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Original article

Abdominal and pelvic floor muscle function in women with and without long lasting pelvic girdle pain

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Abstract

Approximately 5–20% of postpartum women suffer from long-lasting pelvic girdle pain (PGP). The etiology and pathogenesis of PGP are still unclear. The aim of this study was to examine whether subjects with and without persisting PGP and disability differed with respect to their ability to voluntarily contract the deep abdominals (TrA and IO) and to the strength of the pelvic floor muscles (PFM). Twenty subjects (12 with persisting PGP, 8 recovered from PGP) were examined. Contractions of the deep abdominal muscles (TrA and IO) were imaged by real-time ultrasound. Vaginal palpation and observation were used to assess the women's ability to perform correct a PFM contraction. PFM strength was measured by a vaginal balloon catheter connected to a pressure transducer. The active straight leg raise test was used to assess the ability of load transfer. The results showed no statistical significant difference between the groups in increase of muscle thickness of the deep abdominal muscles (TrA; $P = 0.87$ and IO; $P = 0.51$) or regarding PFM strength ($P = 0.94$). The ability to voluntarily contract the deep abdominal muscles and the strength of the PFMs are apparently not associated to PGP. However, the results are based on a small sample and additional studies are needed.

Keywords: Postpartum pelvic girdle pain; Pelvic floor; Deep abdominals; Ultrasound

1. Introduction

Low back and pelvic girdle pain (PGP) during pregnancy is a common ailment (Endresen, 1995; Kristiansson et al., 1996; Ostgaard et al., 1991). After childbirth, the pain disappears in most cases within 6 months (Kristiansson et al., 1996; Ostgaard et al., 1996, 1997). However, about 5–20% suffer from long-lasting pain and disability (Albert et al., 2001; Larsen et al., 1999; Wu et al., 2004). The etiology and pathogenesis of PGP is still not clear. Hypermobility of the pelvic joints has been described to be a causative factor of PGP (Hagen, 1974; Snijders et al., 1995), even though mechanical hypermobility has not been demonstrated (Sturesson et al., 1999; Walheim, 1984). However, pain and disability seem to correlate with asymmetric laxity of the left and right sacroiliac joint (SIJ) (Buyruk et al., 1999; Damen et al., 2001, 2002), which could be caused by asymmetric muscle tone (De Groot et al., 2004).

It has been suggested that PGP is related to insufficient stability of the lumbopelvic region. According to a model of SIJ function, stability is claimed to be obtained by a combination of form and force closure (Snijders et al., 1995; Vleeming et al., 1997). It is thought that SIJ shear may be prevented by friction (form closure), and dynamically influenced by muscle force and the integrity of facial structures and ligament tension (force closure). Impairment of form and force closure may be associated with pain disorders of the lumbopelvic region (Mens et al., 1999; Snijders et al., 1993; Vleeming et al., 1992). The transversus abdominis (TrA), internal oblique (IO), diaphragm, and the pelvic floor muscles (PFM) work together to produce and

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control intraabdominal pressure (Critchley, 2002; Hodges and Richardson, 1996; Neumann and Gill, 2002; Richardson et al., 2002; Sapsford and Hodges, 2001), and thereby increase stiffness of the lumbar spine (Hodges et al., 2003a, 2005). The PFM may thus indirectly contribute to lumbopelvic stability. A recent study based on a biomechanical model revealed that simulated tension in the PFM increased the stiffness of the SIJs in female specimens (Pool-Goudzwaard et al., 2004). Furthermore, co-activation of the abdominal and the PFM have been reported (Bø and Stien, 1994; Critchley, 2002; Neumann and Gill, 2002; Sapsford et al., 2001). However, as discussed by Bø et al. (2003) one may question to what extent these results can be generalized.

