evaluation ($p = 0.023$) and a mildly positive stress test ($p = 0.009$) were significantly associated with complete relief of UUI. These associations were validated in the multivariate analysis for both the initial digital evaluation ($p = 0.003$) and for negative ($p = 0.005$) or mildly positive stress tests ($p = 0.003$).

The univariate analysis also showed that women with a history of prior gynecological surgery were 51.3% less likely to achieve at least a 50% reduction in the number of pads used compared to those without a surgical history ($P = 0.128$; odds ratio [OR]: 0.49). In addition, women with initial digital evaluation were twice as likely to experience a >50% reduction in pad usage ($p = 0.016$; OR: 2.130). However, no significant relationship was found in multivariate analysis. Interestingly, subgroup analysis of MUI women (via multivariate logistic regression) revealed that the absence of prior surgery ($p = 0.021$) and an initial digital evaluation ($p = 0.026$) were associated with a >50% reduction in pad usage. Furthermore, in MUI patients, improvement in endurance was independently associated with a more than 50% reduction in pad usage (OR = 3.794; $p = 0.019$).

3.4. Secondary outcomes

3.4.1. Bladder diary and urodynamic characteristics

Bladder diary data were available from 83 women. Before the intervention, the median number of micturitions was 9 (IQR = 2), with a median of three incontinence episodes (IQR = 3) and three pads used (IQR = 3) per day. The median fluid intake was 1,615 mL/24 h (IQR = 600), and the voided volume per micturition ranged from 100 mL to 480 mL (IQR = 60–60) (Table 2).

Of the 51 women who underwent urodynamic testing, the median cystometric capacity was 402 mL (IQR = 265), the median Q_{max} was 21 mL/s (IQR = 13), and the median post-void residual was 0 mL (IQR = 40). Urodynamic SUI was confirmed in the majority of patients ($n = 31$; 60.8%), MUI was diagnosed in 8 women (15.7%), and detrusor overactivity was observed in 17 women (33.3%) (Table 3).

Both micturition frequency and nocturia improved significantly following PMFT. The percentage of women experiencing frequent micturition decreased from 61.2% at baseline to 31.4% at 3 months ($p < 0.001$). Similarly, 67% of women reported nocturia at baseline, which decreased to 43.6% by the end of the study ($p < 0.001$). A significant reduction in constipation was also observed, with 67 women reporting constipation at baseline compared to 48 at 3 months ($p < 0.001$).

Table 2. Bladder diary parameters and urodynamic findings

Parameters	Values
Number of pads	3 (2)
Bladder diaries (*n*=83)	
Number of micturitions	9 (2)
Incontinence episodes	3 (3)
Number of pads	3 (3)
Fluids consumed (mL)	1,615 (600)
Voided volume (mL)	
Max (mL)	480 (260)
Min (mL)	100 (60)
UDS (*n*=51)	
MCC	402 (265)
Qmax	21 (13)
PVR	0 (40)
Urodynamic findings	
Stress urinary incontinence	
No	20 (39.2)
Yes	31 (60.8)
Mixed urinary incontinence	
No	43 (84.3)
Yes	8 (15.7)
Detrusor overactivity	
No	34 (66.7)
Yes	17 (33.3)

Note: All parameters are presented as median (interquartile range), except for urodynamic findings, which are expressed as numbers (percentage).
Max: Maximum, MCC: Maximum cystometric capacity, Min: Minimum, PVR: Post-void residual, Qmax: Maximum flow rate, UDS: Urodynamic study.

