This review formed part of Jill Depledge’s MHSc thesis at AUT University

**Treatment of symphysis pubis dysfunction**

**Introduction**

A review of the literature revealed relatively few scientific studies investigating the effectiveness of treatment of peripartum pelvic joint pain, and no studies looking at primarily symphysis pubis pain. Generally, posterior pelvic pain has been considered to be the primary symptom of pelvic joint instability. According to Fry (1999), treatments for symphysis pubis dysfunction during pregnancy include education about the condition, appropriate advice regarding function and rest, pelvic support, crutches, pain relief, ice and exercises to improve muscular support for the unstable pelvis.

The evidence presented in this Review suggests that treatment of symphysis pubis dysfunction and associated problems be largely directed towards regaining pelvic stability. The areas where there is some research on the treatment of pelvic joint problems, in particular sacroiliac joint pain, during the perinatal period are the use of pelvic support belts, exercise and advice based treatments. A review of individual studies will be considered, divided into those investigating the use of pelvic support belts and those involving exercise and advice based treatments.

**Pelvic support belts**

In the literature reviewed, which was from a search of Medline, CINAHL, AMED and the Cochrane library, no studies were identified that have investigated the effect of wearing a pelvic belt to treat symphysis pubis pain, nor have any studies specifically investigated the effect of wearing a belt on posterior pelvic pain. However, one randomised controlled trial looking at the effects of different treatments on pain and functional activities in pregnant women with pelvic joint pain did give belts to all groups. Nilsson-Wikmar et al. (1998) recruited women who tested positive for at least three pain provocation tests for pain in the area of the pelvic joints
and tested negative for pain in the lumbar spine area. In total there were 118 subjects. The women were randomised into three treatment groups. Group 1 received a non-elastic sacroiliac belt and information about their condition. Group 2 received the same as group 1 plus a home training and stretching program (not detailed) and group 3 received the same as group 1 plus medical training therapy using special (unspecified) training equipment in order to improve strength and posture. The treatment time and duration was not specified. The women rated pain intensity and 12 different functional activity items on visual analogue scales initially, and were then requested to complete a questionnaire including questions about pain and functional activities every five weeks of the pregnancy and at 38 weeks of pregnancy, as well as three, six and 12 months postpartum. The results showed no statistically significant differences between the three groups at baseline and week 38 of the pregnancy with respect to pain intensity and functional activities. In their conclusion, the authors stated that the belt and information about the condition (which all groups received) seemed to be important regarding the reduction of pain intensity and the ability to accomplish the different functional activities. The small amount of information included in the analysis of this study made it difficult to follow the procedures undertaken and therefore accept the results with any degree of confidence.

Ostgaard et al. (1994) undertook a randomised clinical trial investigating the prevention of back problems in pregnant women by education relating to back care. These researchers randomly gave non-elastic pelvic support belts to 59 women who developed posterior pelvic pain and who were also receiving either individual or group back care education. They found that 83% of these women experienced reduced problems when wearing the belt, 12% experienced no relief and 5% were worse. However, as a result of wearing the belt, none of the women experienced any pain reduction at work or at rest, and sick leave from work and pain intensity in general did not decrease as measured by visual analogue scales. The authors concluded that the use of a non-elastic sacroiliac belt reduced posterior pelvic joint problems in a large majority of the women.

Other studies commenting on the effectiveness of pelvic belts in treatment of pelvic joint pain have been questionnaire type studies. In a retrospective questionnaire study of Dutch women with peripartum pelvic pain Mens et al. (1996) reported that a pelvic belt was effective in the treatment of this condition, but was less effective
during pregnancy than after delivery. About half of the pregnant patients experienced some relief with the belt, and two-thirds had relief from pain after pregnancy when wearing a belt. These authors commented that in some patients (no figures given), the application of a belt led to increased pain.

Based upon a prospective questionnaire study Berg, Hammar, Moller-Nielson, Linden, & Thorbold (1988) found that of 54 pregnant women with low back pain who used a rigid trochanteric belt, 39 experienced relief during its use. They did not state whether these women also received other treatment, or the degree of relief that they experienced.

**Exercise and advice based treatments**

The prescription of specific exercises and administration of advice on how to modify daily activity and to avoid difficult positions is commonly used to treat pelvic joint problems during pregnancy including symphysis pubis dysfunction. As with the literature concerning belts there is no research investigating symphysis pubis dysfunction alone.