The neuromuscular system contributes to motor control and dynamic stability of the lumbopelvic joints. Several studies have demonstrated altered motor control strategies in subjects with pain related to the SIJ region (Avery et al., 2000; Hungerford et al., 2003; O'Sullivan et al., 2002; Sturesson et al.,1997; Wu et al., 2002). One hypothesis is that a dysfunction of the PFM causes a deficit in the force closure mechanism of the SIJ (O'Sullivan et al., 2002). When pelvic stability is compromised, load transfer may be impaired. The functional integrity of the force closure mechanism may be examined clinically by use of the active straight leg raise (ASLR) test, which has been found to be a reliable measure of the ability of load transfer through the lumbopelvic region (Mens et al., 2001). A positive ASLR test has been associated with a descent of the pelvic floor and an altered motor control of the diaphragm (O'Sullivan et al., 2002). Also, a significantly increased activity and shorter endurance time of the PFM have been found in lumbopelvic pain patients than in healthy subjects (Pool-Goudzwaard et al., 2005). Decreased laxity of the SIJ has been demonstrated during contraction of the TrA muscle (Richardson et al., 2002).

In a randomized controlled trial, we included 81 women with postpartum PGP and compared physical therapy with a focus on specific stabilizing exercises with individualized physical therapy without specific stabilizing exercises (Stuge et al., 2004a). The stabilizing exercise group demonstrated statistically and clinically significant lower pain intensity, and lower disability and higher quality of life than the comparison group one and 2 years after delivery (Stuge et al., 2004a, b). However, a large variability in improvement was seen in both groups. Some subjects completely recovered, while others exhibited significant disability. In an attempt to understand why some suffer from long-lasting PGP we took advantage of having the access to these subjects.

The aim was thus to examine whether subjects with and without persisting PGP and disability, independent of the preceding treatment, differed with respect to the ability to voluntarily contract the deep abdominal muscles (TrA and IO) and to the strength of the PFM. We examined whether there was any association between the ability to voluntarily contract the TrA and the strength of the PFM. In addition, we examined whether subjects with and without positive ASLR tests revealed any differences in the voluntary contractions of the deep abdominal muscles and the PFM.

2. Materials and methods

2.1. Subjects

The study group consisted of women with PGP who had participated in a randomized controlled trial ($n = 81$) with a 2-year follow-up study, evaluating the effect of two different physical therapy interventions to treat postpartum PGP (Stuge et al., 2004a, b). Based on their reported pain and disability scores 2 years postpartum, two groups of women were invited to participate in the present study: a recovered group with no or minimal pain (VAS < 30 mm) and disability (Disability Rating Index (DRI) scores < 4) and a group with persistent PGP reporting moderate to serious disability (DRI > 25). Categorization by pain and disability were chosen because they are commonly used aspects in clinic and research. Thirty-nine women fulfilled these criteria and were thus invited. Twenty-four of them agreed to participate. However, four reported inconsistent scores on PGP and were excluded, thus 20 subjects remained for this study, 12 with pain and disability (PGP group) and eight without (recovered group) (Fig. 1). The subjects were also categorized as ASLR positive or ASLR negative. There were no significant differences regarding pain and disability 2 years postpartum between the 20 included subjects and

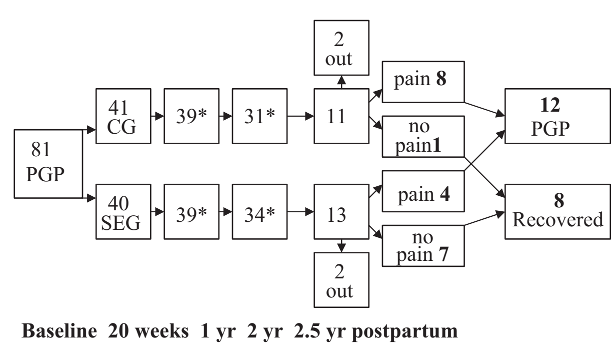

Fig. 1. Eighty-one women with postpartum PGP, included in a RCT, received physical therapy with or without stabilizing exercises for 20 weeks and follow-up data were collected 1 and 2 years postpartum. Subjects were included in present study on average 2.5 years postpartum, based on pain and disability reported on the questionnaire 2 years postpartum. *Those having a new pregnancy and those not fulfilled the 2-year questionnaire were excluded. PGP = pelvic girdle pain, CG = control group, SEG = specific exercise group

the 15 subjects who did not agree to participate ($P > 0.17$).

