

Pelvic-Floor Rehabilitation, Part 1: Comparison of Two Surface Electrode Placements During Stimulation of the Pelvic-Floor Musculature in Women Who Are Continent Using Bipolar Interferential Currents

Background and Purpose. Electrical stimulation of the pelvic floor is used as an adjunct in the conservative treatment of urinary incontinence. No consensus exists, however, regarding electrode placements for optimal stimulation of the pelvic floor musculature. The purpose of this study was to compare two different bipolar electrode placements, one suggested by Laycock and Green (L2) the other by Dumoulin (D2), during electrical stimulation with interferential currents of the pelvic-floor musculature in continent women, using a two-group crossover design. **Subjects.** Ten continent female volunteers, ranging in age from 20 to 39 years ($X=27.3$, $SD=5.6$), were randomly assigned to one of two study groups. **Methods.** Each study group received neuromuscular electrical stimulation (NMES) of the pelvic floor musculature using both electrode placements, the order of application being reversed for each group. Force of contraction was measured as pressure (in centimeters of water [$\text{cm H}_2\text{O}$]) exerted on a vaginal pressure probe attached to a manometer. Data were analyzed using a two-way, mixed-model analysis of variance. **Results.** No difference in pressure was observed between the two electrode placements. Differences in current amplitude were observed, with the D2 electrode placement requiring less current amplitude to produce a maximum recorded pressure on the manometer. Subjective assessment by the subjects revealed a preference for the D2 electrode placement (7 of 10 subjects). **Conclusion and Discussion.** The lower current amplitudes required with the D2 placement to obtain recordings comparable to those obtained with the L2 technique suggest a more comfortable stimulation of the pelvic floor muscles. The lower current amplitudes required also suggest that greater increases in pressure might be obtained with the D2 placement by increasing the current amplitude while remaining within the comfort threshold. These results will help to define treatment guidelines for a planned clinical study investigating the effects of NMES and exercise in the treatment of urinary stress incontinence in women postpartum. [Dumoulin C

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

View metadata and citation for this article at: <https://www.physiotherapyjournal.com>

COBE

1: comparison of two surface electrode placements during stimulation of the pelvic floor musculature in women who are continent using bipolar interferential currents. *Phys Ther.* 1995; 75:1067-1074.

Key Words: Bipolar technique, Electrode position, Interferential currents, Pelvic floor electrostimulation, vaginal pressure probe.

Urinary continence is the capacity to retain urine in the bladder between two voluntary micturitions.¹ Incontinence is the involuntary loss of urine, which can be demonstrated and which presents a social and hygienic problem.²

Genuine urinary stress incontinence (GSI) results from urethral sphincter incompetence and is defined by the International Continence Society as "the involuntary loss of urine occurring when, in the absence of a detrusor contraction, intravesical pressure exceeds the maximal urethral pressure."² Genuine stress incontinence is the most common form of urinary incontinence, with an estimated 78% of cases of GSI being related to pregnancy and the birth process.² Persons with this condition experience incontinence of urine when the intra-abdominal pressure is raised, for example, during coughing, sneezing, or any form of physical activity that increases intra-abdominal pressure.¹

Neuromuscular electrical stimulation (NMES) has been shown to be effective in the treatment of GSI. Stimulation via the pudendal nerve, at frequencies of 20 to 50 Hz, improves urethral closure by activating the pelvic-floor musculature.⁴ In addition, NMES can increase consciousness of the action of these muscles, thus facilitating the ability to perform a voluntary muscle contraction.⁵ Several methods of stimulating the pelvic-floor

muscles have been described, including the use of both low-frequency faradic currents^{6,7} and medium-frequency interferential currents.⁸⁻¹⁰ The use of medium-frequency interferential currents has been suggested as a means of overcoming the problem of stimulating deep-seated structures more effectively, without using invasive methods. The capacitive component (reactance) of tissue resistance has been hypothesized to decrease inversely with the current frequency.¹¹ By decreasing the reactance, the overall tissue resistance will diminish, thereby facilitating the stimulation of deep structures.¹²