Back care advice given as a group and individually was compared by Ostgaard et al. (1994). This study involved recording the development of back or posterior pelvic pain in 407 pregnant women who registered their pregnancy at one maternity-care unit. One third were offered a back school education and training programme modified for pregnant women in the form of two 45 minute classes taken by a physiotherapist before the 20th week of pregnancy. The class included simple anatomy, posture, physiology, lifting and working technique, muscle training and relaxation training. Another third received the same education but in a different format. In this case the education was given individually and for a longer period (five 30 minute lessons from weeks 18 to 32). These women were also given an individualised training programme to undertake at home three times a week. The final third were controls and received no back care input. Symphysis pubis pain was not considered important in this study because “it is of little diagnostic and prognostic value”; and because the authors believed that due to the anatomy of the pelvis, symphyseal pain can not exist without posterior pelvic problems, “although these may
be minor” (Ostgaard et al., 1994). Hence only posterior pelvic pain and back pain was recorded. Posterior pelvic pain was measured by a standardised examination protocol investigating the history of pain, a pain drawing, a positive posterior pain provocation test, free movements in the hips and spine, the absence of nerve root syndrome, and pain when turning in bed. Back pain included pain from the lumbar region only, with or without radiation to the legs. Questionnaires regarding pain and sick leave from work were completed during the 36th week. The study found that 47% of all women developed back pain or posterior pelvic pain (the latter being four times as common as the former). The two experimental groups found that the information on muscular training and body posture reduced pain, and the women in the group receiving individual tuition additionally found the information on ergonomics and vocational techniques useful. Total sick leave was significantly decreased in the individual exercise group compared with the control group, but there was no difference in sick leave for the group education group compared with controls. Pain intensity did not differ amongst the three groups during pregnancy but was decreased in the individual exercise group at eight weeks postpartum. The authors concluded that an individually designed programme (rather than the group programme) was most effective in reducing sick leave during pregnancy.

Group back care advice without any other treatment was also given to a group of 85 women in early pregnancy by Mantle et al. (1981). The number of women who experienced “severe” or “troublesome” backache (assessed by questionnaire) was compared with the rates of back problems in 90 women who received no back care advice. The experimental group attended two informal sessions (with up to six women in each) consisting mainly of ergonomic advice adapted to pregnancy. Back care was related to individual occupation and circumstances, however no specific abdominal exercises were taught. Back pain was discussed and simple methods of relieving it outlined. The same information was given in both sessions. Most women were first seen between ten and 15 weeks of pregnancy. A very large number (40%) of the experimental group did not, despite having previously stated they would like to, attend any classes. They found that 68% of the women in the experimental group (whether they actually attended back care classes or not) experienced mild backache, and 32% experienced moderate backache compared to 46% mild and 54% moderate backache in the control group. The greater number of women experiencing moderate backache in the control group was significant \(p<0.01\). However, it should be noted
that back pain during pregnancy was evaluated a few days postnatally which may have had some effect on results. Their conclusion was that the availability of back care classes to women (whether they attended them or not) in early pregnancy resulted in significantly less backache during pregnancy.

Noren et al. (1997) analysed the impact of an individual-based treatment program on sick leave for low back or posterior pelvic pain during pregnancy. The intervention group consisted of 54 women with posterior pelvic or low back pain (mostly posterior pelvic pain), all of whom were registered at one antenatal clinic. A similar antenatal clinic recruited 81 women, also with posterior pelvic or low back pain for the control group. The intervention group was offered five physiotherapy sessions where they received an individually designed programme, which included education, anatomy, posture training, pelvic floor exercises and relaxation training. They also received an individual exercise programme designed for pain type and intensity. Pain intensity was only significantly less at the first visit (mean maximum VAS 7.3) compared to week 36 (mean 6.3). However sick leave in the intervention group (mean: 3.1 occasions for 33 of the women with a total average of 30.4 days per woman) was significantly lower than the control group (mean: 3.3 occasions for 45 women on sick leave with a total average of 53.6 days per woman). The conclusion drawn by Noren et al was that sick leave for posterior pelvic or low back pain was significantly reduced in the intervention group, resulting in a large economical gain when cost of sick leave was compared with cost of physiotherapy.

Specific exercises to prevent back pain during pregnancy were given to 65 women volunteers by Dumas et al. (1995). One group of women (by their own choice) were enrolled in exercise classes which were aimed at preventing or reducing back pain during pregnancy by specific exercises and promoting good posture. The other group acted as sedentary controls. The authors aimed to determine whether there was a difference in the level of function and incidence of back pain between the two groups. Functional limitations were assessed by a questionnaire with a list of ten activities and a three point rating scale. There was no statement as to the reliability and validity of this questionnaire. In terms of functional activities, both groups ranked maintaining prolonged standing or sitting posture and load-bearing activities such as lifting and carrying as the most difficult. The results showed no significant difference between groups in terms of functional limitation. In the exercise group, 78% complained of
moderate or severe pain at least once during their pregnancy compared with 81% of the control group. There was no significant difference between the groups.

Wedenberg et al. (2000) compared the effects of physiotherapy with acupuncture for treatment of low back and pelvic pain during pregnancy. Sixty women were randomly assigned to acupuncture or physiotherapy groups. “Physiotherapy” consisted of treatment once or twice a week, totalling ten treatments in six to eight weeks. This treatment was very wide ranging and included advice on daily activities, ergonomics, correction of faulty posture and how to perform physical exercises according to a home training programme (although these were not described). Treatment was individualised and may have included the use of a pelvic belt, heat, soft tissue mobilisation and massage. “Acupuncture” involved ten treatments in one month. All 30 women in the acupuncture group completed the treatment but there were 12 dropouts from the physiotherapy group. Pain was measured using a visual analog scale (VAS) from zero to ten in the morning and evening. The mean scores for the acupuncture group were significantly lower after treatment both in the morning and in the evening, and in comparison with the physiotherapy group. However in the physiotherapy group, before-after treatment difference was significant in the evening (6.6 vs 4.5 p<0.01) but not in the morning (3.7 vs 2.3). The Disability Rating Index values were significantly less after treatment in the acupuncture group compared with baseline values and with physiotherapy group values. The authors concluded that acupuncture relieved back pain and diminished disability in low back pain during pregnancy better than “physiotherapy”.