2.2. Measurements and equipment

The women completed a short questionnaire addressing weight, height, pain location, functional status, symptoms of urinary incontinence and other pelvic floor complaints, physical activity level and age of youngest child. The measurement procedure was standardized. After the questionnaire was completed, ultrasound assessment of the deep abdominal muscles, measurements of the pelvic floor, the ASLR test and the posterior pelvic pain provocation (P4) test were executed. The two researchers (SM, HHD) performing the assessments were blinded to the patients' symptoms, history of treatment and the results of the other assessor's assessments. As an additional background description of the included subjects, the scores of the Hopkins Symptoms Check List (Rickels et al., 1976), obtained 2 years postpartum are given to describe emotional distress by the subjects. All participants gave written consent to participate, and the study was approved by the regional ethics committee.

The following measurements were obtained:

Pain and disability: Pain intensity was measured on a 100 mm VAS scale. Disability was measured by Roland-Morris Disability Questionnaire (Roland and Morris, 1983) and DRI (Salèn et al., 1994).

Contractions of the deep abdominals (TrA and IO) were measured using ultrasound, with the subject in a comfortable supine position with a small pillow under her head, about 30° hip flexion, aiming at a neutral lumbar position. The subject was instructed to relax and to inhale, exhale, and gently and slowly draw in the lower abdomen (Richardson et al., 1999). In order to prevent feedback effects, the subject was unable to view the scanner screen. Real-time ultrasound images were made with a B-mode 7–10 MHz, linear array (Vingmed System Five) at the end of expiration. The measurements alternated between left and right side. The transducer was placed transversely across the abdominal wall, about 1/5 along a line drawn from anterior superior iliac spine (ASIS) to processus xiphoideus, measured from ASIS. However, the position of the probe was adjusted to ensure that the distance from the medial edge of TrA was at a standardized distance from the medial edge of the ultrasound image when the subject was relaxed. The location of the transducer was marked so that the identical position was used for all measurements. In addition we standardized the transducer state by holding at right angle to the fibre orientation, and avoided to tilt the probe. Images were recorded on prints and videotapes. The thickness of TrA and IO were measured at three sites, 5 mm apart, and the average was used. Calculation of TrA and IO muscle thickness was based on the average of three contractions on each side and two measures in relaxed situation. The thickness of TrA during contraction was divided by the thickness of TrA in relaxed position to get a ratio. External oblique was not assessed because ultrasound measurements of this muscle have not been found to be valid for estimating muscle activity (Hodges et al., 2003b).

Pelvic floor muscle (PFM) contraction: Vaginal observation and palpation was used to assess each woman's ability to perform correct PFM contractions (Bø et al., 1990; Kegel, 1956). An inward movement of the perineum and a palpable vaginal squeeze was considered a correct PFM contraction. Furthermore, the PFM contractions were to be performed without observable synergistic contractions of hip adductors and gluteal muscles, or pelvic tilt. The women were in a supine position (with straight legs). One finger was used for palpation.

Measurement of pelvic floor muscle strength: A vaginal balloon catheter (balloon size 6.7 × 1.7 cm) connected to a pressure transducer (Camtech Ltd. 1300 Sandvika, Norway) was used to measure vaginal squeeze pressure during PFM contractions. The balloon was positioned with the middle of the balloon about 3.5 cm inside the introitus vagina. PFM contractions with observed inward movement of the balloon catheter were classified as correct and used in the data analysis. Apart from one subject, all were able to perform correct contractions repeatedly. The mean pressure (measured as cm H_2O) of 10 correct contractions was used as a measure of PFM strength. The method has been found to be reliable and valid (Bø et al., 1990).

Physical tests: The ASLR test was performed with the subject in a supine position with straight legs. The subject was asked to raise one leg after the other 20 cm above the couch, and then asked to score the difficulty of raising the leg on a 6-point scale from 0 (''not difficult at all'') to 5 (''unable to do''). Scores from both legs were added, giving a summed score ranging from 0 to 10 (Mens et al., 2001). The intention of the ASLR test is to examine the ability to transfer loads from the legs to the trunk. Mens et al. (2001) found a test-retest reliability of 0.87, a sensitivity of 87% and specificity of 94%, when using self-reported history of PGP as external criterion. In addition to scoring the level of difficulty, the women were asked about pain when performing the ASLR test. The performance was also videotaped and the subjects later divided into groups according to their compensation patterns; this division was carried out by two physical therapists, blinded to the history of the patients. The main compensation strategies were categorized as bracing, bulging or rotation. It was considered a compensation strategy when prior to initiation of lifting either leg, a clearly observable bracing of the upper abdomen (the thorax was compressed) or bulge of the upper and lower abdomen, or rotation of the pelvic girdle relative to the thorax was observed. When none of these patterns was obvious, the strategy was categorized as no compensation. The posterior pelvic pain provocation (P4) test was performed to assess localized pain deep in the gluteal area on the provoked side (Ostgaard et al., 1994a).

