Pelvic floor muscle activation during singing: a pilot study

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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 (Bo 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
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...
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.

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

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

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Outcome measures

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

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

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

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References


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