Postnatal pelvic pain was studied by Mens, Snijders, & Stam (2000) in a randomised clinical trial which investigated whether graded exercises to strengthen the diagonal trunk muscles were effective in treating postnatal pelvic pain in 44 women with both anterior and posterior pelvic joint pain. Women were assigned to one of three groups, the first of which received strengthening of the diagonal trunk muscles (internal and external obliques, latissimus dorsi, gluteus maximus and multifidus); and the other two of which acted as control groups - one strengthened longitudinal trunk muscles systems and the other did no exercise. All groups were also given instructions on ergonomics, on how to behave if activities caused pain, and on how to use a non-elastic pelvic belt. All instructions for the study were given by video tape. All groups were treated for eight weeks. Measurements used were pain (100mm horizontal
VAS), fatigue (100mm horizontal VAS), perceived general health (Nottingham Health Profile) and mobility of the pelvic joints (by posterior pain provocation test and radiographically using the Chamberlain technique). The results showed that after eight weeks, 63.6% overall improved but there was no significant difference between the three groups, and thus the authors concluded that treating patients with persistent pelvic joint pain six weeks to six months after childbirth by training of the diagonal trunk muscle systems had no value beyond that achieved with instructions and the use of a pelvic support belt without exercises (Mens et al., 2000). Interestingly 25% were unable to do the training because of pain or fatigue, and most of these attributed the pain to the exercise aimed at strengthening the hip extensors (raising the lower extremity in prone lying). The authors of this study suggested that exercises for low back and pelvic pain may exacerbate symptoms by loading of the spinal and pelvic structures.

A final consideration is the work of Deyo (1993) who has suggested with respect to back pain that there are a number of factors other than the actual treatment provided that can influence any improvement noted. These included the placebo effect and an attention effect where there may be improvement noted as a result of attention and concern from researchers and the enthusiasm and conviction of an investigator. Deyo also stated that there is a trend for back pain to improve regardless of therapy, and finally he referred to the concept of “regression to the mean” which suggests that therapists tend to see patients when their symptoms are at their worst, and that, left to their own devices most will return to a more typical level of pain.

**Rationale for treatment of symphysis pubis dysfunction**

**Introduction**

There are several theoretical reasons for improvement in the symphysis pubis with treatment. These will be considered in this section. Firstly, the use of exercise and support belts may have an effect on the various receptors present in the skin, joint or muscle. This may be in the form of a decrease in the firing of nociceptors resulting in a decrease in pain, or an alteration in proprioceptive input to the central nervous system by changing the input of muscle, joint or cutaneous receptors, giving the
woman a better awareness of her movement patterns. Pain may also be reduced if it has an inflammatory component and there is decreased stimulation of chemical nociceptors due to less movement of bone ends as the joint is stabilised.

The increased stability achieved could be attributed to neural adaptation as a result of the muscle strengthening programme. This may be significant in improving function by allowing appropriate muscles to be activated or inhibited and thus increasing mechanical stability. Improvement in stability may also be due to motor relearning where local stability muscles are trained to be activated prior to larger global muscles. This concept will be discussed. Finally mechanical studies investigating the effectiveness of belts in decreasing movement will be reviewed.

**Joint receptors, pain and proprioception**

**Joint receptors**

In order for information to be transmitted from the joints, muscles and skin to the central nervous system, receptors located in these structures must be stimulated. A knowledge of the types of joint, muscle and cutaneous receptors in the area of the symphysis pubis is therefore necessary to gain some understanding into how messages to the central nervous system are altered when changes occur in the tissues in this area. A search of Medline, CINAHL and AMED found no studies investigating the presence of receptors in the symphysis pubis, so it was decided to investigate the nearby areas of the spine and sacroiliac joints to determine what receptor types might be found in the region of the symphysis pubis. Studies examining the distribution and population of receptors in the lumbar spine and sacroiliac joint structures have identified numerous mechanoreceptors and nociceptors in spinal structures (Yamashita, Cavanaugh, El-Bohy, Getchell, & King, 1990; Yamashita, Minaki, Oota, Yokogushi, & Ishii, 1993; Grob, Neuhuber, & Kissling, 1995; Roberts, Eisenstein, Menage, Evans, & Ashton, 1995; McLain & Pickar, 1998; Sakamoto, Yamashita, Takebayashi, Sekine, & Ishii, 2001; Sekine et al., 2001).