2.3. Statistics

Except for background variables, all results are given as median values with 95% confidence intervals (CI). Because the data were not normally distributed, the Mann-Whitney two sample tests were used to test the differences between groups for PFM strength and increase in muscle thickness. Wilcoxon's signed rank test for matched pairs was used for comparison between TrA and IO. Pearson chi-square test was used for correlation between deep abdominals' muscle thickness (relative to rest) and PFM strength. Fisher exact test was used for frequency of urinary incontinence. P values less than .05 were considered significant. The statistical software program used for statistical analysis was SPSS (version 11) for Windows.

3. Results

The subjects in the two groups were comparable regarding background variables and had their last delivery on average 2.5 years ago (Table 1). No pain or disability as determined by DRI and Roland Disability Questionnaire was seen in the recovered group. The women in the PGP group reported moderate pain intensity and mild to moderate disability. Pain was located over the SIJs and the sacrum, but also over the pubic symphysis. As shown in Table 1, the physical tests showed clear differences between the groups.

The thickness of the deep abdominal muscles was similar for the PGP group and the recovered group at rest (Table 2). Furthermore, no statistically significant differences were seen in increase of muscle thickness

Table 1
Description of the subjects ($n = 20$)

	Recovered group ($n = 8$)	PGP group ($n = 12$)
"Background" (mean, SD), (n, %)		
Weight (kg)	69.5 (11.7)	67.3 (13.6)
Height (cm)	169.6 (3.6)	164.5 (5.4)
Body mass index	24.1 (3.3)	25.0 (5.4)
Age of youngest child (months)	29.5 (2.9)	29.6 (3.6)
Regular exercise during last year	5 (63%)	7 (58%)
Functional status (median, CI)		
Disability rating index (DRI) score	1 (0, 12)	42 (25, 59)
Roland morris disability questionnaire score	0 (0, 1)	7 (2, 10)
Pain VAS 0–100 mm (median, CI)		
Morning pain intensity at worst	0 (0, 0)	32 (11, 56)
Evening pain intensity at worst	0 (0, 0)	61 (21, 75)
Pain location (n, %)		
Symphysis	0	7 (58%)
Right sacroiliac joint region	0	9 (75%)
Left sacroiliac joint region	0	8 (67%)
Over sacrum	0	9 (75%)
Physical tests (median, CI),(n, %)		
Active Straight Leg Raise (ASLR) test	[a]	
Sum score left and right (0–10)	0 (0, 1)	4 (2, 5)
Positive (>1)	0	10 (83%)
Asymmetric	2 (25%)	9 (75%)
Pain	1 (13%)	7 (58%)
Compensation patterns	4 (50%)	10 (83%)
Posterior pelvic pain provocation (P4) test *(n, %)*		
Positive left and/or right	0[a]	5 (46%)[b]
Emotional distress (median, CI)		
Hopkins symptom check list (HSCL)[c]	1.3 (1.0, 2.0)	1.5 (1.3, 2.4)

[a] $n = 7$.
[b] $n = 11$.
[c] The scores are based on the questionnaire 2 years postpartum.

during contraction (relative to resting thickness) between the two groups (TrA; $P = 0.87$ and IO; $P = 0.51$) (Fig. 2). Furthermore, as shown in Table 3, there were no significant group differences for thickness of left and right TrA and IO, and no significant side difference between left and right TrA ($P = 0.54$) or IO ($P = 0.88$). When the subjects were categorized according to the ASLR test (positive or negative), no significant difference in muscle thickness was found (Table 4). Moreover, there was a statistical significant difference in increase of thickness during contraction between the TrA (57%) and the IO (20%) ($P = 0.001$).

