Journal of the Association of Chartered Physiotherapists in Women's Health, Spring 2012, **110,** 27–32

CLINICAL PAPER

Pelvic floor muscle activation during singing: a pilot study

N. Bedekar
Physiotherapy Department, Liverpool Women's Hospital, Liverpool, UK

Abstract

The objectives of this study were to examine the effects of voluntary sub-maximal activation of the pelvic floor muscles (PFMs) during singing on PFM strength and compliance with the exercise regime. The participants in this pilot interventional study were a convenience sample of 11 asymptomatic (eight at follow-up) and seven symptomatic (five at follow-up) individuals. The primary outcome measures were: PFM strength assessment by vaginal examination; biofeedback evaluation of electromyographic (EMG) amplitude (in micro-volts, μV); the number of fast contractions (maximum = 10); and the length of the slow hold (maximum = 10 s). The secondary outcome measure was compliance with the exercise regime. The mean pre- and post-test results for the asymptomatic group were, respectively: (PFM manual muscle testing, MMT) 3+ and 4; (EMG amplitude) 27 and 33 μV; (number of fast contractions) 7 and 10; and (length of the slow hold) 8 and 10 s. Compliance in the asymptomatic group was 13 min per day, 6 days a week for 3 weeks. The mean pre- and post-test results for the symptomatic group were, respectively: (PFM MMT) 2 and 2+; (EMG amplitude) 7.6 and 11.4 μV; (number of fast contractions) 4 and 6; and (length of the slow hold) 6.0 and 9.2 s. Compliance in the symptomatic group was 15 min per day, 6 days a week for 3 weeks. Activation of the PFMs during singing improved PFM strength, EMG amplitude, the number of fast contractions and the length of the slow hold with 3–4 weeks of practice. Compliance with the exercise regime was good. Further research using larger samples and a control group is required to investigate whether this method consistently improves PFM strength and whether compliance is maintained.

Keywords: pelvic floor muscle exercises, recreational exercise, singing.

Introduction

Pelvic floor muscle exercises (PFMEs) are an important component of physiotherapy for the prevention and treatment of various pelvic floor dysfunctions, and PFM activation is an integral part of pelvic girdle stabilization (Richardson *et al*. 2004). Along with the transversus abdominis and the multifidus muscles, the PFMs play an important role in lumbopelvic stability (Lee 1999), and weakness can lead to various conditions, including urinary incontinence (Bø 2004; Quartly *et al*. 2010). Strengthening is a fundamental aspect of PFM rehabilitation (Kegel 1948), and voluntary training, activation or strengthening may be a life-long requirement for women. For this reason, it is important to find recreational ways of exercising these muscles.

Methods of assessing and re-educating the PFMs are constantly under investigation, and various exercise regimes have been suggested in the literature on women's health (Mantle & Haslam 2001; Hay-Smith & Dumoulin 2006). Patient compliance with PFM training programmes is a recurrent problem (Ashworth & Hagan 1993; Mason *et al*. 2001; Borello-France *et al*. 2010). Haslam (2004) stated that modern technology and fun equipment designed to help

Correspondence and present address: Professor Nilima Bedekar, Sancheti Institute College of Physiotherapy, Shivajinagar, Pune 411005, India (e-mail: nilimabedekar@yahoo.com).

in the co-activation of other areas of the musculature appear to enhance motivation and promote compliance. Sapsford (2001) recommended that PFM activation or exercises should be performed during the expiratory phase of breathing or breath control.

Singing requires specialized breath control (Murdock 2000), and therefore, the present author, who has formal training in this area and holds a degree in Hindustani classical music, suggests that it is one way to achieve motivation and compliance. Little work has been done on PFM contractions in conjunction with functional activity, or on the relative importance of isometric, concentric and eccentric muscle work (Naylor 2002).

Yoga teachers have suggested that PFM activation leads to better breath control and *vice versa*. Known as Mūla Bandha or root lock (i.e. the anterior aspect of the PFMs), and Ashwini Mudra (anal sphincter) activation, these concepts are explained in depth in yogic texts (Saraswati 1969, 2008; Yogendra 1988, 1997). It has been suggested that concentrating on the sensations while activating the PFMs improves the function of these muscles, and that Mūla Bandha becomes natural and comfortable over time; this approach is also recommended for meditation or chanting (Coulter 2001).

Singing is a popular recreational activity or hobby for some, and a profession for others. It requires modified control of breathing at various levels (e.g. the vocal cords and the diaphragm), and to be effective, a balanced abdominal component or core, along with pelvic musculature stability, is needed (Murdock 2000). Abdominal muscle activation has been well documented in relation to muscle work analysis in singing (Watson *et al.* 1989).

