Research Report

Pelvic-Floor Rehabilitation, Part 2: Pelvic-Floor Reeducation With Interferential Currents and Exercise in the Treatment of Genuine Stress Incontinence in Postpartum Women—A Cohort Study

Chantale Dumoulin
Derek E Seaborne
Cécile Quirion-DeGirardi
S John Sullivan

Background and Purpose. *This descriptive cohort study investigated a physical therapy program of pelvic-floor neuromuscular electrostimulation (NMES) combined with exercises, with the aim of developing a simple, inexpensive, and conservative treatment for postpartum genuine stress incontinence (GSI).* ***Subjects.*** *Eight female subjects with urodynamically established GSI persisting more than 3 months after delivery participated in the study. The subjects ranged in age from 24 to 37 years ($\bar{X}$=32, SD=4.2).* ***Methods.*** *This was a descriptive multiple-subject cohort study. Each subject received a total of nine treatment sessions during 3 consecutive weeks, consisting of two 15-minute sessions of NMES followed by a 15-minute pelvic-floor muscle exercise program. Patients also practiced daily pelvic-floor exercises during the 3-week treatment period. The treatment intervention was measured using three separate variables. Maximum muscle contractions (pretraining, during training, and posttraining) were measured indirectly as pressure, using perineometry. Urine loss pretraining and posttraining was measured by means of a Pad test. Self-reported frequency of incontinence was recorded daily throughout the period of the study, using a diary. Data were analyzed using a one-way repeated-measures analysis of variance (ANOVA), a Wilcoxon signed-ranks test, and a Friedman two-way ANOVA by ranks.* ***Results.*** *The results indicated that maximum pressure generated by pelvic-floor contractions was greater and both the quantity of urine loss and the frequency of incontinence were lower following the implementation of the physical therapy program. Five subjects became continent, and three others improved. A follow-up survey 1 year later confirmed the consistency of these results.* ***Conclusion and Discussion.*** *The results suggest that the proposed physical therapy program may influence postpartum GSI. Further studies are needed to validate this simple, inexpensive, and conservative physical therapy protocol. [Dumoulin C, Seaborne DE, Guirion-DeGirardi C, Sullivan SJ. Pelvic-floor rehabilitation, part 2: pelvic-floor reeducation with interferential currents and exercise in the treatment of genuine stress incontinence in postpartum women—a cohort study. Phys Ther. 1995;75:1075–1081.]*

Key Words: *Electrode position, Genuine stress incontinence, Interferential currents, Neuromuscular electrical stimulation, Pelvic floor, Pelvic-floor exercises, Perineometer, Postpartum.*

Genuine stress incontinence (GSI) is the most common form of urinary incontinence and affects as many as 40% of women.[1] The high prevalence of GSI in women is reflected in the cost of managing the problem. In the

United States alone an estimated $10 billion in direct and associated costs is spent annually on the treatment of all forms of urinary incontinence.[2]

Genuine stress incontinence is defined by the International Continence Society (ICS) as "the involuntary loss of urine occurring when, in the absence of a detrusor contraction, the intravesical pressure exceeds the maximum urethral pressure."[3] Numerous factors are involved in the etiology of GSI, including pregnancy, childbirth, and aging.[4] Beck and Hsu[5] estimated that a total of 78% of all female urinary stress incontinence is related to maternity, with 64% reporting an onset during pregnancy and a further 14% reporting an onset during puerperium.

During pregnancy and delivery, the prolonged stretching and trauma sustained by the pelvic musculature and the concomitant neural damage thought to accompany this stretching can reduce the strength of the pelvic-floor musculature. These changes can interfere with the normal transmission of changes in abdominal pressure to the proximal urethra, thereby predisposing the individual to GSI.[6,7] Cotelle[8] listed five risk factors predisposing the individual to postpartum GSI: vaginal delivery, high infant birth weight (>3.7 kg), large cranial circumference (>35.5 cm), high maternal weight gain during pregnancy (>13 kg), and tearing of the perineum during delivery. Women experiencing GSI during pregnancy and/or childbirth are generally thought to run a greater risk of developing the condition in later life.[9] Early intervention could reduce this tendency and help lower the cost of managing the problem.