The intervertebral joint was of particular interest since this joint is also a symphysis type joint. The intervertebral disc is recognised as being innervated and responsible for back pain, however the exact relationship between these two factors is not fully
understood (Roberts et al., 1995). In human thoracic and lumbar discs, and attached anterior longitudinal ligaments obtained from patients undergoing anterior fusions for low back pain and scoliosis, Roberts et al. (1995) investigated the occurrence and morphology of mechanoreceptors. They found that there were mechanoreceptors in the outer 2-3 lamellae of the intervertebral disc and anterior longitudinal ligament, with a greater incidence of mechanoreceptors in those patients with low back pain than in pain-free patients with scoliosis. These resembled Pacinian corpuscles, Ruffini endings and Golgi tendon organs. They concluded therefore that these structures could provide individuals with sensation of position, movement and possibly pain. Also in the intervertebral joint somatosensory units of the lumbar intervertebral disc and adjacent muscle in rabbits were studied by Yamashita et al. (1993). Receptive fields of mechanosensitive afferent units were investigated and electrophysiologic recordings obtained from filaments of the dorsal root. Thirteen units were identified, three in the intervertebral disc and the remaining ten in psoas muscle. They concluded that the units in the disc area may serve as nociceptors sensitive to strong noxious stimulation, and the units in the psoas muscle may contribute to nociception and proprioception.

Following an investigation of the lumbar region of cats, Sekine et al. (2001) suggested that the lumbar posterior longitudinal ligament may be one of the origins of low back pain. These authors used an electrophysiologic technique to show that all units identified in the lumbar posterior lumbar ligament had low conduction velocities (group III or IV) and high mechanical thresholds (>7.0g) and were therefore thought to be capable of serving a nociceptive function.

Studies of the lumbar facet joint were sought to determine whether pain could result from receptors in this area. Yamashita et al. (1990) studied the lumbar facet joint of 24 adult male rabbits. They identified 24 mechanosensitive afferent units in the region of the facet joint, ten in the joint capsule, 12 in the border regions between capsule and muscle or tendon, and two in the ligamentum flavum. Most of these units were group III, indicating that the facet joint is mainly innervated by small, myelinated fibres, some of which may conduct nociceptive sensations. There were also group IV mechanosensitive afferent units of varying thresholds. High threshold units may serve as nociceptors and low threshold units may serve as proprioceptors, so they concluded that the facet joint may be a source of low back pain and was
capable of conveying proprioceptive information. These above mentioned receptors were also found to be present in human lumbar facet joint capsules by McLain & Pickar (1998) who investigated the extent of mechanoreceptor innervation in healthy human lumbar and facet joint capsules from one healthy donor (who died in a motor vehicle accident), and from uninjured facet joints of patients treated for spinal fractures. These authors found a small number of encapsulated nerve endings in the facet joints of the lumbar and thoracic spine, which they believed to be primarily mechanosensitive and possibly able to provide proprioceptive and protective information to the central nervous system regarding joint function and position.

Finally, the receptors in the sacroiliac joint were considered worthy of investigation due to the close relationship of these joints to the symphysis pubis. Sakamoto et al. (2001) investigated the somatosensory afferent units in the sacroiliac joints of cats. Ten cats (under anaesthesia, L4-7 laminectomy performed and L4-6 dorsal roots cut at their proximal ends) had their sacroiliac joints and adjacent tissues probed to search for mechanosensitive units. Twenty-nine discrete mechanosensitive units were identified, 26 of these were in the posterior sacroiliac ligament and the remaining three in the adjacent muscles. Sixteen units were also identified in the proximal third of the sacroiliac joint. Most of the units in the sacroiliac joint were high-threshold group III units that may have a nociceptive function, suggesting that the sacroiliac joint itself may be a source of lower back pain. Grob et al. (1995) investigated the innervation of the human sacroiliac joint in cadavers. Besides determining how the joint was innervated these authors found numerous thick myelinated, thin myelinated and unmyelinated nerve fibres compatible with a broad repertoire of sensory receptors including encapsulated mechanoreceptors.

The above studies have shown that receptors in the lumbar spine and sacroiliac joint regions of humans and animals have been found in joint capsules, ligaments, muscles and intervertebral discs. The receptor types include high and low threshold units, indicating that both nociceptive and proprioceptive information can be transmitted via these structures. Hence it would seem that the sacroiliac, lumbar facet and intervertebral joints are structures capable of producing pain when noxious stimuli are applied, and of transmitting proprioceptive information to the central nervous system. Whether the symphysis pubis has similar receptors is unknown but based on studies
of surrounding and similar joints, it may have the potential to evoke pain and provide information on proprioception.

Pain

Siddall & Cousins (1995) have described two types of pain. Nociceptive pain is due to stimulation of somatic or visceral nociceptors by a noxious stimulus and neuropathic pain is due to damage or disease of the peripheral or central nervous system. These two types of pain (nociceptive and neuropathic) together with psychological and environmental factors can contribute to perceptions of discomfort either on their own or in any combination.