The abdominal muscles and PFMs work in synergy. If the abdominals are contracted strongly, this leads to an increase in intra-abdominal pressure and may stress the pelvic floor. However, it has also been observed that gentle activation of the transversus abdominis co-activates the PFMs and *vice versa* (Sapsford 2001).

Several methods are used to assess PFM strength, including digital vaginal examination (Polden & Mantle 1990; Laycock & Jerwood 2001), the use of a pressure perineometer (Laycock & Jerwood 1994), electromyographic (EMG) biofeedback (Haslam 2002; Mantle *et al.* 2004) and magnetic resonance imaging (DeLancey & Ashton-Miller 2007). Various strengthening and endurance training techniques can be used to tone muscle fibres and improve function (Bø *et al.* 2007).

The Physiotherapy Department of Liverpool Women's Hospital (LWH), Liverpool, UK, where the present study was conducted, offers EMG biofeedback. It is routine practice to examine the muscles by digital palpation, and to assess the number of contractions and hold time with EMG biofeedback.

The aims and objectives of this study were to study: (1) the effect of voluntary sub-maximal activation of the PFMs during singing on muscle strength; and (2) compliance with exercise.

Participants and methods

The present study was approved by the Research Department of LWH, the Chairman of the Research and Development Committee, and Liverpool Adult Research Ethics Committee.

Since this was a pilot study, power calculations were not appropriate to determine sample size, and the aim was to recruit a convenience sample of a minimum of five individuals in each group (i.e. the asymptomatic and symptomatic participants). It has been well documented that there is a difference in PFM strength in asymptomatic and symptomatic individuals (Devreese *et al.* 2004; Thompson *et al.* 2006). Pelvic floor muscle exercises are designed to prevent as well as manage PFM weakness, and therefore, both groups were considered. A convenience sample of normal, healthy and asymptomatic individuals that was comprised of female staff at LWH was recruited following an appeal made through the hospital intranet and notices with information about the study displayed in staff rooms. Referring consultants at LWH were approached and details about the research were circulated. An information sheet about the study was posted to the symptomatic women along with their outpatient appointment. The inclusion criterion was individuals who were interested in singing and trying a different approach to PFMEs. The exclusion criteria included participants or patients for whom digital vaginal examination to evaluate PFM strength was contraindicated, and women reporting pain during PFM examination.

Participants

The asymptomatic group initially consisted of 11 women who consented to their involvement, eight of whom completed the study and

Table 1. Demographic details of the participants

Participant	Age (years)	Obstetric and gynaecological history
*Asymptomatic group**		
1	55	Two vaginal deliveries
2	59	Nulliparous
3	34	Nulliparous
4	47	Two Caesarean sections
5	48	Two Caesarean sections
6	39	One Caesarean section
7	52	Two vaginal deliveries
8	42	Two vaginal deliveries, two Caesarean sections
Symptomatic group†		
9	44	Three vaginal deliveries, hysterectomy 11 years previously
10	48	One vaginal delivery
11	63	Four vaginal deliveries
12	57	Three vaginal deliveries, five pregnancies
13	39	Two vaginal deliveries (one with forceps)

*Mean age = 47.0 years.
†Mean age = 50.2 years.

attended the follow-up appointment. Two individuals had personal reasons for not attending follow-up in the given time. One did not like evaluation with the EMG biofeedback electrode, and hence, follow-up EMG analysis was not possible.

In the symptomatic or patient group, seven participants attended the initial check-up, of whom five attended the follow-up appointment. Of the two patients who dropped out of the study, one had another medical issue, and the other could not concentrate on singing and the PFM hold at the same time. The symptoms of the five patients referred to physiotherapy were varied. The diagnosis of urinary symptoms was confirmed urodynamically.

A comparison of the symptomatic and asymptomatic groups was not made because of baseline variations. Table 1 shows the demographic details of the participants who completed the study.

Methods

Pelvic floor muscle assessment was undertaken with each woman in crook-lying. The method described by Mantle *et al.* (2004, p. 356) was used. The initial assessment consisted of PFM assessment by vaginal digital examination. The Modified Oxford Scale was employed, and the PFMs were graded on a six-point scale: (0) no contraction felt; (1) flicker; (2) weak; (3) moderate; (4) good; and (5) normal/strong. Plus and minus signs were used to describe a contraction that the examiner perceived to be slightly stronger or slightly weaker than the grade given, which is common clinical practice, but not an approach based on evidence.