Certain physical therapy procedures have been shown to increase the strength of the pelvic-floor musculature and promote continence. Pelvic-floor exercises, introduced by Kegel in 1948,[10] have been used with moderate to good success.[11,12] Neuromuscular electrical stimulation (NMES), using both intravaginal[8] and surface electrodes,[13] has also been used with promising results in the treatment of GSI. The most effective results, however, appear to have been achieved through combinations of exercises and NMES.[14] Although these treatments have been shown to reduce the symptoms of incontinence, few attempts have been made to evaluate their efficacy in a postpartum GSI population.[8,15]

Cotelle,[8] in her unpublished thesis on postnatal urogenital rehabilitation, proposed a treatment protocol for female incontinence. The protocol included pelvic-floor exercises, perineal massage, and low-frequency NMES using an intravaginal electrode. Although good results were reported, the absence of details regarding the program and the use of nonstandardized procedures preclude replication of this treatment protocol. The high cost of the specialized equipment needed to perform the NMES is an additional drawback to its use on a regular basis.

Laycock and Green[13] studied the effects of interferential stimulation of the pelvic-floor muscles in women, using equipment currently available in most physical therapy departments. They compared three different electrode positions, one described in the literature and two evolved in their own clinic. They concluded that a bipolar electrode placement, with both electrodes placed in the median plane over the perineum, was the technique of choice, based on ease of application and efficacy of stimulation. In a recent study using asymptomatic continent women, we have shown that a modified Laycock bipolar electrode placement can decrease the discomfort of the stimulation, while retaining its effectiveness in stimulating the pelvic-floor musculature (see other article by Dumoulin et al in this issue). In view of the prevalence of GSI, the spiraling cost of its management, and its impact on the quality of life of the individual, we feel that the need still exists for continued evaluations of early treatment strategies in women postpartum.

The purpose of this study was to investigate a program of NMES combined with exercises of the pelvic-floor muscles, with the aim of developing a simple, inexpensive, and conservative (noninvasive) treatment for women experiencing postpartum GSI. Results will be assessed using measurement of objective and subjective phenomena.

Method

Subjects

Ten female subjects with urodynamically proven GSI persisting more than 3 months after delivery (range=3–24 months) and without significant prolapse volunteered as subjects for this study. The subjects were aged between 24 and 37 years ($\bar{X}$=32, SD=4.2). A minimum 3-month limit was necessary to exclude the effects of hormonal changes brought about by pregnancy and childbirth, which can influence urinary continence by increasing the laxity of muscles and ligaments in the pelvic region. Hormonal levels have generally returned

C Dumoulin, MSc, PT, is Physical Therapist, Hôpital Ste-Justine de Montréal, 3175 Côte Ste-Catherine, Montréal, Québec, Canada H3T 1C5, and Teaching Assistant and Lecturer, L'Ecole de Réadaptation, Faculté de Médecine, Université de Montréal, Montréal, Québec, Canada H3C 3J7. Address all correspondence to Ms Dumoulin at the second address.

DE Seaborne, MSc, PT, is Professor, Department of Physiotherapy, L'Ecole de Réadaptation, Faculté de Médecine, Université de Montréal.

C Quirion-DeGirardi, MA, PT, is Associate Professor (ret), L'Ecole de Réadaptation, Faculté de Médecine, Université de Montréal.

SJ Sullivan, PhD, is Associate Professor and Chair, Department of Exercise Science, Concordia University, Montréal, Québec, Canada H4B 1R6, and is affiliated with the Centre de Recherche, Institut de Réadaptation de Montréal, 6300 Darlington Ave, Montréal, Québec, Canada H3S 2J4, and L'Ecole de Réadaptation, Faculté de Médecine, Université de Montréal.

This study was approved by the Ethics Committee of L'Hôpital Ste-Justine de Montréal.

This article was submitted October 5, 1994, and was accepted August 15, 1995.

Table 1. *Subject Characteristics*

Subject No.	Age (y)	Height (m^2)	Weight (kg)	BMI[a] (kg/m^2)	Parity
1	28	1.64	62.1	23	2
2	31	1.63	62.6	24	2
3	34	1.75	58.9	19	1
4	37	1.70	63.5	22	1
5	24	1.62	73.9	28	2
6	34	1.60	54.4	21	3
7	37	1.70	64.8	22	1
8	35	1.52	52.1	23	4
9	29	1.58	55.3	22	2
10	31	1.63	58.0	22	1
$\bar{X}$	32.0	1.64	60.6	22.6	1.9
SD	4.2	0.07	6.3	2.3	1.0

[a]BMI=body mass index.

to normal in women who are not breast-feeding at 3 months postpartum.[17] None of the subjects in this study were breast-feeding. None had an intrauterine device implanted.