Regardless of the method used, the localization of the stimulating electrodes is of critical importance in obtaining a maximal contraction. The intensity of an electrically induced muscle contraction is directly related to the number of motor units activated.¹³ The number of motor units activated, in turn, is influenced by the current amplitude and frequency and the placement of the stimulating electrodes.¹³

In 1988, Laycock and Green¹⁴ compared different electrode placements during stimulation with interferential currents of the pelvic-floor muscles of female subjects. Using vaginally located sensors, they measured peak currents and peak pressures evoked in the perivaginal tissues, as well as tissue resistance, for each of three elec-

trode placements during stimulation of the pelvic floor. They concluded that a bipolar electrode placement, with one electrode placed between the ischial tuberosities (over the anus) and the other electrode placed over the anterior perineum, inferior to the pubic symphysis, produced an equally effective stimulation of the pelvic floor, as compared with a quadripolar electrode placement. They recommended the bipolar placement, based on its ease of application.¹⁴

Electrical stimulation at current intensities necessary to produce adequate muscle contractions can result in unpleasant or painful sensations. Because patient discomfort is often the limiting factor during NMES,¹⁵ this discomfort can reduce the effectiveness of the treatments. In our clinical practice, we have utilized the bipolar technique suggested by Laycock and Green¹⁴ for treating women with postpartum GSI. During stimulation, some of our patients have complained of intense discomfort due to high current concentration under the anterior electrode (in the region of the clitoris). We have therefore suggested an alternative electrode placement for the anterior electrode, to a position immediately superior to the pubic symphysis. We postulate that this modified electrode placement will decrease the discomfort and increase the efficacy of NMES of the pelvic floor.

The suggested alternative position produces a current spread estimated from anatomical measures to be slightly greater than the 140 cm² (approximate) reported by Laycock and Green.¹⁴ The direction of current flow follows closely that of the bipolar electrode placement suggested by Laycock and Green.¹⁴ By displacing the anterior electrode to a point superior to the pubic symphysis, however, the current will theoretically penetrate deeper within the pelvis.¹¹ To avoid confusion between these two techniques, for the purpose of this study only, we have reclassified the bipolar female electrode placement suggested

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 Faculté de Médecine, Université de Montréal.

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

Subject No.	Age (y)	Height (m)	Weight (kg)	BMI (kg/m ²)
	24	1.70	65.8	22.0
2	39	1.62	60.0	23.0
3	25	1.68	61.2	21.5
4	25	1.57	52.1	21.0
5	24	1.68	53.5	19.0
6	26	1.68	56.7	20.0
7	20	1.60	51.3	20.5
8	37	1.63	56.7	21.5
9	26	1.52	49.9	21.5
10	27	1.70	72.6	25.0
X	27.3	1.64	58.0	21.6
SD	5.6	0.06	7.1	1.7

*BMI=body mass index.

by Laycock and Green¹⁴ as L2 and the alternative electrode placement as O2.

The purpose of our study was to compare the two different electrode placements (L2 and O2) in the stimulation of the pelvic-floor musculature, using bipolar interferential currents, to determine which of the two methods produced a stronger contraction with the lowest current amplitude. The force of contraction of the pelvic-floor musculature was measured indirectly as pressure (in centimeters of water [cm H₂O]) registered on a manometer attached to a vaginal pressure probe. We expected that O2 would be the more effective of the two electrode placements. The results obtained from this study helped to determine treatment guidelines for a clinical study of the effects of noninvasive electrical stimulation of the pelvic-floor musculature in women with postpartum urinary stress incontinence (see our companion article in this issue).

Method

Subjects

Ten continent women aged between 20 and 39 years (X=27.3, 50=5.6), who were recruited from a population of clinicians and graduate and undergraduate university students, volunteered as subjects for this study. All subjects demonstrated the ability to perform a voluntary pelvic-floor contraction. None of the subjects had any previous history of urinary incontinence or any neuromuscular injury likely to influence our results. All subjects were nulliparous, and during the period of data acquisition, none were menstruating or had an intrauterine device implanted. Descriptive statistics are shown in Table 1. Before participating in the study, all volunteers signed an approved informed consent form.

