WG4 Pelvic girdle pain

CONCEPT VERSION

EUROPEAN GUIDELINES
ON THE DIAGNOSIS AND TREATMENT OF PELVIC GIRDLE PAIN.

COST ACTION B13
"LOW BACK PAIN : GUIDELINES FOR ITS MANAGEMENT"
The guidelines are developed within the framework of the COST ACTION B13 "Low back pain: guidelines for its management", issued by the European Commission, Research Directorate-General, Department of Policy, Coordination and Strategy

Andry Vleeming (chairman)	Clinical anatomist	(NL)
Hanne B Albert	Physical therapist	(DK)
Hans Christian Östgaard	Orthopedic surgeon	(SWE)
Britt Stuge	Physical therapist	(NOR)
Bengt Sturesson	Orthopedic surgeon	(SWE)

WG4 Pelvic girdle pain

Summary of basic studies, epidemiology and risk factors for pelvic girdle pain (PGP)

- Pelvic girdle pain (PGP) is a specific form of low back pain (LBP), that can occur separately or in conjunction with LBP; a new definition of PGP is recommended.
- Although it is possible to focus on and specify PGP, functionally the pelvis can not be studied in isolation.
- PGP is related to non-optimal stability of the pelvic girdle joints
- The typical anatomy of the sacroiliac joint (SIJ) (which is characterized by a coarse cartilage texture, cartilage-covered grooves and ridges, a wedge-like shape of the sacrum, and a propeller-like shape of the joint surface) leads to the highest coefficient of friction of diarthrodial human joints. This friction can be altered according to the loading situation and serves to stabilize the pelvic girdle.
- Nutation of the sacrum (flexion of the sacrum relative to the ilia), is generally the result of load bearing and a functional adaptation to stabilize the pelvic girdle.
- More research is needed in patients with PGP to verify whether counternutation of the SIJ (anterior rotation of the ilia relative to the sacrum) in load bearing situations is a typical sign of non-optimal stability of the pelvic girdle.
- The incidence/point/ prevalence of pregnant women suffering from PGP is about 20%. The evidence for this result is strong.
- Risk factors for developing PGP during pregnancy are most probably: a history of previous LBP, and/or previous trauma to the pelvis. There is slight conflicting evidence (one study) against the following risk factors; pluripara and high work load. There is agreement that non risk factors are: contraceptive pills, time interval since last pregnancy, height, weight, smoking and most probably age (one study reports that young age is a risk factor).
- No studies have been published on the risk factors for the *non-pregnant* population to develop PGP, or which women or men are at risk of developing chronic PGP.

Summary of recommendations for diagnosis and imaging of PGP

- To make the diagnosis PGP the following tests are recommended for use during the clinical examination: (see appendix 1)
- *SIJ Pain:* Posterior pelvic pain provocation test (P4), Patrick's faber test, palpation of the long dorsal SIJ ligament, and Gaenslen´s test.
- *Symphysis:* Palpation of the symphysis and modified Trendelenburg's test of the pelvic girdle.
- *Functional pelvic test:* Active straight leg raise test (ASLR).
- It is recommended that a pain history be taken with specific attention paid to pain arising during prolonged standing and/or sitting. To ensure that the pain is in the pelvic girdle area, it is important that the precise area of pain be indicated: the patient should either point out the exact location on his/her body, or preferably shade in the painful area on a pain location diagram.

Diagnostic imaging

- There are limited indications for the use of conventional radiography due to its poor sensitivity in detecting the early stages of degeneration and arthritis of the SIJ.
- In most cases of nonankylosing spondylitis (non-AS) PGP, there is limited value for imaging.
- Magnetic Resonance Imaging (MRI) discriminates changes most effectively in and around the SIJ. Early AS and tumors can be easily detected. To establish the diagnosis of PGP imaging techniques are generally only needed in AS, for patients showing "red flag" signs, and when surgical intervention procedures are considered.
- Do not use scintigraphy for PGP.
- Use pain referral maps for PGP.
- Do not use local SIJ injections as a diagnostic tool for PGP. A combination of simple manual diagnostic tests, with high sensitivity and specificity, will analyse a broader spectrum of PGP complaints.

Recommendations for treatment of PGP

- Consider using physical therapy during pregnancy.
- We recommend an individualized treatment program, including specific stabilizing exercises, as part of a multifactorial treatment.
- Consider using water gymnastics (exercises) during pregnancy.
- Consider using acupuncture during pregnancy.
- Consider using therapeutic intra-articular SIJ injections for ankylosing spondylitis (under imaging guidance).
- Do not surgically fuse sacroiliac joints.

Recommendations for future research

Basic studies

- Verify whether counternutation of the SIJ (anterior rotation of the ilium relative to the sacrum) in load bearing situations is a typical sign of non-optimal stability of the pelvic girdle in PGP patients.