Recruitment of subjects was achieved by means of a questionnaire distributed by nurses to patients during their regular postnatal visits with the obstetrician. None of the subjects experienced any neurological pathology, pelvic or vertebral fracture, diabetes, cardiovascular disease, or present or previous malignancy. Four subjects were primiparas, and 6 subjects were multiparas. The mean parity of all subjects was 1.9. Subjects' descriptive data are shown in Table 1.

Study Design

The design used in this study was a cohort study design. The treatment intervention was measured using three separate variables. Maximum muscle contractions (pretraining, during training, and posttraining) were measured indirectly as pressure, using perineometry. These measurements were taken at the initial physical therapy evaluation (1 week prior to the initiation of training), following each treatment session (three sessions per week for 3 weeks), and 1 week following the cessation of training. The mean maximum reading for each week was calculated and retained for analysis (Tab. 2). Urine loss pretraining and posttraining was measured by means of a Pad test,[17] using a preweighed sanitary pad. Frequency of incontinence (number of incidents) was recorded daily throughout the period of the study, using a daily self-report diary. These recordings were made during the week preceding the study, during the 3 weeks of the study, and continuing throughout the week following cessation of treatment, for a total of 5 consecutive weeks. Maximum pressure readings were recorded by the treating physical therapist, who was not masked. Pad-test measurements were recorded by a urodynamic nurse, who was masked, and frequency of incontinence was recorded by the individual subjects.

Instrumentation

The muscle stimulator used throughout this study was an Endomed 433 medium-frequency interferential current stimulator,* with a medium-frequency output of either 2 or 4 kHz. According to the manufacturer, the amplitude-modulated frequency spectrum (interference frequency) is continuously adjustable between 0 and 100 Hz. The force of a maximum voluntary muscle contraction was measured as pressure (in centimeters of water [cm H_2O]) on a perineometer, which consisted of a manometer† attached to a vaginal pressure probe.‡ Before experimentation, the manometer was examined and calibrated by the bioengineering department of a major Montréal teaching hospital (Hôpital Ste-Justine de Montréal). A more complete description of the instrumentation is presented in our companion article in this issue.

Procedure

A detailed explanation was given to each subject regarding the aims of the study, the equipment and techniques to be used, and the extent of their participation. All subjects signed an institutionally approved consent form before participating in the study. A urologic evaluation and physical therapy assessment were performed on all subjects prior to the initiation of treatment.

Urologic Evaluation

Diagnosis of GSI was determined by an examination performed by a urologist and a urodynamic nurse. This examination included a complete medical history, a physical examination, a urodynamic examination, compilation of a frequency/volume chart, and performance on a modified 40-minute Pad test.[18] The 40-minute Pad test is a simple, standardized test used as a measure of urine loss. For this test, the subject's bladder is filled transurethrally with sterile water to a defined volume (300 cc). Subsequently, wearing a preweighed pad, she performs a 30-minute exercise program, approximating the normal

*Enraf-Nonius Delft, Équipement de Physiothérapie P Gélinas Ltée CP68, Succ "D," Montréal, Québec, Canada H3K 3B9.
†Med-O-Gen Inc, 5181 Metropolitain E, Montréal, Québec, Canada H1R 1Z7.
‡Portex Ltd, Hythe, Kent, England CT21 6JL.

Table 2. *Mean Maximum Pressure (in Centimeters of Water [cm H_2O]) Obtained With a Pelvic-Floor Contraction for the Weeks Prior to, During, and Following Completion of the Study*

Subject No.	Pretest	Week 1	Week 2	Week 3	Posttest
1	34.0	34.0	38.0	44.0	44.0
2	4.0	25.0	26.0	36.0	38.0
3	4.0	18.0	25.0	27.0	27.0
4	20.0	30.0	32.0	40.0	42.0
5	22.0	24.0	30.0	30.0	32.0
6	30.0	37.0	40.0	48.0	48.0
7	32.0	34.0	36.0	43.0	45.0
8	30.0	40.0	50.0	60.0	62.0
$\bar{X}$	22.0	30.3	34.6	41.0	42.3
SD	12.1	7.4	8.2	10.5	10.6

activities of daily living. Immediately following the exercise program, the pad is reweighed, and the increase in pad weight, measured to the nearest gram, is interpreted following ICS standards. As a result of the Pad test, four subjects were classified as severely incontinent (≥51 g), three subjects were classified as moderately incontinent (11–50 g), and one subject was classified as slightly incontinent (1–10 g). One of the remaining volunteers, who demonstrated a urine loss of less than 1 g, decided not to participate in the study. Another volunteer failed to complete the full urodynamic evaluation and was therefore excluded from the study.

