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CORE STABILITY RESEARCH: PILATES

The influence of Pilates training on the ability to contract the Transversus Abdominis muscle in asymptomatic individuals

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Abstract The neuromuscular system acts to maintain postural stability and reduce the impact of deleterious loads on the spine. Exercising of the abdominal muscles has become widely used in the management of low back pain in order to provide this supplement to spinal stability. Several exercise programmes have been advocated to promote stabilization but evaluation is difficult. This study evaluates two common forms of exercise effects on the ability to appropriately contract Transversus Abdominis (TrA) muscle, whose normal function is regarded as significant in spinal stability.

Thirty-six asymptomatic females were examined. Twelve formed the Pilates trained group, 12 the abdominal curl group (both attending a minimum of 25 classes in 6 months) and 12 were non-training controls. A pressure biofeedback unit (PBU) was used to assess performance of the TrA muscle during an abdominal hollowing activity (TrA isolation test) and under limb load (Lumbo-pelvic stability test).

The percentage of subjects passing the TrA isolation test was 10 subjects (83%) from the Pilates group, four subjects (33%) from the abdominal curl group, and three subjects (25%) from the control group. The percentage of subjects passing the lumbo-pelvic stability test was five subjects (42%) from the Pilates group, all the subjects from both the abdominal curl and control groups failed the test. The study appears to indicate that Pilates trained subjects could contract the TrA and maintain better lumbo-pelvic control than do those who perform regular abdominal curl exercises, or no abdominal muscle exercises.

Introduction

Low back pain (LBP) affects virtually everyone at some time during their life; studies indicate that there is an annual prevalence of symptoms in 50% of working age adults (van Tulder et al., 1997). One of the reasons reported for this is that the ligamentous spine has been described as unstable at loads far less than that of body weight. This leads to the potential for trauma at the relatively low loads of the activities of daily living. It has been suggested that the neuro-muscular system must fulfil a

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supplementary and adaptive role to maintain postural stability while controlling and initiating movement (Crisco and Panjabi, 1991). The neuromuscular system acts to maintain postural stability and reduce the impact of deleterious loads on the passive restraints of the spine (O'Sullivan et al., 1998). The therapeutic application of exercise of the abdominal muscles therefore, has become widely used in the management of LBP in order to provide this supplement to spinal stability. However, general exercise regimes have not succeeded in reducing LBP, and their physiological and practical foundations have been questioned (Koes et al., 1991; Richardson and Jull, 1995).

Recently, the focus of research attention has been on the Transversus Abdominis muscle (TrA). This is the deepest of the abdominal muscles and it has been proposed that this component of the abdominal muscle group provides a specific contribution to spinal stability (Hodges, 1999).

The dysfunction of TrA may be related to a lack of spinal stability, and hence the incidence of LBP (Richardson et al., 1992; Hodges et al., 1996; O'Sullivan, 2000). Some evidence supports this, TrA activation has been shown to be significantly delayed in LBP patients and fails to occur in the preparatory period prior to movement in all directions (Hodges and Richardson, 1996, 1997a, b). These authors concluded that a change in TrA activation is not simply a delay, but is in fact a dysfunction in its motor control. TrA is often difficult to activate and may weaken in both sedentary individuals and those with chronic LBP (Soderberg and Barr, 1983). Evidence exists suggesting that the internal oblique and TrA muscles may not be optimally recruited, or may fatigue in their stabilizing role, even in normal, currently asymptomatic individuals (Parnianpour et al., 1988). These asymptomatic individuals with dysfunctional TrA action may be in a 'at risk' group of developing LBP symptoms, because of their failure to fully activate their dynamic spinal support system.

A test to estimate the stabilizing function of TrA whilst working to stabilize the spine was developed by Richardson and Jull (1995). This static holding test was used because it is similar to the functional stabilizing role of the TrA (Richardson and Jull, 1995). The ability of TrA to actively stabilize the lumbar spine is tested by estimating the ability of the patient to hold and control the position of the lumbar spine while load is added to the spine via the lower limbs. If poor muscle control is present, such muscle action will result in movement or lack of active stabilization of the lumbar spine. The measurement of the lumbar spine movement as a result of poor muscle control can then be used as an indicator of the ability of the TrA to stabilize the lumbar spine. A pressure biofeedback unit (PBU) has been used to monitor this movement, which is reflected in pressure changes between the lumbar spine and the supporting surface.