Age, weight (wt), and height (ht) were recorded and body mass index (BMI) was computed for each subject. Body mass index¹⁶ is a measure of obesity

and is derived from the formula: wt (kg)/ht (m²). Because fat has an electrical impedance of between 1,000 and 3,000 Ω/cm²,¹⁵ obesity could have influenced our findings. All our subjects had a BMI below 27. Persons having a BMI greater than 27 are considered clinically obese.¹⁶

Instrumentation

The electrical stimulator used during 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's specifications, this stimulator has an amplitude modulation frequency spectrum (interference frequency) continuously adjustable between 0 and 100 Hz. A bipolar application implies that the two medium frequencies are superposed within the stimulator and applied directly as an interferential current at the preselected frequency. The force of contraction of the pelvic-floor musculature elicited by the stimulation was measured indirectly as pressure (in centimeters of water [cm H₂O]) registered on a manometer attached to a vaginal pressure probe.* The pressure-sensitive manometer used in this study was capable of detecting and measuring changes in perivaginal pressure resulting from contractions of the pelvic-floor muscles. Prior to the experiment, the manometer was examined and tested by the engineering department of a major Montréal teaching hospital (Hôpital Ste-Justine de Montréal), which reported a high level of reliability for this instrument. Both the manometer and vaginal probe are illustrated in Figure 1.

Experimental Design

Our experimental design was a two-group crossover design, with all subjects receiving stimulation with the two different electrode placements. To reduce any experimental effect resulting from the order of stimulation, the 10 subjects were randomly assigned to one of two groups (n=5 per group) prior to the experiment. Each subject selected 1 of a series of 10 sealed envelopes containing an equal num-

*Enraf-Nonius Delft, equipment de Physiothérapie P Gélinas Ltée CP68, Succ "D," Montréal, Québec, Canada H3K 3R9.

†Med-0-Gen Inc, Hll MétropolitainE, Montréal, Québec, Canada HIR 1Z7.