Physical Therapy Assessment

This evaluation included a questionnaire, a digital assessment of pelvic-floor contractions, and instrumental assessment of pelvic-floor contractions using a perineometer (see description of the assessment procedure in our companion article in this issue). This evaluation was performed by a physical therapist trained in these techniques (CD). Using the vaginal examination technique described by Chiarelli and O'Keefe,[18] the therapist, wearing disposable, sterile surgical latex gloves, palpated the medial fibers of each subject's pubococcygeus muscle with her index finger. Following identification and grading of the muscle contraction, the disposable vaginal probe was prepared corresponding to the depth of the subject's musculature. The subject, guided verbally by the therapist, inserted the probe herself, using a sterile water-soluble jelly as a lubricating medium. The probe was then attached to the manometer. On instructions from the therapist, the subject was required to squeeze the probe by contracting the pelvic-floor musculature, while the therapist adjusted the probe position to obtain a maximum reading on the manometer. Visual monitoring of vaginal probe movements (inward with pelvic-floor contractions, outward with abdominal contractions) ensured that the correct pelvic-floor contractions were recorded. Following adjustment of the probe, the subject was required to maximally contract her pelvic-floor muscles by squeezing as hard as possible on the probe for 5 seconds, during which the pressure registered on the manometer was recorded. This procedure was repeated for a total of three maximum contractions of 5 seconds' duration each, with 10 seconds of rest between contractions. The highest of the three recorded readings was retained for subsequent analysis. Perineometer readings were taken throughout the study, following each treatment session. At the end of each week of treatment, the mean maximum was calculated for the week and used in the statistical analysis.

In addition to pelvic muscle assessment, each subject was given a diary in which she was required to record daily the number of incidents of incontinence as well as precipitating factors, if known. These recordings were made beginning the week preceding the study, during the 3 weeks of the study, and continuing throughout the week following cessation of treatment, for a total of 5 consecutive weeks. Pretreatment and posttreatment measurements were taken approximately at the same time in the subject's menstrual cycle to take into account the fluctuation of hormonal levels.

Treatment Protocol

Each subject attended three treatment sessions per week, on alternate days, during 3 consecutive weeks, for a total of nine treatment sessions. Each treatment session consisted of two 15-minute periods of NMES of the pelvic-floor muscles followed by a 15-minute exercise program. At the end of the exercise session, three pelvic-floor contractions were performed and perineometric readings were taken, the highest reading being recorded and retained for analysis. For the treatment, the subject was required to disrobe the lower part of her body and assume a semisupine position (trunk at 50° from the horizontal) on a padded wooden treatment table, with her knees and hips supported at approximately 70 degrees of flexion and both hips in abduction and lateral (external) rotation.

Electrical Stimulation

Two carbon-silicone electrodes,* enclosed in cellulose sponge pads* soaked in warm tap water, were applied, one (6×8 cm) directly over the subject's anus and the other (4×6 cm) in the median plane immediately superior to the pubic symphysis. The electrodes were secured in position by means of a perforated rubber band* passing between the legs of the subject and attached anteriorly and posteriorly to insulated metal rings on a lumbar traction belt* secured around the subject's waist. Sterile procedures

Table 3. *Urine Loss (in Grams) at Pretest and Posttest 40-Minute Pad Tests*

Subject No.	Pretest (g)	Posttest (g)
1	30	0
2	90	30
3	240	100
4	15	0
5	160	65
6	25	0
7	30	0
8	5	0
$\bar{X}$	74.4	24.4
SD	84.3	38.5

were followed throughout the treatment. A detailed description of these procedures is given in our companion article in this issue. The electrical stimulation protocol consisted of 15 minutes of stimulation in a rhythmic mode, with the interference frequencies changing rhythmically between 10 and 50 Hz, followed by 15 minutes of stimulation at a constant interference frequency of 50 Hz. For the second 15 minutes of stimulation only, the subject, using the remote amplitude control under instructions from the therapist, increased and decreased the stimulating current every 4 seconds, producing a rhythmical contraction and relaxation of her pelvic-floor musculature. In both applications, a carrier frequency (base frequency) of 2 kHz was used. These frequencies conform with those reported by Laycock and Green.[13] Under the close supervision of the physical therapist, the subject was encouraged to increase the current to the maximum tolerated amplitude without causing pain.