In the case of nociceptive pain, the central nervous system receives information from receptors located in the peripheral tissues. Different receptors respond to different, specific stimuli and Meyer, Campbell, & Raja (1994) reported that from these receptors highly specialised sensory fibres provide information to the central nervous system about the environment and the state of the organism itself. According to Johansson & Sjolander (1993) traditionally joint afferents are classified into four different groups according to fibre diameter and conduction velocities. The fibres with the greatest diameter and therefore the greatest conduction velocities are type I fibres. Those with the smallest diameter and slowest conduction velocity are type IV fibres. In synovial joints, four types of articular mechanoreceptors have been identified - Ruffini corpuscles, Pacinian corpuscles, Golgi tendon organlike (GTO like) corpuscles and free nerve endings. There is considerable overlap between the connection of fibres to these receptors but in pure joint nerves group I fibres mostly come from GTO like endings, group II fibres from Pacinian corpuscles and Ruffini endings, and group III and IV afferents from free nerve endings (Johansson & Sjolander, 1993). Articular sensory endings respond differently to different stimuli, so that the sensory system within the articular tissues can detect noxious stimuli and chemical agents. Furthermore, by relaying information related to strain in tissues, they provide the central nervous system with information about speed, acceleration, position and direction of joint movements (Johansson & Sjolander, 1993). Types I to III receptors (from Type I to II afferents) are involved in joint proprioception and movement, whereas type IV receptors, also known as nociceptors, are receptors for pain. Johansson & Sjolander (1993) reported that nociceptors are widely distributed
throughout the articular tissues and are usually activated by abnormal mechanical deformation or contact with certain chemical agents or inflammatory mediators such as histamine, bradykinin and prostaglandin, but remain inactive under normal circumstances. Jessell & Kelly (1991) described nociception as the reception of signals in the central nervous system evoked by activation of nociceptors. Thermal or high-intensity mechanical nociceptors have small diameter, thinly myelinated A delta fibres. These are mainly superficial nociceptors but have been found in deep tissues as well (Bowsher, 1994). Polymodal nociceptors are activated by a variety of high intensity mechanical, chemical and hot or cold stimuli and have small diameter, unmyelinated C fibres that conduct slowly. Silent nociceptors are described by Siddall & Cousins (1995) as unmyelinated primary afferent neurons that do not respond to excessive mechanical or thermal stimuli under normal circumstances, however in the presence of inflammation and chemical stimulation they then become responsive and discharge vigorously even during ordinary movement.

Once the nociceptive input is perceived, Cavanaugh (1995) described the pain pathway as follows. The action potential generated at the nociceptor continues up the axons of small C or A-delta fibres and into the dorsal horn of the spinal cord where the first synapse is made. The most important pain projection pathway to the brain is the spinothalamic tract, and in most cases the message continues up the anterolateral spinothalamic tract to the thalamus where another synapse is made and the message continues on to the somatosensory cortex of the brain. There is then a contribution of descending pain inhibitory pathways which are affected by multiple environmental factors including nociceptive inputs, physical stress, anxiety, depression and emotional distress (Abram, 2000).

Sensitisation of nociceptors may result from injury or inflammation as a result of local tissue damage. The ensuing release of a variety of chemical mediators (including 5-hydroxytryptamine, histamine and bradykinin) decreases the threshold and sometimes activates nociceptors. Meyer et al. (1994) reported that sensitisation can be seen in all types of afferent fibres. This may take the form of afferent activation by movements in the working range, activation by pressure, or an induction or increase in resting discharges, and results in sensitisation of silent nociceptors and those that usually respond to pressure and not movement. Repeated applications of noxious mechanical stimuli do not decrease the threshold of nociceptors, however they can sensitise
nearby nociceptors that were previously nonresponsive to mechanical stimuli (Jessell & Kelly, 1991). Sensitisation results in hyperalgesia which means that even slight motion of the joint leads to pain (Meyer et al., 1994). Jessell & Kelly (1991) suggested that this phenomenon may involve a lowering of nociceptor threshold or an increase in the magnitude of pain evoked by a suprathreshold stimulus. Secondary hyperalgesia involves the undamaged areas surrounding the site of tissue damage having enhanced sensation of pain in response to subsequent stimuli, which may be due to sensitisation of central nociceptor neurons as a result of sustained activation.

There may be an inflammatory component to pain produced at the symphysis pubis. Schaible & Schmidt (1985) have showed in animal models of arthritis that some mechanoreceptors can become more sensitive to mechanical stimuli in inflamed joints compared with normal, non-inflamed joints. In this case if there were mechanoreceptors and inflammation present in the region of the symphysis pubis, it would provide an opportunity to cause an abnormal response to a normal stimulus. Saal (1995) described an approach to the role of inflammation in lumbar pain. He suggested that there is a strong theoretical basis to support the concept that the clinical features of many lumbar disc pain patients may be explained by inflammation caused by biochemical factors alone or combined with mechanical deformation of lumbar tissues, rather than mechanical factors alone.

The lack of literature available in the specific region of the symphysis pubis means it is not possible to determine exactly how the pain here is perceived, however the presence of mechanoreceptors and nociceptors in surrounding regions suggests that the pain may be produced by stimulation of mechanosensitive and chemically sensitive nociceptors as a result of hypermobility of the joints, with the ongoing increased movement of bone ends resulting in ongoing pain, possibly due to sensitisation of nociceptors.