Table 3. Clinical characteristics of urinary incontinence at baseline and at 3-month follow-up

Clinical characteristics	Baseline	3-month follow-up	*p*-value
Reported number of pads	3 (2)	1 (1)	<0.001*
Stress test (%)			
Negative	80 (43.1)	167 (88.8)	<0.001*
Positive	106 (56.9)	21 (11.2)	
Mild	49 (26.1)	19 (10.1)	
Moderate	38 (20.2)	-	
Severe	19 (10.6)	2 (1.1)	
UUI (%)			
No	90 (47.9)	125 (66.5)	<0.001*
Yes	98 (52.1)	63 (33.5)	
Frequency of UUI (*n*=98) (%)			
Daily	52 (51)	12 (12.2)	<0.001*
Weekly/monthly	46 (49)	51 (52)	
Severity of UUI (*n*=98) (%)			
Light	51 (52)	47 (47.9)	<0.001*
Moderate/severe	47 (48)	16 (16.3)	
Micturition frequency (%)			
No	63 (38.8)	129 (68.6)	<0.001*
Yes	115 (61.2)	59 (31.4)	
Nocturia (%)			
No	62 (33)	82 (43.6)	<0.001*
Yes	126 (67)	106 (56.4)	
Constipation (%)			
No	121 (64.5)	140 (74.5)	<0.001*
Yes	67 (35.5)	48 (25.5)	
Digital evaluation			
Endurance	4 (2)	6 (2)	<0.001*
Number of repetitions	5 (1)	6 (2)	<0.001*
Fast contraction	6 (2)	8 (3)	<0.001*
Muscle strength	3 (0)	3 (0)	0.157

Notes: *indicates statistical significance. All parameters are presented as numbers (percentage), except for "reported number of pads" and "digital evaluation," which are expressed as median (interquartile range).
IQR; Interquartile range, UUI: Urge urinary incontinence.

Among the 72 women with available data on digital pelvic floor evaluation, significant improvements were noted in endurance ($p < 0.001$; median$_1$ = 4, IQR1 = 2; median2 = 6, IQR2 = 2), the number of repetitions ($p < 0.001$; median1 = 5, IQR1 = 1; median2 = 6, IQR2 = 2), and fast contractions ($p < 0.001$; median1 = 6, IQR1 = 2; median2 = 8, IQR2 = 3). However, no significant improvement was found in muscle strength ($p = 0.157$; Wilcoxon signed-rank test).

4. DISCUSSION

Although the literature extensively documents the positive impact of PMFT on managing incontinence symptoms in women, the factors predictive of better or worse patient responses remain poorly defined. A recent meta-analysis of studies examining the role of PMFT in women with UI described patient-reported improvement rates of 74% for symptom relief and 56% for complete cure of SUI, respectively [6]. However, this analysis did not identify specific risk factors influencing PMFT efficacy. In our study, PFMT improved both SUI and MUI symptoms, which is consistent with existing literature. Across the entire set of samples, the median number of pads used was significantly reduced (three at baseline versus one at study completion; $p < 0.001$). Notably, the percentage of women with a negative stress test doubled by the end of the study (88.8% vs. 43.1% at baseline). Although the complete cure rate for SUI was modest (10.6%), the rate of at least 50% improvement in SUI, as measured by a reduction in daily pad usage, was 60%. Heterogeneity in clinical improvement rates and predictive factors among published studies can often be attributed to baseline recruitment characteristics, such as the type and severity of incontinence or the participants' age. In response, our study specifically assessed the efficacy of PFMT in women of similar age with either SUI or MUI. In addition, the intensity of the PFMT program could contribute to the final outcomes, with higher-intensity programs generally yielding superior results compared to lower-intensity ones [15,16].

A systematic review of 11 studies concluded that PFMT could benefit women with overactive bladder symptoms. However, the existing data have several limitations, highlighting the need for further research [17]. In the MUI subpopulation of our study, the cure rate was notably higher for the UUI component (35.7%) than for the SUI component (11.2%). This difference could be ascribed to the generally mild severity of UUI in our cohort, as 52% of patients initially reported only light leakage (drops). A significant reduction in constipation was also observed. PFMT has an established role in treating bowel dysfunction, including idiopathic constipation, primarily through biofeedback methods [18].

As previously mentioned, despite the well-established benefits of PMFT, there is a paucity of studies exploring predictive factors that influence treatment outcomes. Prior research has suggested that the severity of UI is a significant predictor of poor PFMT outcomes [19-21]. In our study, the complete cure of the stress incontinence component for both SUI and MUI was correlated with an initially negative or mildly positive stress test.