Regarding PFM strength, no significant difference ($P = 0.94$) was found between the PGP group (median: 18.0 cm H_2O, 95% CI: 16.4, 28.8) and the recovered group (median: 18.4 cm H_2O, 95% CI: 0, 45.4). However, the number of women with urinary incontinence was significantly higher in the PGP group (75%) than in the recovered group (13%) ($P = 0.02$) (Table 5). Frequent leakage, difficulties in emptying the bladder, frequent visits to the bathroom at night, and regular pain in the lower abdomen were reported by less than half of the women in the PGP group (see Table 5).

Table 2
Muscle thickness of TrA and IO at rest

	Recovered group ($n = 8$)	PGP group ($n = 12$)	P value
TrA right (mm)	2.4 (1.9, 3.7)	2.7 (2.3, 2.9)	0.39
TrA left (mm)	2.8 (2.3, 3.7)	2.9 (2.5, 3.2)	0.97
IO right (mm)	5.8 (4.8, 7.6)	6.3 (4.7, 7.0)	0.64
IO left (mm)	6.0 (5.1, 7.3)	5.3 (4.3, 6.4)	0.28

Data are given as median (95% confidence interval).
PGP = pelvic girdle pain.
TrA = transversus abdominis.
IO = internal oblique.

Table 3
Muscle thickness of TrA and IO during contraction relative to rest (ratio)

	Recovered group ($n = 8$)	PGP group ($n = 12$)	P value
TrA right (ratio)	1.6 (1.0, 2.0)	1.5 (1.3, 1.8)	0.82
TrA left (ratio)	1.5 (1.2, 1.8)	1.5 (1.3, 1.9)	0.62
IO right (ratio)	1.2 (1.0, 1.6)	1.2 (1.1, 1.7)	0.56
IO left (ratio)	1.2 (1.1, 1.3)	1.2 (1.2, 1.5)	0.59

Data are given as median (95% confidence interval).
PGP = pelvic girdle pain.
TrA = transversus abdominis.
IO = internal oblique.

Table 4
Muscle thickness of TrA and IO during contractions relative to rest (ratio) and PFM strength in ASLR positive and negative subjects

	ASLR positive ($n = 10$)	ASLR negative ($n = 9$)	P value
TrA ratio	1.5 (1.4, 1.8)	1.6 (1.2, 1.8)	0.87
IO ratio	1.2 (1.2, 1.8)	1.2 (1.1, 1.4)	0.51
PFM strength (cmH_2O)	18.2 (13.8, 44.0)	18.0 (9.6, 44.8)	0.71

Data are given as median (95% confidence interval).
TrA = transversus abdominis.
IO = internal oblique.
PFM = pelvic floor muscles.
ASLR = Active straight leg raise.
Data for TrA and IO are based on average of left and right side.