‡Ponex Ltd, Hythe, Kent, England CT21 6JL

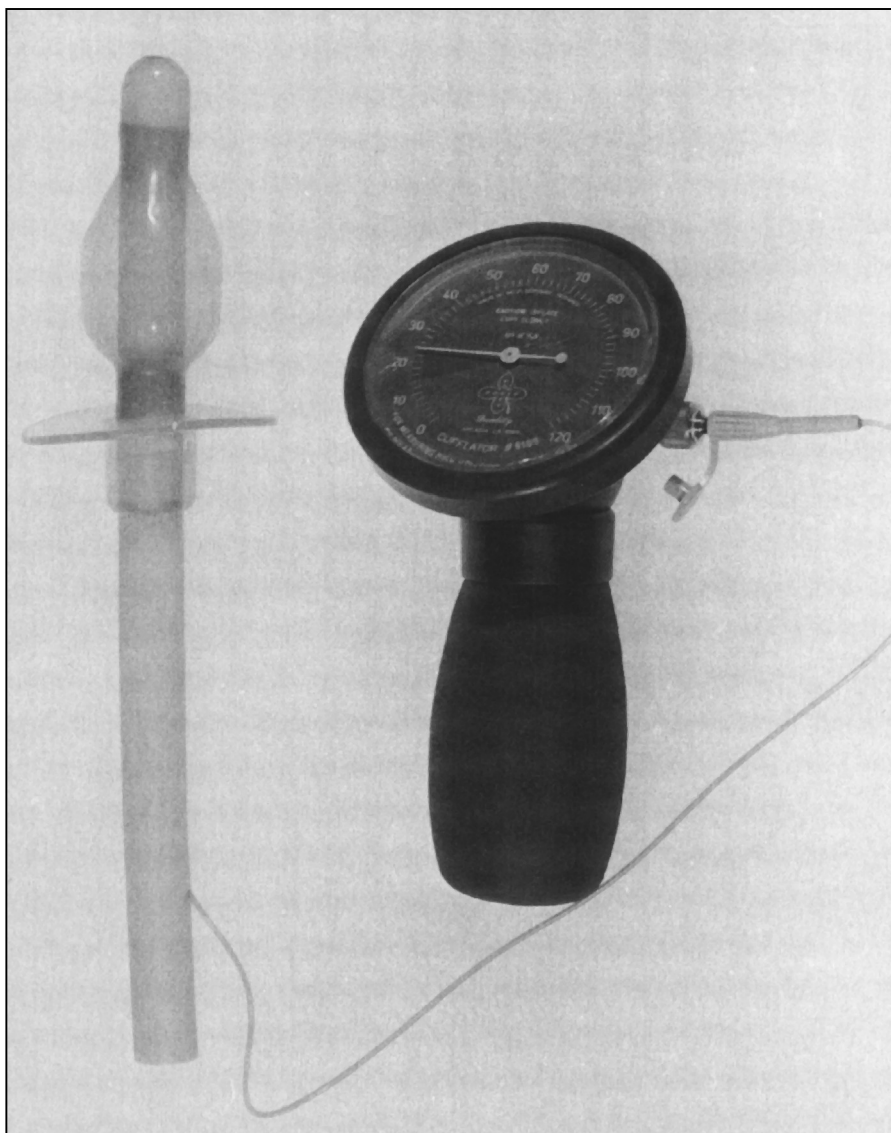


Figure 1. Pressure-sensitive manometer attached to the vaginal pressure probe.

ber of odd and even numbers. The 5 subjects who selected an envelope containing an even number began the experiment with the L2 electrode placement, followed by the O2 electrode placement. The 5 subjects selecting an envelope with an odd number were treated in the reverse order.

Procedure

Detailed explanations were given to each subject regarding the aims of the study, the equipment to be used, and the techniques. The subject was al-

lowed to test the effects of the stimulating current on an exposed portion of her forearm, using a remote current amplitude control. It has been our experience that patients will tolerate higher current amplitudes if the current is self-regulated. Following this initial briefing, the subject was required to perform her perineal toilet using soap and water, in an adjoining private washroom. She was then instructed to disrobe the lower part of her body and assume a semisupine position (trunk inclined at 50° from the horizontal) on a padded wooden

treatment table, with the knees and hips supported in flexion at approximately 70 degrees and both hips in lateral (external) rotation.¹⁴ This position facilitated the positioning of the electrodes, encouraged relaxation, and reduced intra-abdominal pressure,¹¹ which could register on the manometer and thereby influence the results of the study.

Pelvic-floor assessment. The pelvic-floor assessment was performed by a physical therapist (CD), using a vaginal examination technique described by Chiarelli and O'Keefe.¹⁸ The therapist wore disposable, sterile surgical latex gloves. After palpating the medial fibers of the subject's pubococcygeus muscle with the index finger, she instructed the subject to contract her pelvic-floor musculature to more accurately identify its precise location. According to Bo et al,¹⁹ the center of pelvic-floor activity is located in an area approximately 3.5 cm from the introitus.

The disposable vaginal pressure probe was adjusted corresponding to the depth of each subject's musculature, as determined by vaginal palpation. Following instructions given by the therapist, the subject then inserted the probe herself, using a sterile water-soluble jelly as a lubricating medium. The probe was then attached to a manometer. The subject was required to squeeze on the probe by contracting her pelvic-floor muscles. At the same time, the therapist completed the adjustment of the probe position to a site where maximum pressure was obtained, as indicated by the manometer.

Electrode placement and stimulation sequence. The electrodes were placed in position in the predetermined order. The posterior (6X8-cm) carbon-silicone electrode,* enclosed in a cellulose sponge pad* moistened with warm tap water, was placed directly over the subject's anal region. The anterior electrode (4X6 cm), similarly enclosed, was placed in the median plane, immediately inferior to the pubic symphysis for the L2 technique, or immediately superior to the

*MUKO Lubricating Jelly, Ingram & Bell Medical, Don Mills, Ontario, Canada M3B 1L9.