**Proprioception**

McNair (2000) suggested that having a greater awareness of where ones body segments are in space when performing daily activities might be beneficial, and could theoretically decrease the likelihood of injury. Proprioceptive organs exist in
muscles, skin and articular tissues, which respond to static or dynamic changes occurring through positioning, motion, vibration or pressure (Edin, 1992). Their relative importance is debated and most work has focused on muscle and joint receptors. In terms of treatment of symphysis pubis dysfunction, proprioceptive awareness may be increased by the effect of the exercises on the muscle spindles, the mechanical effect of the exercises or belt on joint position and therefore joint receptors, or the effect of the belt on the skin. There is, however, no research-based support for this conjecture.

As the studies of receptors mentioned previously have indicated, damage to joints may result in damage to receptors which usually provide information to the central nervous system about proprioception. In a review of proprioception, Laskowski, Newcomer-Aney, & Smith (2000) emphasised the importance of this concept in the prevention of and recovery from injury. These authors concluded that proprioception played a significant role in the afferent-efferent neuromuscular control arc, and that this control arc was disrupted with joint and soft tissue injury. Restoring proprioception after injury allowed the body to maintain stability and orientation during static and dynamic activities.

As no work has been found specifically in the area of the pelvis in terms of the possible role of proprioception, particularly related to instability of joints, an investigation of the role of proprioception in other joints may give some insight. Mallik, Ferrell, McDonald, & Sturrock (1994) examined 12 patients with hypermobility to establish whether they showed any impairment of proprioception. Subjects were required to match a finger silhouette with the kinaesthetically perceived position of their hidden index finger. At the proximal interphalangeal joint position sense was found to be significantly (p<0.0001) impaired in hypermobile subjects compared with age and sex matched controls. These authors concluded that it is not clear whether this impairment of proprioception is a cause or an effect of the hypermobility. Hall, Ferrell, Sturrock, Hamblen, & Baxendale (1995) showed similarly, using ten female subjects, that the proprioceptive acuity of subjects with hypermobility in the knee is less sensitive than subjects with normal joints. These studies indicate a possible relationship between instability and loss of proprioception. Based upon this premise, it may be that pregnancy related laxity of the joints causes instability and therefore decreased proprioceptive awareness. Bullock-Saxton (1998)
has suggested that the increased mobility in the symphysis pubis joint during pregnancy is likely to have significant influences on the afferent input to the spinal cord and higher cortical centres.

There is controversy concerning the importance of joint receptors in providing information concerning proprioception. Some researchers strongly advocate their importance. For instance in the index finger, Ferrell & Craske (1992) applied a digital nerve block to the proximal interphalangeal joint. In this condition, subjects consistently perceived their finger to be in the mid-position irrespective of its actual position, thus indicating that receptors within the joint provide valuable information to the central nervous system. However not all work supports joint receptors as being of such importance. Burke, Gandevia, & Macefield (1988) used microneurographic techniques to record activity from finger joint receptors of six human subjects. They found that the majority of the receptors responded only towards the limits of joint rotation and they had a limited capacity to signal the direction of joint movement. These authors concluded that human joint receptors have a very limited capacity to provide kinaesthetic information, and that this is likely only to be significant when muscle receptors can not contribute to kinaesthesia. During pregnancy it is likely that the muscles, which may have been affected directly by the presence of relaxin and/or biomechanical changes, have a role in proprioceptive awareness.

Treatment of instability in any joint frequently involves bracing. This may involve an increase in proprioceptive awareness, so that the wearer has an increased knowledge of position and motion sense. The effect on proprioception of bracing the lumbar spine in healthy individuals (with no history of back pain) was studied by McNair & Heine (1999). Forty subjects were asked to perform a position matching task where they flexed the spine in the sagittal plane until asked to stop, and then repeated the exercise in an attempt to match the original position. Each subject was tested with and without a neoprene support brace. The results showed that errors were decreased when wearing a brace, particularly for those individuals who had less ability to match trunk position without a brace, that is, poorer proprioceptive ability.

Newcomer, Laskowski, Yu, Johnson, & An (2001) used 20 subjects with chronic low back pain and 20 controls to determine whether a lumbar support improved proprioception. They measured the trunk repositioning error after subjects were
asked to replicate predetermined target positions of the trunk. Testing was performed with and without a lumbar support both before and after wearing the support for two hours. The results showed that the lumbar support significantly decreased repositioning error in subjects with low back pain in three out of four directions. In controls, there was an improvement with the support in only one of the four directions.

With respect to skin, the work of Edin & Abis (1991) has demonstrated that this can function as a proprioceptive organ. In their study the role of the skin receptors in proprioception was studied in the human hand by examining these receptors in the radial nerve during index finger movements and during pinching. The results showed that a large majority of these units were sensitive to movement, indicating that dorsal skin receptors could supply the central nervous system with accurate information about joint movements. These authors concluded that cutaneous mechanoreceptors in the dorsal skin could provide the central nervous system with detailed kinematic information, at least for movements of the hand.

Researchers, for example McNair, Stanley, & Strauss, (1996), examining peripheral joints such as the knee have noted that neoprene braces cannot provide a large amount of mechanical stability and have therefore suggested that the brace provides stability indirectly by increasing awareness of joint position, most likely by the stimulation of skin receptors. In the absence of any research investigating the proprioceptive effect of pelvic belts, it can be hypothesised that any functional improvement noted after the application of a pelvic support belt for pain during pregnancy may be partly due to the increased sense of proprioception when cutaneous receptor input is increased by the presence of a belt against the skin.