For the MUI group, an initial digital evaluation was also associated with the complete cure of UUI, as well as a two-fold increase in the likelihood of achieving at least a 50% improvement in pad usage across the entire study samples. Digital evaluation provides valuable insights into a patient's ability to contract PFM and allows clinicians to tailor the most appropriate PFMT program for each individual. Through digital evaluation, aspects of PFM function, such as contraction power, endurance, and fast contraction rates,

can be assessed [22]. This method is straightforward and is considered the gold standard for the physical examination of PFM [22]. The Oxford Grading Scale, a widely used system for grading PFM strength through digital evaluation, categorizes muscle response from absent to strong, on a six-point scale [14,23,24]. Despite its common use, there is a lack of studies examining its role in predicting PFMT outcomes. In our study, digital evaluation was significantly associated with improvements in endurance, number of repetitions, and fast contractions by the end of the study. Moreover, in the MUI subgroup, improvement in PFM endurance was independently associated with a >50% decrease in the number of pads used.

Several other factors have been identified in the literature as having predictive value for PFMT outcomes. Lower symptom severity, for both MUI and SUI, is strongly associated with more favorable treatment outcomes, which aligns with the findings of our study [19,21,25,26]. Additional positive predictive factors include menopausal status, higher education, the absence of prior UI surgery, and better bladder support in the standing position [19,21,25,26]. On the other hand, women with high-grade pelvic organ prolapse, obesity, psychological and physical comorbidities, poor outcomes from previous PFMT, and prolonged second-stage labor may experience poorer outcomes [19,21,26,27].

A Cochrane systematic review and meta-analysis found that women with SUI who underwent PFMT had an eight-fold higher probability of achieving complete continence (56% vs. 6%; risk ratio [RR] 8.38) compared to those who received no treatment. Independent of the type of UI, women who underwent PFMT had a five-fold higher probability of attaining complete continence compared to those who did not (35% vs. 6%; RR 5.34) [6]. Another systematic review suggested that targeted PFMT may be more effective than population-based approaches, and that it may be particularly beneficial for primiparous women, those with bladder neck hypermobility during pregnancy, or those who experienced large baby or forceps deliveries. The authors also recommend further studies to identify predictive factors and assess the long-term efficacy of PFMT [28].

The primary limitation of this study is its retrospective design. Data extraction and outcome analysis were based on the accurate screening of institutional records, which means the analysis was limited to the available data. Additional limitations include potential selection bias in the cohort of women recruited into this study, as well as the challenge of controlling for confounding factors. Furthermore, non-statistical relationships observed in this study might be influenced by the relatively small sample size and the existence of systematic biases, which could not be controlled within the scope of the present study. Finally, this study primarily focused on middle-aged women, mostly postmenopausal, with few comorbidities; thus, the results might not be generalizable to women with different characteristics. Further prospective studies with more diverse populations are warranted to identify the precise predictive factors for favorable PFMT outcomes and to clarify the role of initial digital evaluation in PFMT.

5. CONCLUSION

PFMT demonstrated significant efficacy in alleviating incontinence symptoms in both SUI and MUI patient cohorts. The key factor predicting favorable PFMT outcomes in both patient groups was a mildly positive or negative stress test at baseline. In addition, the initial digital evaluation appeared to play a potentially beneficial role in the treatment outcomes, as it was associated with a two-fold increase in the likelihood of accomplishing at least a 50% improvement in incontinence. Notably, in the MUI subgroup, an improvement in PFM endurance was independently associated with a reduction of more than 50% in pad usage. Beyond incontinence, PFMT also exerted positive effects on urinary frequency, nocturia, and constipation. Further well-designed prospective studies, with larger sample sizes and varying PFMT protocols, are needed to validate these findings, assess the long-term efficacy of PFMT, and explore additional predictive factors for favorable treatment outcomes.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Scientific Council of "Papageorgiou" General Hospital, Thessaloniki (registration number 341st/April 04, 2021), and it complies with the Declaration of Helsinki. Due to the retrospective nature of the study, obtaining patient consent to participate was not feasible.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA

Data of this study are available at https://github.com/iliasgiann/urodynamicss.

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