Order	Subject No.	Maximum Pressure (cm H ₂ O)	
		L2	D2
L2/D2	2	2.5	10.0
	4	2.0	3.0
	6	2.0	3.0
	8	3.0	5.0
	10	4.0	4.0
	X	2.7	5.0
	SD	0.8	2.9
D2/L2	1	4.5	5.0
	3	2.0	3.0
	5	16.0	12.0
	7	4.5	4.0
	9	5.0	6.0
	X	6.4	6.0
	SD	5.5	3.5
	Grand X	4.6	5.5
	Grand SD	4.2	3.1

"Subjects with even numbers were treated with electrode placement suggested by Laycock and Green (L2) followed by electrode placement suggested by Dumoulin (D2); subjects with odd numbers were tested in the reverse order.

pubic symphysis for the D2 technique. 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. To avoid any possibility of cross infection between subjects, we used only new cellulose electrode envelopes, which were changed for each subject. The carbon-silicone electrodes and leads were cleaned with alcohol and the perforated rubber band was disinfected in Cidex solution following each application.

An amplitude-modulated medium-frequency (AMF) current of 10 Hz and a base frequency (carrier frequency) of 2 kHz were used throughout the study as the stimulating current. To achieve this AMF current, two separate

medium-frequency currents, one of 2,000 Hz and the other of 2,010 Hz, are superposed within the stimulator. The result is an AMF current rising and falling in amplitude 10 times per second. The effect on the tissues is that of a low-frequency stimulating current of 10 Hz. When muscle tissue is stimulated via the nerve at this frequency, the result is a subtetanic muscle contraction.

Three muscle contractions were elicited with each electrode placement. Using the remote control, the subject, under the supervision of the therapist, increased the current amplitude gradually to a level of maximum tolerance, remaining at this level for 3 seconds. Maximum tolerance was defined as a point just below the pain threshold. To reduce the possibility of any Wedensky inhibition, 30 seconds only was allowed for each subject to reach

maximum intensity²⁰ Wedensky inhibition is the state of incomplete repolarization of a nerve fiber when the nerve is stimulated with a high-intensity, medium-frequency (2,000-Hz) current. Complete repolarization can only occur if the current intensity is reduced periodically.²¹ To limit muscle fatigue, a 2-minute rest period separated stimulated contractions and a 1-minute rest period separated the two electrode placement techniques. During this 15-minute period, the electrodes were removed and the pads were moistened prior to being secured in the alternative position. At the same time, the vaginal probe was checked to ensure that its position remained unchanged. Of the three contractions elicited in each electrode placement, the strongest contraction was retained for use in the statistical analysis. All readings were verified by two researchers, neither of whom was masked.

Data Analysis

Descriptive statistics were calculated for maximum pressure and current amplitude. In addition, both maximum pressure and current amplitude were analyzed using a two-way, mixed-model (one between-group factor and one within-subject factor) analysis of variance (ANOVA),²² the between-group factor being the order of stimulation (L2 followed by D2 or D2 followed by L2) and the within-subject factor being the electrode placement (L2 and D2). The ANOVA procedures were performed using the SYSTAT statistical package.²³ A probability level of $P < .05$ was adopted for all statistical tests.

Results

Descriptive statistics for maximum pressure and current amplitude are presented in Tables 2 and 3. No difference was observed between the maximum pressures obtained for both the L2 and D2 electrode placements ($P = .34$), nor was there any effect due to either the order of application or the interaction between the order and the electrode placement (Table 4).

Johnson & Johnson Medical Products, Peterborough, Ontario, Canada K9J 7B9.

²³SYSTAT Inc., 1100 Sherman Ave, Evanston, IL 60201.

muscular Electrical Stimulation"

Order	Subject No.	Current Amplitude (mA)	
		L2	D2
L2/D2	2	68	45
	4	39	39
	6	60	32
	8	53	40
	10	61	53
	X	56.2	41.8
	SD	11.0	7.8
D2/L2	3	50	26
	5	16	18
	7	118	78
	9	100	57
	9	82	28
	X	73.2	41.4
	SD	40.7	25.2
	Grand X	64.7	41.6
	Grand SD	29.5	17.6

"Subject with en n numbers were treated with electrode placement suggested by Laycock and Green (L2) followed by electrode placement suggested by Dumoulin (D2); subjects with occlusion

re treated in the reverse order.