The number of quick contractions and the length of the hold were also noted. For practical reasons, a maximum of 10 fast contractions and a 10-s hold limit were set, as per the PERFECT scheme: (P) power (or pressure, a measure of strength using a manometric perineometer); (E) endurance; (R) repetitions; (F) fast contractions; and (ECT) every contraction timed (Laycock & Jerwood 2001). These findings formed the basis of patient-specific training, and it has been suggested that this method of assessment and training allows small changes and/or effects to be analysed (Laycock & Jerwood 2001).

Electromyographic biofeedback assessment was undertaken using an ISIS Femelex Vaginal Probe (Biomation, Almonte, Ontario, Canada) and a Myomed unit (Enraf-Nonius B.V., Rotterdam, the Netherlands). The following data were recorded while the participants performed fast and slow PFM contractions: the amplitude of the quick contractions; the number of fast/quick contractions (maximum = 10); and the length of hold for slow, sustained submaximal contractions (maximum = 10 s). A modification of the PERFECT method was that the number of repetitions of hold contractions was not assessed. It has been observed in clinical practice that women who have not voluntarily activated their PFMs or done PFMEs before report some discomfort that may be caused by the delayed onset of muscle soreness.

The participants were advised to undertake any type of singing practice (e.g. scales) with intermittent slow holds of the PFMs for a comfortable duration during singing (e.g. when trying to reach high notes, they were to hold notes for longer), as per the initial assessment. They were advised to practice for a minimum of 15 min a day, five times a week for 3 weeks. This allocation of time was to be divided up according to each individual's convenience. A record of daily singing exercise was kept on a sheet that was provided. A follow-up check was done after 3 weeks because of the time constraints on this pilot study.

Outcome measures

The primary outcome measures were: PFM strength assessment by vaginal examination;

Table 2. Mean results (ranges in brackets) of the pre- and post-test outcome measures, and percentage change for the better in the asymptomatic and symptomatic participants*

Variable	Pre-test	Post-test	Change (%)
*Asymptomatic group**			
Manual muscle testing	3+ (2–4+)	4 (2+–4+)	12.5
Electromyographic amplitude (μV)	27.0 (7.0–80.0)	33.0 (15.0–80.0)	22.0
Fast contractions (*n*)	7 (5–10)	10 (9–10)	42.0
Length of hold (s)	8.0 (5.0–10.0)	10.0 (9.0–10.0)	25.0
Symptomatic group†			
Manual muscle testing	2 (2–2+)	2+ (2–3)	14.3
Electromyographic amplitude (μV)	7.6 (3.0–12.0)	11.4 (7.0–16.0)	50.0
Fast contractions (*n*)	4 (3–6)	6 (5–8)	50.0
Length of hold (s)	6.0 (3.0–8.0)	9.2 (8.0–10.0)	53.3

*Compliance = 13 min per day, 6 days a week for 3 weeks.
†Compliance = 15 min per day, 6 days a week for 3 weeks.

biofeedback evaluation of EMG amplitude (in micro-volts, μV); the number of fast contractions (maximum = 10); and the length of the slow hold (maximum = 10 s). The secondary outcome measure was compliance with the exercise regime.

Results

Measurement of change on a percentage basis was recommended by a statistics expert at LWH. The following changes were recorded in the asymptomatic and symptomatic groups, respectively: EMG amplitude increased by 22% and 50%; the number of fast contractions increased by 42% and 50%; and the time for the slow hold increased by 25% and 53%.

Six out of eight participants in the asymptomatic group found this to be a good and interesting way to do exercise, while one found it difficult to concentrate on both singing and PFM activation, but managed. One other participant was not able to comment.

In the symptomatic group, four participants found that this was a good way to do exercise, but one was not sure (Table 2).

Discussion

Repetition increases neuronal pools and cognitively changes the motor command to restore muscle function. Within 3–4 weeks, the change may be attributed to improvements in neuromuscular coordination, rather than an alteration in muscle morphology, as discussed by Bø *et al.* (2007).

In the present study, follow-up was done 3 weeks later. This short time-scale was a result of the restrictions inherent in the nature of the intervention.

Long-term follow-up was not proposed for several reasons: this was a novel study; the researcher believed that a longer study might have affected the subjects' willingness to participate; and for the symptomatic women, a shorter study meant that other interventions could be offered if there was no improvement.

Activation of the PFMs during singing improved the length of hold contractions, which had been experienced and noted in a pre-pilot study. The slow, gentle and low-effort contractions of the PFMs employed could also have activated the transversus abdominis and the core group muscles, as discussed by Watson (2002). Involvement of the core muscles increases PFM strength if PFMs are co-activated voluntarily (Sapsford 2004).