Several different exercise programmes have been advocated to promote active stabilization but have been difficult to evaluate due to a lack of appropriate measurement techniques (Saal and Saal, 1989; Robison, 1992; Richardson and Jull, 1995). Specific training of the deep abdominals in LBP patients has been shown to influence the automatic recruitment of these muscles (O'Sullivan et al., 1998). Furthermore, a sustained reduction in symptoms and an increase in functional mobility had been observed (O'Sullivan et al., 1997). In this study though no explanation of the specific training was given and the subjects were restricted to those with a diagnosis of spondylolisthesis. Once the initial control of spinal motion is achieved, a number of authors have proposed that Pilates exercise is a key method for maintaining TrA and progressing current stabilization training methods into more dynamic and functional movements (Comerford and Mottram, 2001).

There has been little research however, on the effectiveness of Pilates exercise and any studies found have been poorly controlled. There would appear therefore to be an opportunity to assess the effect of Pilates exercises on the ability to activate the TrA. Therefore the aims of this study was to assess and compare TrA muscle contraction in a Pilates trained, abdominal curl trained, and a control group using a PBU during a TrA isolation test in the prone position and unilateral heel lift test.

Method

Subjects

Thirty-six healthy females with a mean age of 32.6 years (SD 8.2 years, range 20–54 years), with an average height of 160 cm, and an average weight of 66 kg, volunteered to participate in the study. Twelve of the subjects were Pilates trained having attended one or two 45-min Pilates classes per week for the past 6 months. Twelve of the subjects participated in 15-min abdominal curl classes once or twice per week for the past 6 months. Both groups having attended a minimum of 25 classes in the last six months (mean = 28, range 25–32). The remaining 12 subjects were females who did not attend Pilates classes, and did not do abdominal

curls. The specific exclusion criteria for the study, was a history of back pain, abdominal or gynaelogical surgery, which may have interfered with the subjects ability to perform the tests accurately. Each subject gave informed consent prior to entry into the study and ethical clearance was obtained from the University of Salford Ethics Committee.

Apparatus

A Stabilizer pressure biofeedback unit (Chattanooga Group, Inc.) was used to indirectly measure the subjects' ability to perform a TrA isolation test, and to monitor lumbo-pelvic stability. This has been shown to be a reliable and valid tool for evaluation of deep abdominal muscle function (Cairns et al., 2000), lumbar stabilization (Richardson et al., 1992; Wohlfart et al., 1993) and rotational control (Jull et al., 1993).

Testing procedures

The TrA isolation formal test

All subjects were familiarized with the abdominal hollowing action in the four point kneeling position (Hodges et al., 1996) where substitution strategies can be identified (Richardson and Jull, 1995) and corrected before the test.

Once the abdominal hollowing action was understood and practiced once, the test was conducted. The subjects lay prone, arms by the side, with the pressure sensor under the abdomen, navel in the centre and the distal edge of the pad in line with the right and left Anterior Superior Iliac Spines (Hodges et al., 1996). The PBU was inflated to 70 mmHg (Richardson et al., 1999). The subjects were instructed to draw in their lower abdomen to support the weight of the abdominal contents off the pad, on exhalation without any movement of the pelvis or trunk (Richardson et al., 1999). Normal breathing commenced throughout the drawing-in action and the contraction was held for 10 s (Richardson et al., 1999). A successful performance reduced the pressure by 6–10 mmHg and indicated correct localized contraction of the TrA independent of the other abdominal muscles (Richardson and Jull, 1995). A drop of <6 mmHg, no change or an increase in pressure indicated a fail test result (Richardson et al., 1999). The tester (RD) was blind to the exercise grouping of the subjects, their intra-tested reliability was examined in pilot work prior to the study commencing and it was found for the same five subjects on two separate occasions their test result remained the same.

The lumbo-pelvic stability test

The subject was in supine crook lying position, with 70° of hip flexion to place the lumbar spine in mid-position (Richardson et al., 1992). A barrier was positioned to standardize and limit leg movement to 90° hip flexion. After randomly selecting the initial test leg, the PBU was placed beneath the lumbar spine from S1 to L1 and inflated to 40 mmHg. The resting leg was placed on weighing scales ensuring that the subject was not pushing through this leg for stability and counterbalance (Richardson et al., 1992). Subjects were instructed to breath in and out, then hold the abdominal hollowing action throughout, beginning the test movement on the end of exhalation (Hodges and Richardson, 1997b). A unilateral heel-lift in the sagittal plane was performed requiring flexion of the hip from the starting position (70°), to the barrier (90°), then returning to 70° with the knee flexed (Leckie, 2001). An ability to maintain the registered pressure at 40 mmHg (± 2 mmHg) during this manoeuvre indicated a successful performance. The tester (RD) was blind to the exercise grouping of the subjects, their intra-tested reliability was examined in pilot work prior to the study commencing and it was found for the same five subjects on two separate occasions their test result remained the same.