Table 4. Analysis of Variance Summary for Maximum Pressure Obtained With Neuromuscular Electrical Stimulation

Source	df	SS	MS	F	p
Order		27.61	27.61	1.22	.30
Error	8	180.75	22.60		
Placement		4.51	4.51	1.35	.28
Order x placement	1	9.11	9.11	2.73	.14
Error	8	26.75	3.34		

Maximum Pressure Obtained With Neuromuscular Electrical Stimulation

Source	df	SS	MS	F	p
Order	1	344.45	344.45	0.32	.59
Error	8	8686.60	1085.83		
Placement		2668.05	2668.05	17.81	.003
Order x placement		378.45	378.45	2.53	.151
Error	8	1199.00	149.88		

In contrast, the mean CUITent amplitude required to produce the maximum recorded pressure was found to be less ($F=17.81, P<.003$) with the D2 placement (41.6 mA) than that required with the L2 placement (64.7 mA). No effects due to the order of presentation or the interaction between order and placement were observed (Tab. 5). These results suggest that the D2 placement was capable of producing a contraction of comparable magnitude at a reduced CUITent amplitude. At the end of the session, when asked which technique they preferred, 7 of the 10 women indicated a preference for the D2 electrode placement.

Discussion

The objective of this study was to determine the most effective of two electrode placements in stimulating the pelvic-floor musculature in continent, nulliparous women. The results showed that both electrode placements achieved contractions of comparable force, as measured by the manometer. The current amplitude required to achieve the contractions, however, was lower with the D2 electrode placement than with the L2 electrode placement. Based on these results, we concluded that D2 was the more effective electrode placement for these subjects. The subjects' preference for this electrode placement, which they expressed verbally, might also indicate that the D2 electrode placement is also the more acceptable of the two electrode placements, an important consideration in the treatment of female urinary incontinence.

A major problem encountered in attempting to stimulate deep-seated structures, using noninvasive techniques, is the electrical impedance offered by the intervening tissues, which resist the flow of the stimulating current.¹⁴ The depth and consistency of the tissues between the stimulating electrodes and the motor nerve of a muscle will affect this impedance, thereby influencing the density of current at the target site and thus the quality of the muscle contraction. The motor nerve of the pubococcygeus

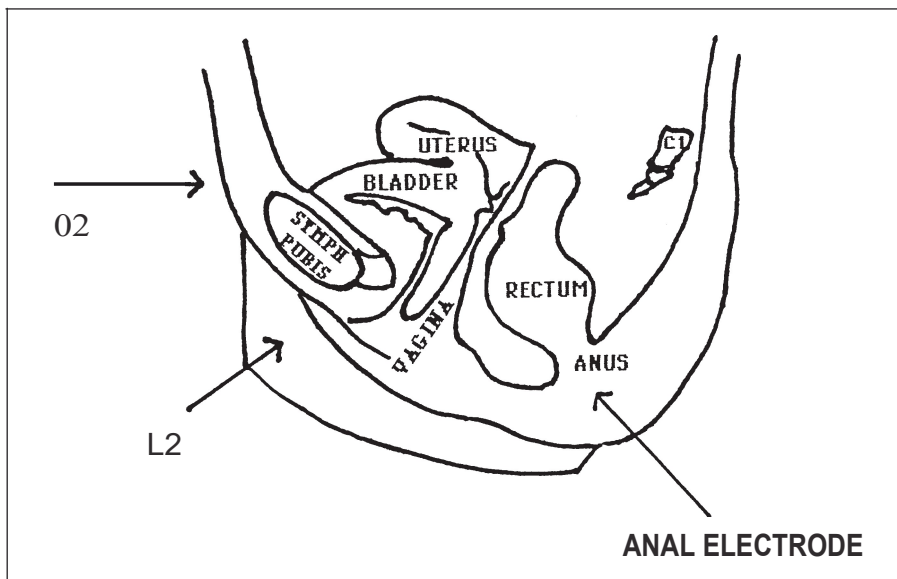


Figure 2. Diagrammatic representation of a median sagittal section through the female pelvis. Arrows indicate the anterior (D2, L2) and posterior (anal) electrode placements. (Adapted from Johnston TB, Whillis J, eds. Gray's Anatomy: Descriptive and Applied. 31st ed. New York, NY: Longmans, Green & Co; 1956.)

muscle (pubococcygeus) is deeply situated at a depth of between 7.5 and 10 cm in the pelvic cavity.⁶ Low-frequency stimulating currents (0-50 pulses per second), using a noninvasive electrode placement technique, are incapable of adequately stimulating the pelvic-floor muscles, unless current amplitudes are increased to levels that can be extremely painful and potentially harmful to the intervening tissues.⁶

The problem of tissue resistance has, seemingly, been overcome with the use of medium-frequency interferential currents.¹² The aim of obtaining a maximal contraction of the pelvic-floor musculature with minimal current amplitudes is, however, still desirable, and electrode placement can be of critical importance in achieving this aim.