Pelvic Exercise Program

For the exercise session following NMES, the subject's position was maintained and the vaginal probe was inserted by the subject herself prior to performing the exercises. The position used for the testing and treatment of subjects during this study facilitates positioning of the probe, encourages relaxation of the abdominal muscles, and reduces intra-abdominal pressure.[18] Individual instruction in pelvic-floor exercises was given by the therapist, using the manometer as visual feedback. The exercise program was as follows: two repetitions of 10 maximum contractions of the pelvic-floor muscles, each of 5 seconds' duration, with a 10-second rest between contractions. The subject was instructed to squeeze and attempt to draw her vagina and anus upward and inward. These same exercises were used for the home exercise program, which the subjects were required to perform four times daily. To encourage compliance, the subjects were asked to note in the diary the number of times the exercise program was performed daily. Practice of the home exercise program was reinforced during the treatment sessions.

Data Analysis

Descriptive statistics were calculated for mean maximum muscle contraction, urine loss, and frequency of incontinence (episodes) (Tabs. 2–4). In addition, the effects due to training were assessed. Changes in the maximum pressure recorded prior to training, for each of the 3 weeks of training, and 1 week following training were analyzed, using a one-way repeated-measures analysis of variance (ANOVA). Differences in mean maximum pressure were further explored using the Newman-Keuls *post hoc* procedure. Pretraining to posttraining changes in urine loss (Pad test) were examined using the Wilcoxon signed-rank test. The frequency of urine loss was computed on a weekly basis and examined (before, during, and after training) using a Friedman two-way ANOVA by ranks, with subsequent analyses being performed using the Wilcoxon signed-rank test to locate specific changes. A nonparametric approach was chosen for these latter analyses due to the heterogeneity of variances associated with the variables. A probability level of $\leq .05$ was adopted as the indicator of statistical significance for all tests. All statistical procedures were performed using the SYSTAT statistical package.[§]

Results

The maximum pressure recorded prior to, during, and following training (Tab. 2) increased ($F=31.57$; $df=4.28$; $P=.0001$). Mean maximum pressure increased by 92%, from 22.0 to 42.3 cm H_20. *Post hoc* analysis revealed systematic increases with time, with all pairings being different except for the week 3-posttraining pairing. The systematic increase was confirmed by regression analysis.

Urine loss, as determined by the Pad-test pretraining and posttraining measurements, is shown in Table 3. The mean reduction of 50.0 g was determined to be significant ($t=2.525$, $P=.012$). Based on the results of the posttraining Pad test, five of the eight subjects were classified as being continent (ie, a urine loss of <1 g). The frequency of urine loss (episodes) was also observed to decrease (Tab. 4) following the training program (Friedman $\chi^2=19.90$, $P=.001$). Subsequent Wilcoxon signed-rank tests found the urine loss recorded during weeks 1 to 3 and posttraining to be less than reported prior to beginning the program. In addition, the values for week 3 and posttraining were less than those reported for the pretest period. No difference was found between week 3 and the posttest, thus indicating the stability of the change, at least over the time frame investigated here.

Discussion

The aim of this report was to examine a program of perineal stimulation with interferential currents, using a bipolar electrode arrangement combined with exercises, in patients experiencing postpartum GSI. The results indicated that maximum pressure (in centimeters of water [cm H_2O]) generated by the pelvic-floor contractions was

[§]SYSTAT Inc, 1800 Sherman Ave, Evanston, IL 60201.

Table 4. *Frequency of Incontinence (Episodes) for Each Subject Prior to, During, and Following Completion of the Study*

Subject No.	No. of Episodes				
	Pretest	Week 1	Week 2	Week 3	Posttest
1	3	1	0	1	1
2	1	0	0	0	0
3	36	32	23	20	15
4	13	1	0	0	0
5	64	52	22	25	17
6	10	3	1	0	0
7	2	1	0	0	0
8	1	3	5	0	0
$\bar{X}$	16.3	11.6	6.4	5.8	4.0
SD	22.6	19.5	10.1	10.4	7.4

greater and both the quantity of urine loss and frequency of incontinence were lower following the implementation of the training program.