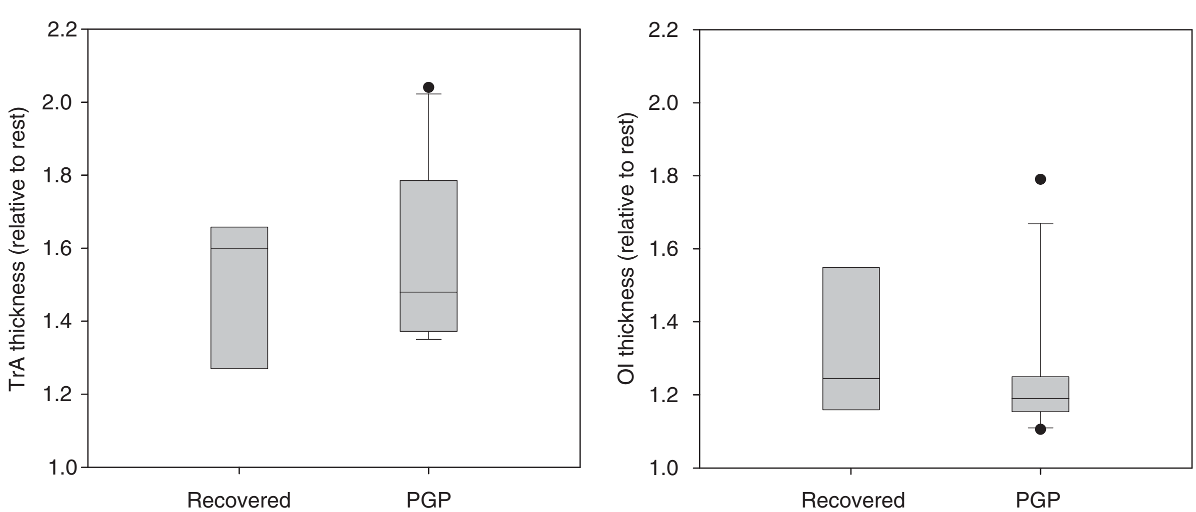

Fig. 2. Muscle thickness of the deep abdominals (TrA, IO) during contraction relative to the resting thickness, in a group of women with long-lasting pelvic girdle pain (PGP) ($n = 12$) and a group of women recovered from pelvic girdle pain (recovered) ($n = 8$). Data are based on average of left and right side, and are given as median (middle line) with 10th and 90th percentiles at the ends. TrA = transversus abdominis. IO = internal obliquus.

Table 5
Complaints related to the pelvic floor region (n, %)

	Recovered group ($n = 8$)	PGP group ($n = 12$)
Urinary incontinence	1 (13%)	9 (75%)
Frequent leakages	0	2 (17%)
Urinary infection last year	0[b]	1 (8%)
Difficulties in emptying the bladder	0	4 (33%)
Frequent visits the bathroom at night	0	2 (17%)
Regular pain in the lower abdomen	0	5 (46%)[a]

Data are given as median (95% confidence interval).
PGP = pelvic girdle pain.
[a] $n = 11$.
[b] $n = 7$.

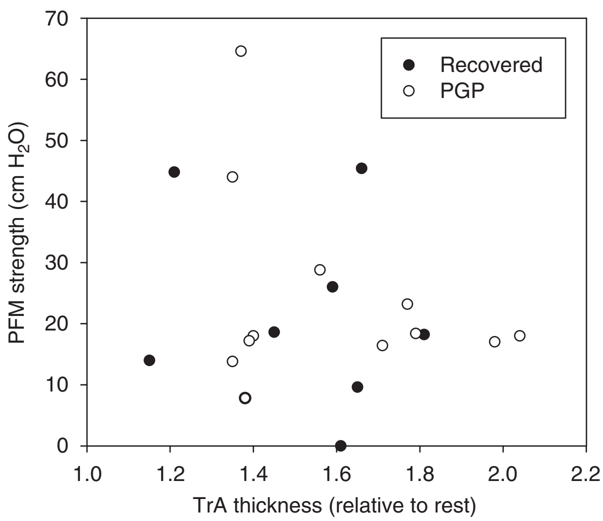

Fig. 3. Association between the increase in thickness of muscle transversus abdominis (TrA) during contraction and pelvic floor muscles (PFM) strength. Data for TrA are based on average of left and right side. Data for women with long-lasting pelvic girdle pain (PGP) and for women recovered from pelvic girdle pain (recovered).

No such complaints were described in the recovered group.

No statistical significant association was found between the increase in thickness of the TrA and the PFM strength ($r = 0.25$). As shown in Fig. 3, the data were distributed equally with similar ranges and distributions for the PGP and the recovered group. Furthermore, there was no statistical significant association between increase in IO thickness and PFM strength ($r = 0.05$). These data suggest that the ability of low graded activity of the deep abdominal muscles is unrelated to the strength of the PFM.

4. Discussion

Comparison between the groups of recovered women and women with persistent PGP showed no significant difference in the ability to voluntarily contract the deep abdominals or in PFM strength. Neither was any association found between the increases in average thickness of TrA and the PFM strength. Thus, our results do not support a hypothesis that PGP patients suffer from dysfunction of voluntary muscle contraction of the local muscles.

4.1. Subjects

As far as can be ascertained, no other studies have compared the voluntary contraction of local muscles in women with PGP, an ailment that is understood to be different from LBP (Ostgaard et al., 1994a, b). Our classification was based on self-reported pain and disability with strict cut-off values. To reduce the possibility of misclassification, we excluded four women with uncertain scores. The subjects in the PGP group reported mild to moderate pain and disability, and had scores comparable to those in other studies of PGP (Mens et al., 2000; Nilsson-Wikmar et al., 2003; Padua et al., 2002; Stuge et al., 2004b). One important limitation in the present study is the small sample size and there is thus a need for a larger study to provide more conclusive evidence. However, as illustrated in Fig. 3, the two groups showed almost complete overlap and similar distributions in increase in muscle thickness and in PFM strength. Based on the means and standard deviations of the present study, about 200 subjects are needed to detect the difference of 0.1 in TrA thickness with 80% power and 5% significance level.