By displacing the anterior electrode from the anterior perineum, inferior to the pubic symphysis (L2), to the region immediately superior to the pubic symphysis (D2), the depth of the current field could, theoretically, be increased.^{11,12} Figure 2 illustrates this point diagrammatically. Assuming a greater depth of penetration, a more effective stimulation of the motor

nerve to the pubococcygeus muscle might be achieved. Although no experimental evidence exists to support this hypothesis, a change in direction of the electrical field, produced by displacing the anterior electrode, could explain our results.

Our expectation that the D2 electrode placement would elicit a stronger muscle contraction than the L2 electrode placement was not realized during this study. No differences were observed between the force of contraction (measured as pressure in centimeters of water) provoked by the two electrode placements, nor was there any carryover effect from D2 to L2, or vice versa (Tab. 2).

Two possible explanations might account for the lack of any difference in the force of contraction. The instructions given to the subjects regarding the effects of the stimulation could have been misunderstood. Follow-up calls to all subjects, made in an attempt to clarify this point, revealed that all subjects ceased increasing the current amplitude upon perception of an appreciable muscle contraction and not necessarily for a maximum contraction. Thus, it is possible that for

the D2 electrode placement, if the current amplitude had been increased to the same levels that were achieved with the L2 electrode placement, a more forceful contraction would have resulted.

An alternative, or additional, explanation for the submaximal responses is that, when the subjects sensed the contraction, nervousness or the unusual sensation in a very sensitive and intimate region of the body could have caused them to stop increasing the current amplitude, while still well below the actual pain threshold, in both electrode placements. Delitto et al.¹³ have shown that the physical sensation of a muscle contracting as a result of electrical stimulation, combined with the effect of stimulation of local nociceptors, can lead to apprehension and fear, thereby reducing the effectiveness of NMES as a means of eliciting a maximum or near-maximum contraction. Emotional factors, either consciously or subconsciously, may have influenced our subjects, affecting their comprehension of the instructions or causing them to overreact to the stimulus. In a normal treatment situation, this apprehension and misconception regarding the perceived effects could gradually be overcome with repeated sessions. In such a situation, and with encouragement and guidance, we feel that the D2 electrode placement would have resulted in a stronger muscle contraction at current amplitudes still below those obtained with the L2 electrode placement.

The choice of a nontetanic frequency (10 Hz) for this study was based on our concern with regard to fatiguing the muscle. Stimulation at higher frequencies (30-50 Hz) may have resulted in a tetanic muscle contraction, further enhancing the efficacy of the stimulation. However, as any frequency changes would have applied equally to both the L2 and D2 electrode placements, our results would have remained the same.

Dwyer and co-workers² have demonstrated that there is a strong correlation between a high BMI (obesity) and

urinal) stress incontinence in women. Adipose tissue offers a high resistance to current flow," and adipose tissue tends to accumulate in the lower abdominal and suprapubic regions in women.²³ None of our subjects were classified as obese, but this is a factor that could have influenced our results. Further research should take this aspect into consideration. Another limitation of this study was the restricted number of subjects. Recruiting subjects for this type of research is difficult, particularly when time constraints are imposed. Our study would have been strengthened had our groupings been larger. In spite of these drawbacks, however, we feel that the results are encouraging and justify continued evaluation of the D2 technique in clinical trials of interferential currents for the treatment of female urinal) stress incontinence.