**Joint stability**

**Neural adaptation to strengthening exercises**

The ability of muscle strengthening exercises to improve mechanical stability over a short period of time warrants attention. Changes in muscle strength and performance depend not only on the size of the involved muscles but also on the ability of the
nervous system to appropriately activate the muscles (Sale, 1988; Moritani, 1993). Carroll, Riek, & Carson (2001) suggested that many elements of the nervous system exhibit the potential for adaptation in response to resistance training, including supraspinal centres, descending neural tracts, spinal circuitry and the motor end plate connections between motoneurons and muscle fibres. The adaptive changes in the nervous system that enhance strength and power performance in response to training are referred to as neural adaptation (Sale, 1986; Moritani, 1993).

Carroll et al. (2001) undertook a review of experimental trials in order to provide evidence that resistance training is likely to cause adaptations in the various neural elements involved in the control of movement, and is therefore likely to affect movement execution during a wide range of tasks, not just those that have been used during training. This concept is called transfer of learning. These authors found two main areas involved in movement control after strength training. Firstly, the manner in which the individual muscles are activated by the central nervous system. During a trained task the muscles are controlled more effectively, and this control may be transferred to use of the same muscles in functional tasks. Secondly, there is evidence that resistance training impacts upon co-ordination of groups of muscles, in particular the learned ability to decrease antagonist activity with strengthening of agonist muscle groups. This indicates that resistance training can induce adaptations that have the potential to either enhance or interfere with the performance of related tasks. Based on their review, Carroll et al reported that there was direct evidence that resistance training caused changes in synaptic efficiency within the motoneuron pool, and evidence that adaptations occur in various supraspinal motor centres that underlie motor learning. However, the precise nature of many of the neuromuscular responses to resistance training and the principles that allow transfer between this training and the transfer to other movements are still to be determined (Carroll et al., 2001).

Evidence for neural adaptation has also been reviewed by Sale (1986). One aspect of this evidence was the rapid initial increases in strength that occur, even after the first session of exercise, meaning that the improvement in strength is unlikely to be accounted for by muscular adaptation. Sale (1986) reported that EMG studies have provided the most direct evidence of neural adaptation to strength training, including the finding that voluntary strength increases without increases in muscle size. Moritani (1993) reported that increasing strength is commonly seen in daily or weekly
retesting of muscle strength after beginning a strength training programme, and that even after several weeks of training there may be significant improvement in strength without a measurable change in girth. The possible mechanism of neural adaptation has been suggested by Sale (1986) to involve the increased activation of prime movers, more appropriate co-contraction of synergists and increased inhibition of antagonists. Evidence for the former has been provided by EMG studies which have shown increased prime mover activation resulting from increased net activation of prime mover motoneurons. Therefore, by performing exercises an individual may better co-ordinate the activation of muscle groups so greater net force is achieved even without adaptation within the muscles themselves (Sale, 1986).

Instability and motor relearning

There are a number of similarities between instability in the pelvis and in the lumbar spine. Thus, in the absence of literature on pelvic instability, work focused upon the lumbar spine may be useful in giving an insight to problems in the pelvis. In the area of the lumbar spine, a significant number of people with chronic, disabling pain are given the diagnosis of lumbar segmental instability (Friberg, 1987). In this condition the loosening of the motion segment secondary to injury and associated dysfunction of the local muscle system renders it biomechanically vulnerable (O'Sullivan, 2000). Diagnosis is largely clinical, with radiological tests being of limited use as they are often insensitive and not reliable (Dvorak, Panjabi, Novotny, Chang, & Grob, 1991). Fritz, Erhard, & Hagen (1998) commented on the difficulty in defining segmental instability strictly in terms of increased joint laxity. These authors referred to the frequent disparity between joint laxity and the development of symptoms in other joints, and suggested that other factors such as neuromuscular control may influence the relationship between joint laxity and symptom development. In some spinal conditions, certain individuals are unable to compensate for an excessive amount of joint laxity, while other individuals with equal amounts of laxity are able to “cope” without substantial pain and disability (Fritz et al., 1998). As discussed earlier, in the pelvis during pregnancy it has been shown that the amount of instability does not correlate with the degree of symptoms suffered (Ostgaard, 1997; Bjorklund et al., 1999).
Panjabi (1992) described spinal instability as a significant decrease in the capacity of the stabilising systems of the spine to maintain intervertebral neutral zones within physiological limits so there is no major deformity, neurological deficit or incapacitating pain. The neutral zone is defined as the initial portion of the range of motion during which spinal motion is produced against minimal internal resistance (Fritz et al., 1998). Instability is more likely in the neutral zone and at low loads when the muscle forces are low (Cholewicki & McGill, 1996). Normally stability is maintained by co-ordinated muscle recruitment between the large (global) muscles and the smaller (local muscles). The concept of local and global muscles was suggested by Bergmark (1989) who hypothesised the presence of two muscle systems that act in the maintenance of spinal stability. The global muscle system consists of large torque producing muscles that act on the trunk and spine but do not directly attach to it. They therefore do not have a direct segmental influence on the spine. The muscles in the local muscle system directly attach to the lumbar vertebrae and are therefore able to directly control the lumbar segments and provide segmental stability. This concept may be transferred to the pelvis and similar principles applied. Similar muscles groups maintaining control over stability in the pelvis have been described earlier. Cholewicki & McGill (1996) suggested that in the lumbar spine muscle forces as low as 1-3% of the maximum may be sufficient to provide segmental instability. Hodges & Richardson (1996) showed that co-contraction of local system muscles resulted in a stabilising effect on the motion segments of the lumbar spine in normal subjects, with those with low back pain experiencing delayed action of these muscles. The action of these muscles, particularly within the neutral zone, usually provides a stable base upon which the global muscles can safely act.