4.2. Local muscle function

Our results revealed no difference between groups in increase of TrA thickness. This contrasts to studies examining TrA in LBP patients (Critchley and Coutts, 2002; Ferreira et al., 2004). These studies, however, looked at two different tasks. The subjects ($n = 44$) in the study by Critchley and Coutts (2002) were scanned during low abdominal hollowing in four-point kneeling whereas the subjects ($n = 20$) in the study by Ferreira et al. (2004) were scanned when performing isometric knee flexion or extension. Critchley and Coutts (2002) found a significantly smaller increase in TrA thickness in patients than in healthy controls. Interestingly, both our groups (PGP and recovered women) demonstrated similar increase and variations in TrA thickness as the healthy group in the study by Critchley and Coutts (2002). There are no established norms regarding normal increase in thickness of TrA. However, the LBP patients demonstrated less than half of the increase in muscle thickness than the healthy group and our groups, yet with wide variation.

Ultrasound assessment of TrA is reported to be a reliable and valid method of isometric muscle contraction and motor control of the deep abdominals (Bunce et al., 2002; Ferreira et al., 2004; Hodges et al., 2003b; McMeeken et al., 2004; Pietrek et al., 2000). However, several aspects may influence the results. Even though a comfortable supine position for measurements was chosen, the starting position may not have been optimal for all subjects, as the most suitable position to be able to contract the TrA may be individual (Beith et al., 2001; Bunce et al., 2002; Richardson et al., 1999). We also standardized the verbal instruction, since, different commands are shown to give individually different responses (Critchley, 2002). It is important to note that the women were instructed to contract the abdominal muscles, and voluntary contraction does not necessarily represent the automatic strategy for recruitment of the trunk muscles. Hence, we cannot rule out the possibility that the automatic response during a movement task or during functional activity might be different (Bunce et al., 2004; Critchley and Coutts, 2002). In a recent comparison with healthy controls, Cowan et al. (2004) showed that in subjects with long-standing groin pain the onset of TrA contractions was significantly delayed when performing the ASLR task .

When a muscle or a group of muscles is not adequately activated, compensation by changes in the pattern of motor activity of other muscles may occur (Edgerton et al., 1996). Thus, we also assessed the activity of IO. We found, however, no difference in either TrA or IO between the groups. A trend towards increased thickening of the IO compared with the TrA was found in a LBP study (Critchley and Coutts, 2002) and greater EMG activity in rectus abdominis than in IO was found in another study (O'Sullivan et al., 1997). In the study by O'Sullivan (1997), however, the lower fibres of IO medial to the ASIS were measured. Medial to the ASIS the IO and the TrA are thought to run parallel to one another with a similar fibre orientation, (Williams et al., 1989), suggesting that the muscles act in a similar manner and possibly a different function from the upper obliquely oriented fibres. Whether any part of the muscles is more important for stability of PGP patients is an open question. Regional variations in morphology of the deep abdominals may reflect functional differentiation between regions of TrA (Urquhart et al., 2005). We used a measuring point between the ASIS and the ribs, which is commonly utilized in LBP patients. However, this may not be optimal for PGP. The medial edge of TrA was often more lateral for our subjects compared to what was found for LBP patients and healthy persons in a study by Dahl (2000). This could be related to a slightly higher average body mass index among our subjects or to a possible rectus abdominis diastases; however, only three of the included revealed diastases 1 year postpartum.