Conclusion

Two electrode placements for NMES of pelvic-floor muscles have been described and compared, using continent female volunteers as subjects. Equivalent maximum pressures were observed with both electrode placements. Current amplitudes required to obtain maximum pressure readings were less using the D2 electrode placement. Our interpretation of these findings is that the D2 electrode placement produces a deeper, and therefore a more precise and effective, stimulation of the pelvic-floor musculature. This interpretation suggests that a stronger muscle contraction might be obtained with the D2 electrode placement in subjects who become progressively more familiar with the

stimulation process while undergoing a treatment program. This hypothesis is examined in our companion article in this issue.

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.

References

- Hilton P. Unstable urethral pressure: towards a more relevant definition. In: *Proceedings of the international Continence Society, Boston Mass.* 1989;37-39.
- Ahrams P, Blaivas J, Stanton S, Andersen J. The standardisation of the terminology of lower urinary tract function. *Scand J Urol Nephrol.* 1988;114:17.
- Beek RP, Hsu N. Pregnancy, childbirth, and menopause related to the development of stress incontinence. *Am J Obstet Gynecol.* 1965;91:820-823.
- Fall M, Lindstrom S. Electrical stimulation. *Urol Clin North Am.* 1991;18:393-407.
- Leriche A, Leriche B. Place à la rééducation dans l'incontinence urinaire de la femme. *J Urol (Paris)* 1988;94:285-288.
- Scott B, Green V, Couldrey B. Pelvic faradism: investigation of methods. *Physiotherapy.* 1969;55:302-305.
- Plevnik S, Janez J, Vrtacnik P. Short-term electrical stimulation: home treatment for urinary incontinence. *World J Urol.* 1986;4:24-26.
- McQuire W. Electrotherapy and exercises for stress incontinence. *Physiotherapy.* 1975;61:305-307.
- Laycock J. *Assessment and Treatment of Pelvic Floor Dysfunction.* Bradford, England: Postgraduate School of Biomedical Sciences, Bradford University; 1992. Doctoral thesis.
- Olah K, Bridges N, Denning J, et al. The conservative management of patients with symptoms of stress incontinence: a randomized, prospective study comparing weighted vaginal cones and interferential therapy. *Am J Obstet Gynecol.* 1990;162:87-92.
- Meyer-Waarden K, Hansjurgens A, Friedmann B. Representation of electric fields in inhomogeneous biological media. *Biomed Tech (Berlin).* 1980;25:295-297.
- Goats GC. Interferential current therapy. *Br J Sports Med.* 1990;2:87-92.
- Barnett S, Cooney K, Johnston R. Electrically elicited quadriceps femoris muscle torque as a function of various electrode placements. *Clin Electrophysiol.* 1991;3:5-8.
- Laycock J, Green R. Interferential therapy in the treatment of incontinence. *Physiotherapy.* 1988;74:161-168.
- Delitto A, Strube M, Shulman A, Minor S. A study of discomfort with electrical stimulation. *Phys Ther.* 1992;72:410-424.
- Health and Welfare Canada. *Weight Levels Associated With Health: Canadian Guidelines 1988.* Ottawa, Ontario, Canada: Supply and Services Canada; 1989:26. Catalogue no. H3J134.
- Baker LL. Neuromuscular electrical stimulation in the restoration of purposeful limb movement. In: Wolf SL, ed. *Electrotherapy.* New York, NY: Churchill Livingstone Inc; 1981:2548.
- Chiarelli P, O'Keefe D. Physiotherapy for the pelvic floor. *Australian Journal of Physiotherapy.* 1981;27:103-108.
- Bo K, Hagen R, Jirgenssen J, et al. The effects of two different pelvic floor muscle exercise programs in the treatment of urinary stress incontinence in women. *Neurology and Urodynamics.* 1989;H:355-356.
- Kloth L. Interference current. In: Nelson RM, Currier DP, eds. *Clinical Electrotherapy.* East Norwalk, Conn: Appleton & Lange; 1987:183-207.
- Hansjurgens A, May LI. *Additional and Modern Aspects of Electrotherapy* 2nd ed. Temecula, Calif: Nemotron Medical Inc; 1984:37.
- Myers J. *Fundamentals of Experimental Design.* 2nd ed. Boston, Mass: Allyn and Bacon Inc; 1973:111-119.
- Dwyer P, Lee E, Hay D. Obesity and urinary incontinence in women. *Br J Obstet Gynaecol.* 1988;95:91-96.