In terms of management of lumbar segmental instability, O'Sullivan (2000) described a motor relearning model involving the specific training of muscles whose primary role is considered to be the provision of dynamic stability and segmental control to the spine (transversus abdominis, lumbar multifidus and the diaphragm). The faulty movement patterns in these muscles are identified and the muscles are retrained into functional tasks specific to the patient’s individual needs.

There is no research specifically investigating the mechanism behind the benefit of giving advice on the alteration of movement patterns in daily activities, however the principles being followed with giving this advice are those related to the activation of
local stability muscles prior to performing movements using the larger global muscles.

**Mechanical effect of belts**

The proprioceptive benefit of using a brace has been discussed previously. The other area which may be involved in the effectiveness of bracing is its ability to decrease range of motion or increase mechanical stability. In the pelvis, when force closure is insufficient to allow stability, this may be increased by means of a pelvic support belt, enhancing stability in all of the pelvic joints so that the muscular and ligamentous system is not required to exert so much force. Several authors have considered the biomechanical principles behind wearing a pelvic belt. Vleeming et al. (1992a) investigated the influence of pelvic support belts on the stability of the pelvis. They measured the effect of a 110 x 5 x 0.3 cm leather pelvic belt on nutation and counternutation in 12 sacroiliac joints of human cadavers, aged 83-97. Forces were applied to the acetabula to induce movement in the sacroiliac joints and movement was measured without a belt and with belts of 50N and 100N tension. They found that movement was significantly decreased in all subjects when wearing a belt, with no significant difference between the two belts. They concluded that a pelvic belt enhances pelvic stability because it reduces movement in the sacroiliac joints. The location of the belt rather than the force was emphasised. A location just proximal to the greater trochanter and caudal to the sacroiliac joints was best to increase force closure.

In another biomechanical study, Snijders et al. (1993) concluded that if a pelvic belt is worn with a small force (resembling the force tied in a shoelace) it will be sufficient to generate a self-bracing effect in the sacroiliac joints under heavy load. These authors proposed that the belt force acts like the ligaments and muscles acting to draw the ischium from lateral to medial, in particular, the line of action of the piriformis muscle is compared to that of the pelvic belt. The biomechanical model presented by these authors also indicated that the location of the belt must be just cranial to the greater trochanter and caudal to the sacroiliac joint. They suggested that a large belt force is not recommended because it can cause irritation and oedema and may actually be detrimental to the symphysis pubis by causing artificial compression, a
factor that is particularly important to consider when treating symphysis pubis
problems by stabilising the sacroiliac joints. A wide and pliable (but inextensible)
belt which does not irritate the thighs in sitting was advised.

In the treatment of an unstable and therefore presumably hypermobile sacroiliac joint
DonTigny (1995) proposed that stabilisation is possible using a good lumbosacral
support (however he did not describe a suitable support). He recommended
application of a belt when the patient was supine and advocated wearing it during the
day to stabilise the pelvis and maintain self-bracing.

Based on a review of the use of back belts in the lumbar spine, McNair (2000)
reported that the most common finding related to wearing belts is that they decrease
range of movement. In healthy males Lee & Chen (2000) measured lumbar sagittal
angles both radiographically and videographically when wearing pelvic and lumbar
belts. They found that the use of different belts can affect lumbar curvature in
different postures. For example pelvic and lumbar belts increased the L1S1 angle in
standing and slumped sitting, whereas in erect sitting the L1S1 angle actually
decreased. Lantz & Schultz (1986) investigated the mechanical effectiveness of
orthoses for the lumbar spine in five healthy males. They showed that when wearing
a belt gross trunk motion was decreased by up to 20% in flexion and 48% in
extension, lateral bending and twisting. Braces used, from the most to the least
effective were a thoracolumbosacral orthosis, a chairback brace and a lumbosacral
corset. These authors concluded that the braces were able to restrict some motion and
that restrictions of upper body gross motions very likely relieve the loads placed on
the lumbar trunk muscles and lumbar spine in activities of daily living.

In summary, the use of pelvic support belts in the treatment of pelvic instability is
supported by biomechanical studies. Retrospective studies using questionnaires and
one randomised clinical trial have provided some evidence that belts may be useful
during pregnancy for pelvic joint pain (P.29 of this Review). It seems likely that
wearing a pelvic support belt or performing stabilising exercises may reduce joint
movement, thus allowing less ongoing afferent input from damaged tissues.

REFERENCES