Data analysis

All statistical analysis was undertaken using SPSS software (version 10). To determine whether a pass/fail in the TrA isolation test and a pass/fail in the lumbo-pelvic stability test were associated with a particular group, an extended χ^2 test was performed using cross tabulation at a significance level of 5%.

Results

The ability of the Pilates group, abdominal curl group, and the control group to perform the TrA isolation test was determined using a PBU. The percentage of subjects from each group passing or failing this test was calculated (Fig. 1). Analysis of these results identified that ten subjects (83%) from the Pilates group, four subjects (33%) from the abdominal curl group, and three subjects (25%) from the control group passed this test. When all 36 subjects were analysed as a group using the PBU, less than half of the subjects (47%) passed the TrA isolation test. Therefore, 19 subjects (53%) were identified as having an inability to appropriately contract TrA.

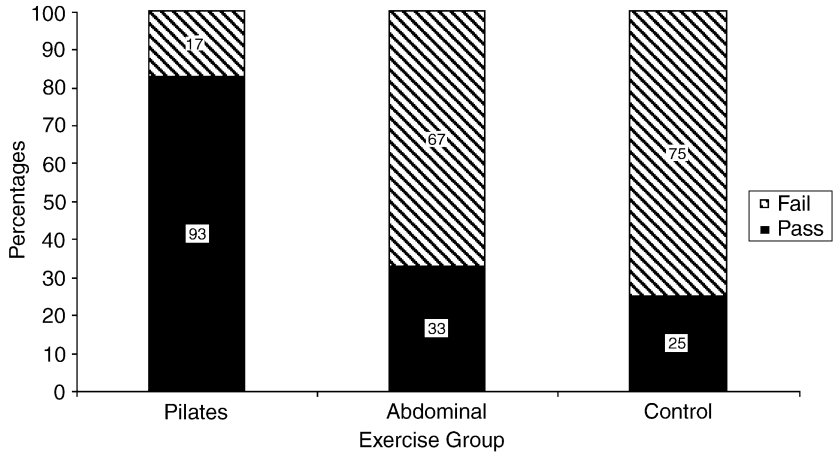

Figure 1 Percentages of the three groups passing or failing the TrA isolation test.

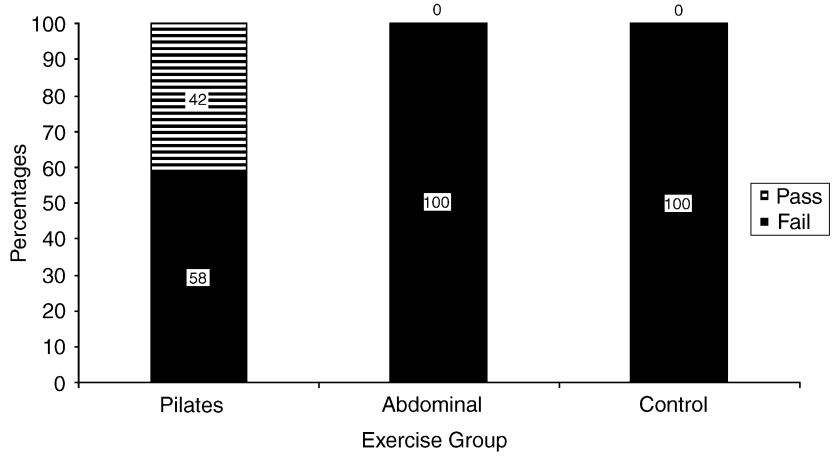

Figure 2 Percentages of the three groups passing of failing the lumbo-pelvic stability test.

The PBU was also used to test the ability of the three groups to perform the lumbo-pelvic stability test. The percentage of subjects from each group passing or failing this test was calculated (Fig. 2). Analysis of these results identified that only five subjects (42%) from the Pilates group passed, and all other failed this test. When all 36 subjects were examined performing the lumbo-pelvic stability test, it can be seen that just five subjects (14%) passed and 31 subjects (86%) failed this test.

The association between scoring a pass/fail in the TrA isolation test and the three groups was determined using Fisher's Exact test, a significant relationship existed when tested at the $P \leqslant 0.05$ level of significance. ($\chi^2 = 9.406$, $P = 0.011$). When the possible association between a pass/fail in the lumbo-pelvic stability test and the three groups was explored using Fisher's exact test at the $P \leqslant 0.05$ level of significance, strong evidence for contingency also existed. ($\chi^2 = 9.031$, $P = 0.006$).

Discussion

As a clinical measurement tool identifying TrA muscle contraction and lumbo-pelvic stability in asymptomatic subjects, the PBU detected significant differences between the Pilates trained, abdominal curl trained, and control groups. This suggests that the type of exercise undertaken was significantly associated with the ability to perform these tests in asymptomatic individuals. The statistical analysis however, did not show where the differences lie, but it appeared that the Pilates group performed best in terms of the number of subjects passing both tests.