Among the many factors that could have contributed to the encouraging results obtained with this perineal reeducation program, NMES, by supplying the sensory output of the "feel" of the desired muscle contraction, could have played a major role. Neuromuscular electrical stimulation can greatly increase a motor response in a patient who has the neural integrity necessary to accomplish a motor task but lacks efficiency in voluntary performance.[19] This enhanced motor response could explain why there was already an increase in maximum intravaginal pressure generated by pelvic-floor contractions accompanied by a decrease in the frequency and quantity of urine loss 1 week following the implementation of the program. The additional stimulus provided by an increase in vascularization as a result of NMES[20] and voluntary muscle contractions might also have been a contributing factor, because the urethral vascular bed is thought to account for about 30% of the resting urethral closing pressure.[21,22]

Aggressive programs of NMES combined with strengthening exercises have demonstrated increases in the force production of atrophied muscles.[20] Although we were unable to measure force directly, we believe it is unlikely that any measurable increases in muscle strength occurred as a result of the treatment during the short period of this study. The increase in pressure observed can possibly be attributed to the NMES and exercises that resulted in more effective contractions of the pelvic-floor musculature. The relative contribution of each, however, cannot be determined by these results.

The rhythmic shortening of the pelvic-floor muscles, due to NMES or the voluntary contractions, could have produced an influence indirectly by stretching the fascial attachments of these muscles. Fascia attached to weakened muscles will undergo degenerative changes. Contraction of the muscle, either voluntarily or by NMES, could reverse this tendency. Contractions of pelvic-floor muscles also tightens the fascial attachment to the urethra, which in turn increases urethral pressure. These fascial attachments, which normally fix the urethra in place, may provide inadequate pelvic-floor support in women with GSI and allow the bladder neck to drop when abdominal pressure increases.[11] Which of these elements made the major contribution toward voluntary control of continence is unclear. The importance of each of these factors on postpartum GSI is yet to be established.

Comparison of our study with those of Laycock and others using interferential currents as treatment protocols is problematic because experimental procedures and population samples differ. Our results, however, do stand up well when compared with the results obtained in other studies. What is encouraging is that, based on the results of the Pad test, five subjects passed from incontinent to continent and the remaining three subjects were improved. A follow-up survey conducted by phone 1 year later confirmed that all five subjects remained continent.

Because we used a descriptive cohort study design, a major limitation of our study was the lack of a control group. Consequently, no inferences can be drawn regarding the efficacy of the intervention. Although pretest-posttest data were collected and changes were observed, these changes cannot be attributed directly to our structured intervention. As a result, the changes observed, although suggestive of a treatment effect, must be treated with caution. A control group included in the experimental design would have allowed scientific assessment of the results. Unfortunately, we were unable to recruit volunteers for this role. Five patients who declined to participate in the study were asked if they would consent to be part of a control group. One person agreed to record, in a diary, the frequency of her incontinence episodes; however, she dropped out after only 1 week. Another limitation is the small size of the treatment group. Recruiting subjects for this type of research is difficult, and time constraints were imposed for the completion of data collection. Finally, the use of surface electrodes might be disputed because intravaginal electrodes can be positioned in closer proximity to the pudendal nerve, although no study has compared the efficacy of the two techniques. Surface electrodes were used in our study, as the primary aim was to evaluate a simple, noninvasive, and inexpensive

treatment with minimal risk of contamination.

Conclusion

A simple, inexpensive, conservative, and noninvasive physical therapy program has been described and evaluated using eight female volunteers experiencing postpartum GSI. The results indicate that maximum pressure generated by a pelvic-floor contraction was greater and both the quantity of urine loss and frequency of incontinence were lower following the implementation of the physical therapy program, with five subjects becoming continent and the other three subjects being improved. This treatment proved effective with the subjects treated during this study. This finding suggests that the proposed conservative physical therapy program may reduce postpartum GSI. Further controlled studies are needed to substantiate these results.

Acknowledgments

We express our appreciation to Dr Robert Gauthier, Department of Obstetrics, and Dr Yves Homsy, Director, Department of Urology, Hôpital Ste-Justine de Montréal, for their help in the selection and urologic evaluation of the patients participating in this research. We also thank Dr Jo Laycock, Bradford Royal Infirmary, Bradford, England, for her helpful comments and support in the preparation of this article.

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