Measurement of EMG amplitude showed an improvement over time, possibly because of the increased activation required in order to reach higher notes. This might be a result of the recruitment of increasing numbers of motor units and the activation of other muscle groups, which would be similar to the "lift" exercise. When singing, the respiratory system is involved in the generation of sound, and at times, inspiration is not possible for some length of time. Breath control is required to produce a wide range of pressures and flows to meet artistic demands. In the expiratory phase of breathing, the abdomen produces volume displacement, and serves to optimize function of the diaphragm and rib-cage (Watson 2002). Core stabilization assists controlled contraction of the diaphragm and resists the expiratory pressure developed by the chest wall. The PFMs are part of the lumbar core and their voluntary activation contributes to lumbar core stability. Core stability can enhance expiratory muscle control, and thus, breath control can be efficient. During singing without pause or when reaching higher notes, activation of the abdominal group and PFMs assists this. However, there is a paucity of scientific evidence about the effect of singing on related or accessory muscle work described in the yogic literature.

Depending on the initial assessment, the hold time for PFM contraction was to be gradually increased over the course of the present study. After any strength training programme, gains in strength are followed by a plateau. Exercise needs to be continued to maintain the improvement in strength (Bø *et al.* 2007). The present participants commented that, instead of getting bored of the exercises or having to undertake them in isolation at specific intervals, their PFMs were activated in a different way and that this was, perhaps, an easier way to remember to do the exercises regularly.

Their comments included the following: "Am now in habit of doing pelvic floor exercises when I hear music." "It was a good way to exercise my pelvic floor and improve my singing technique." For these reasons, the participants' compliance with PFMEs may also be better in the long-term.

The limitations of the present study were that the participants were evaluated by the same therapist, there was no control group and follow-up occurred in the short-term. However, the results of this pilot study show that a similar intervention should be undertaken with larger groups of healthy asymptomatic individuals and symptomatic participants. Single-blinding, a control group and long-term follow-up would improve the level and power of this approach. It would also be interesting to test PFM strength in singers.

Conclusion

The present pilot study indicates that muscle strength and endurance increase with PFM activation during singing. This method of PFM training yielded good participant compliance. Singing can be used as a recreational way of performing PFMEs in both healthy individuals and those with pelvic floor dysfunction, and it may improve compliance with this discreet exercise. In the long term, singing with intermittent activation of the PFMs may result in integrated or reflexive activation of these muscles, which is one of the goals of such an exercise regime. Future research might profitably investigate PFM strength in singers.

Pelvic floor muscle exercises during singing can offer an adjunct approach to the strengthening of these muscles.

Acknowledgements

This study was done at LWH (local project reference: LWH0579; Research Ethics Committee reference number: 05/Q1505/39).

My sincere thanks go to the following members of staff at LWH for their help: Elizabeth Adams, subspecialist consultant in urogynaecology; Sheila Jump, physiotherapist; and Linda Kendrick. Special thanks go to Gill Brook for helping me to write up this research.

References

Ashworth P. D. & Hagan M. T. (1993) The meaning of incontinence: a qualitative study of non-geriatric urinary incontinence sufferers. *Journal of Advanced Nursing* **18** (9), 1415–1423.

Bø K. (2004) Pelvic floor muscle training is effective in treatment of female stress urinary incontinence, but how does it work? *International Urogynecology Journal and Pelvic Floor Dysfunction* **15** (2), 76–84.

Bø K., Berghmans B., Mørkved S. & Van Kampen M. (eds) (2007) *Evidence-Based Physical Therapy for the Pelvic Floor: Bridging Science and Clinical Practice*. Churchill Livingstone, Edinburgh.

Borello-France D., Burgio K. L., Goode P. S., *et al.* for the Urinary Incontinence Treatment Network (2010) Adherence to behavioral interventions for urge incontinence when combined with drug therapy: adherence rates, barriers, and predictors. *Physical Therapy* **90** (10), 1493–1505.

Coulter H. D. (2001) *Anatomy of Hatha Yoga: A Manual for Students, Teachers, and Practitioners*. Body and Breath, Honesdale, PA.

DeLancey J. O. L. & Ashton-Miller J. A. (2007) MRI of intact and injured female pelvic floor muscles. In: *Evidence-Based Physical Therapy for the Pelvic Floor: Bridging Science and Clinical Practice* (eds K. Bø, B. Berghmans, S. Mørkved & M. Van Kampen), pp. 93–105. Churchill Livingstone, Edinburgh.

Devreese A., Staes F., De Weerdt W., *et al.* (2004) Clinical evaluation of pelvic floor muscle function in continent and incontinent women. *Neurourology and Urodynamics* **23** (3), 190–197.