No difference was found in PFM strength between groups with and without PGP. PFM strength is difficult to measure and the reliability and validity of many methods have been discussed (Bø et al., 2003; Hahn et al., 1996; Peschers et al., 2001; Shull et al., 2002). Because many patients do not understand verbal instructions and perform PFM contractions incorrectly (Bø et al., 1988; Dietz et al., 2001; Thompson and O'Sullivan, 2003), a visually observable inward movement of the perineum was used as a criterion for valid PFM contraction (Bø et al., 1990). Nevertheless, an important question is whether vaginal squeeze pressure is the optimal way to assess the role of the PFM related to pelvic girdle stability. Other parameters may be more relevant. According to Hodges and Richardson (1996) timing of the muscle contraction in significant muscle groups is the important issue related to low back pain, and a similar assumption should be studied in relation to PGP. Evidence indicates that TrA is anticipatory and no direction-specific in its activation (Hodges and Gandevia, 2000; Hodges and Richardson, 1997; Moseley et al., 2002). Some evidence also exists for an anticipatory PFM contraction related to increase in abdominal pressure (Constantinou and Govan, 1982). However, Neumann and Gill (2002) found no pre-contraction of the PFM compared to abdominal muscles during voluntary activities in healthy subjects.

In the present study, significantly more women with persistent PGP reported urinary incontinence and other complaints related to the pelvic floor than the recovered women. These findings are in keeping with findings by others (Mørkved, 1998; O'Sullivan et al., 2002; Pool-Goudzwaard et al., 2005). In one study an increased pelvic floor descent was apparent in patients with pain over the SIJ region during the ASLR test (O'Sullivan et al., 2002). It was speculated that the pelvic floor descent reflects a primary motor dysfunction of the PFM. Again, we measured a voluntary PFM contraction, and the ability to perform a correct vaginal squeeze may represent a different phenomenon than holding a contraction during a functional task.

In the present study, different measures and analyses for assessing local muscle contractions have been used with consistent findings of no group differences. An increase in thickness of TrA and PFM strength were apparently not associated to each other or to PGP.

4.3. Other possible mechanisms for PGP

Another explanation could be that persistent PGP is not related to physical impairment. All women included in this study had a history of PGP (included according to strict criteria) (Stuge et al., 2004a), but the inclusion for the present study was based on self-reported pain location, intensity and disability, not based on physical tests. Thus, it is conceivable that those with pain were suffering more from fear and anxiety, than from physical impairments. However, the scores obtained by the Hopkins Symptom Check List 2 years after delivery, showed normal scores in both groups, even though the scores tended to be higher in the PGP group (Table 1). The P4 test was positive in five of the women in the PGP group, versus none in the recovered group, indicating a posterior pelvic pain problem in 46% of the PGP group. The ASLR test was positive only in the PGP group. This may indicate that the subjects were suffering from a load transfer problem related to lack of stability of the pelvic girdle (Mens et al., 1999, 2001; O'Sullivan et al., 2002). Thus, it is likely that physical impairment is a major contributor to the condition.

In the neuromuscular systems, muscle synergies most probably exist where changes in a given muscle activation level rarely occur in isolation but rather are associated with changes in other muscles as well. A significant reduction in segmental multifidus cross-sectional area has been reported in patients with acute unilateral back pain (Hides et al., 1994). We did not examine the multifidus, but it is possible that a dysfunctional multifidus or lack of synergetic activity may have an influencing factor on lumbopelvic stability and persisting PGP. However, while many believe that the local muscles are crucial for lumbopelvic stability, others state that the global larger muscles play a role. Recent studies have concluded that no single muscle dominates in the enhancement of spine stability, and their individual roles change continuously across tasks (Cholewicki and VanVliet, 2002; Kavcic et al., 2004). According to these authors the larger global muscles are better able to alter spine stability than the smaller, intersegmental muscles. Isometric contractions of global muscles have also been shown to increase the stiffness of the SIJs (Wingerden et al., 2004), and a delayed onset of activation of the gluteus maximus has been found in subjects with unilateral pain over the SIJ region (Hungerford et al., 2003). Appropriate and coordinated muscle recruitment patterns are most likely important for adequate lumbopelvic stability (McGill, 2004). It might be that those suffering from long-lasting pain and disability have inadequate motor control strategies of different muscles during functional tasks. Thus, focusing on a single muscle, or a few, appears to be insufficient if the goal is to ensure lumbopelvic stability.

5. Conclusion

This study revealed no significant difference in increase of muscle thickness by voluntary contraction of the deep abdominal muscles and PFM strength between women recovered from PGP and women with long-lasting PGP. The ability to voluntarily contract the deep abdominal muscles and the strength of the PFMs are apparently not associated to PGP. However, the results are based on a small sample and additional studies are needed.

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