TrA isolation test

It has been advocated that the prone lying TrA isolation test can accurately classify subjects into

LBP and painless groups in 80% of subjects (Hodges et al., 1996). There is though an inconsistency in the literature regarding what a normal pressure reduction response is during this test. When Hodges et al. (1996) tested a group of subjects, by classifying normal as a change greater than or equal to 4 mmHg, 33% of non-LBP subjects were deemed as having a TrA dysfunction. When using the guidelines by Richardson and Jull (1995) however, who consider this to be a 6–10 mmHg change, dysfunction was found in 44% of the non-LBP subjects from the same study. In a more recent study by Cairns et al. (2000) using the same test, the level of correct classification (59.9%) which did not reflect the high levels obtained (80%) in the study by Hodges et al. (1996). In the present study the TrA isolation test identified 52.7% of all subjects with an incorrect TrA contraction as measured by the PBU, which supports the findings of Cairns et al. (2000) and the adjusted figures of Hodges et al. (1996).

Recruitment patterns of the abdominal muscles have been shown to change depending on type of training undertaken. An abdominal hollowing action has been shown to give muscle activity suitable for lumbo-pelvic stability (Richardson et al., 1990), and has the ability to dissociate activity in the TrA and internal oblique muscles from that of the rectus abdominis (Richardson et al., 1992). Furthermore, when either an abdominal hollowing or gym exercise including abdominal curl activities was performed over a 10-week programme, rectus abdominis EMG activity increased in the abdominal curl group (O'Sullivan et al., 1998). In the present study, the rectus abdominis muscle may have substituted for the deep abdominals in the 66% of abdominal curl training subjects who failed the TrA isolation test. Therefore this may be due to a motor learning recruitment of the rectus abdominis, and not due to a TrA dysfunction. This should be considered in further research.

It is evident from the present study that 83% of the Pilates subjects passed the TrA isolation test, while just 33% from the abdominal curl group, and 25% from the control group passed this test. This supports the view that Pilates trained subjects incorporate higher levels of deep abdominal muscle activity than abdominal curl trained or untrained subjects. Therefore this activity may be useful for maintaining the stability function of the deep abdominal muscles, but requires further study.

The lumbo-pelvic stability test

Eighty-six per cent of subjects in this study demonstrated poor lumbo-pelvic control. These findings indicate that the deep stabilizing muscles may not be optimally recruited in asymptomatic individuals. The results of this test propose that the Pilates group, where five subjects passed, performed better than the other two groups where all subjects failed. In Pilates the onset of the limb load is predictable, and therefore the body anticipates the load and a pre setting of the TrA could occur (Norris, 2001). A pre-requisite of ability to perform an abdominal setting action was required in previous studies (Jull et al., 1993), which may have enhanced the subject's automatic muscle support through a learning effect. Therefore, due to the Pilates subjects having a pre-requisite ability to perform this manoeuvre, a motor learning effect may have occurred in the 42% of Pilates trained individuals who passed this test.

Several researchers advocate that dysfunction of the TrA muscle may relate to lumbo-pelvic instability and therefore, the incidence of LBP (Richardson et al., 1992; Jull et al., 1993). Although muscle recruitment strategies stabilizing the lumbar spine are individual (Cholewicki et al., 1997), a dysfunction in the recruitment of TrA in the current study does not appear to indicate pathological level of lumbo-pelvic instability, as the subjects were asymptomatic. This inability to control lumbo-pelvic motion under load though, may predispose the individuals to future spinal pathology or indicate that asymptomatic individuals do not require this level of control for their activities of daily life and requires further study. The variability in facilitating a correct TrA contraction across groups proposes that some asymptomatic individuals may have difficulty in gaining a perception of the required contraction. This indicates that a dysfunction in automatic motor control of stability may be present in non-lower back pain population. Therefore, all subjects, including those who are Pilates trained, may need specialized training in learning the correct TrA contraction in order to achieve lumbo-pelvic stability. The findings of this study may also indicate that though these tests have previously been shown to be specific, that is, have consistent results within a pathological population (Richardson et al., 1992; Hodges et al., 1996; O'Sullivan, 2000), they lack sensitivity.

Conclusion

The ability to perform a correct TrA contraction and maintain lumbo-pelvic stability was measured in 36 female subjects from an asymptomatic population

using a PBU. The PBU demonstrated that Pilates trained subjects could contract the TrA, and maintain better lumbo-pelvic control than to those who perform regular abdominal curl exercises, or no abdominal muscle exercises.

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