Haslam J. (2002) Biofeedback for assessment and re-education of the pelvic floor musculature. In: *Therapeutic Management of Incontinence and Pelvic Pain: Pelvic Organ Disorders* (eds J. Laycock & J. Haslam), pp. 75–80. Springer-Verlag, Berlin.

Haslam J. (2004) Margie Polden Memorial Lecture: The continuing challenge of childbirth and the pelvic floor. *Journal of the Association of Chartered Physiotherapists in Women's Health* **94** (Spring), 4–10.

Hay-Smith E. J. & Dumoulin C. (2006) Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. *Cochrane Database of Systematic Reviews* **25** (1): CD005654.

Kegel A. H. (1948) Progressive resistance exercise in the functional restoration of the perineal muscles. *American Journal of Obstetrics and Gynecology* **56** (2), 238–248.

Laycock J. & Jerwood D. (1994) Development of the Bradford perineometer. *Physiotherapy* **80** (3), 139–143.

Laycock J. & Jerwood D. (2001) Pelvic floor muscle assessment: the PERFECT scheme. *Physiotherapy* **87** (12), 631–642.

Lee D. G. (1999) *The Pelvic Girdle: An Approach to the Examination and Treatment of the Lumbo-Pelvic–Hip Region*, 2nd edn. Churchill Livingstone, Edinburgh.

Mantle J., Haslam J. & Barton S. (2004) *Physiotherapy in Obstetrics and Gynaecology*, 2nd edn. Butterworth–Heinemann, Oxford.

Mantle J. & Haslam J. (2001) Raising pelvic floor awareness. *Physiotherapy* **87** (12), 618–619.

Mason L., Glenn S., Walton I. & Hughes C. (2001) Do women practise pelvic floor exercises during pregnancy or following delivery? *Physiotherapy* **87** (12), 662–670.

Murdock R. (2000) *The Alexander Technique for Musicians: Born to Sing*. [WWW document.] URL http://www.alexandercenter.com/pa/voice.html

Naylor D. (2002) Which is the best way to exercise pelvic floor muscles? *Journal of the Association of Chartered Physiotherapists in Women's Health* **91** (Autumn), 23–28.

Polden M. & Mantle J. (1990) *Physiotherapy in Obstetrics and Gynaecology*. Butterworth–Heinemann, Oxford.

Quartly E., Hallam T., Kilbreath S. & Refshauge K. (2010) Strength and endurance of the pelvic floor muscles in continent women: an observational study. *Physiotherapy* **96** (4), 311–316.

Richardson C., Hodges P. & Hides J. (2004) *Therapeutic Exercise for Lumbopelvic Stabilization: A Motor Control Approach for Treatment and Prevention of Low Back Pain*, 2nd edn. Churchill Livingstone, Edinburgh.

Sapsford R. (2001) The pelvic floor: a clinical model for function and rehabilitation. *Physiotherapy* **87** (12), 620–630.

Sapsford R. (2004) Rehabilitation of pelvic floor muscles utilizing trunk stabilization. *Manual Therapy* **9** (1), 3–12.

Saraswati S. (1969) *Asana Pranayama Mudra Bandha*. Bihar School of Yoga, Munger, Bihar.

Saraswati S. (2008) *Asana Pranayama Mudra Bandha*, 4th edn. Yoga Publications Trust, Munger, Bihar.

Thompson J. A., O'Sullivan P. B., Briffa N. K. & Neumann P. (2006) Assessment of voluntary pelvic floor muscle contraction in continent and incontinent women using transperineal ultrasound, manual muscle testing and vaginal squeeze pressure measurements. *International Urogynecology Journal and Pelvic Floor Dysfunction* **17** (6), 624–630.

Watson P. (2002) *What Have Chest Wall Kinematics Informed Us About Breathing for Singing?* [WWW document.] URL http://www.med.rug.nl/pas/Conf_contrib/Watson/Watson_contribution.htm

Watson P. J., Hoit J. D., Lansing R. W. & Hixon T. J. (1989) Abdominal muscle activity during classical singing. *Journal of Voice* **3** (1), 24–31.

Yogendra J. (ed.) (1988) *Cyclopaedia Yoga*, Vol. I: *All About Āsanas and 100 More Topics of Yoga*. The Yoga Institute, Santacruz, Mumbai.

Yogendra J. (ed.) (1997) *Cyclopaedia Yoga*, Vol. II: *A Systematic Programme on Yoga Education for the Child and Adult*. The Yoga Institute, Santacruz, Mumbai.

Nilima Bedekar PhD PT is a professor at the Sancheti Institute College of Physiotherapy, Pune, India.