Diagnosis

- More studies are needed on diagnostic procedures for PGP. The diagnostic tests currently proposed need re-evaluation and trials for falsifications have to be set up.
- More research is needed to verify whether patients with PGP based on ankylosing spondylitis react to the same diagnostic procedures as do non-AS PGP patients.
- Studies are needed with fluoroscopic-guided intra-articular anesthetic SIJ blocks, together with local superficial injections of extra-articular SIJ ligaments and compared to manual diagnostic tests.
- Randomized trials are needed as well as an universal protocol for diagnostic/ follow up procedures after fusion surgery.
- Further evaluate disease-specific outcome measures for PGP.
- **Treatment**
- Different treatment modalities and applications should be investigated to establish evidence for specific recommendations. Future studies should include PGP patients in different cohorts, such as patients with ankylosing spondylitis.The methodological quality of a study is as important as the quality of the intervention studied. High methodological quality does not necessarily guarantee that a study offers a high quality of intervention. Relevant treatment modalities to be studied include:

  -comparison of exercise programs with and without the use of a pelvic belt

-comparison of individualized physical therapy with group treatment

-comparison of cognitive interventions with exercise programs. Study the effect of manipulation, mobilization, massage and relaxation in PGP patients.

- Randomized trials are needed to establish the effect of fusion surgery in PGP patients not responding to non-operative treatment.

WG4 Pelvic girdle pain

Objectives

The focus of Working Group 4 (WG4) is to produce a guideline on pelvic girdle pain (PGP). The WG4 will formulate a rationale to support the proposition that PGP is a *specific* form of back pain. The guideline will provide recommendations on the diagnosis and treatment of pelvic girdle pain.

The guideline seeks to improve the clinical management of PGP by making recommendations that are acceptable to healthcare professionals and their respective organizations. Other objectives are to initiate new research and to promote consistency in definitions, diagnosis and treatment between the various healthcare providers.

Target population

The guideline is directed to professional national healthcare organizations that will disseminate and implement these guidelines among their members. The guideline is intended to inform policymakers, healthcare providers, the general public, and patients suffering from PGP.

Guideline pelvic girdle pain

The guideline was developed within the framework of the COST ACTION B13 “Low back pain: guidelines for its management”, issued by the European Commission, Research Directorate-General, Department of Policy, Coordination and Strategy.

The guideline working group consisted of experts in the field of PGP who have been involved in primary, secondary and tertiary healthcare as well as in research projects related to PGP patients.

The WG4 consists of 5 members, two orthopedic surgeons from Sweden, two physiotherapists form Denmark and Norway, and one clinical anatomist from the Netherlands. The overpresentation of members originating from the Nordic countries is primarily the result of extensive clinical research on PGP conducted by these members.

Evidence

To ensure an evidence-based approach, a strategy broadly conducive with the other guidelines in COST ACTION B13 was adopted. In the first instance systematic reviews were sought, supplemented by individual scientific studies where systematic reviews were not available.

Three subgroups were formed to explore: a) basic information, b) diagnostics and epidemiology, and c) therapeutical interventions.

Because it became apparent that limited evidence-based knowledge was available in the form of randomized clinical trials (RCTs), a wider search of the literature was made, including basic studies.

The literature search covered the period from the beginning of the 1890s to August 2004.

The major databases were searched (without language restrictions), using Medline, the Cochrane library, the Internet and any available dissertations on this subject. No national guidelines for PGP were identified.

The progress of the subgroups was discussed at each meeting and the final report is based on group consensus.

A grading system was used to denote the strength of the evidence (see appendix WG1). This grading system is simple and easy to apply, and shows a large degree of consistency between the grading of therapeutic and preventive, prognostic and diagnostic studies. The system is based on the original ratings of the AHCPR Guidelines (1994) and levels of evidence recommended in the method guidelines of the Cochrane Back Review group.

WG4 Pelvic girdle pain

Grading of evidence and strength of recommendations according to the guidelines of the acute group (WG1) for therapy and prevention:

Level A:

Generally consistent findings provided by (a systematic review of) multiple high quality randomised controlled trials (RCTs).

Level B:

Generally consistent findings provided by (a systematic review of) multiple low quality RCTs or non-randomised controlled trials (CCTs).

Level C:

One RCT (either high or low quality) or inconsistent findings from (a systematic review of) Multiple RCTs or CCTs.

Level D:

No RCTs or CCTs.

A checklist for the methodological quality of therapy/prevention studies was used to assess internal validity (Hagen et al. 2000). The studies were ranked as high methodological quality studies (low risk of bias) and moderate to low methodological quality (high risk of bias). The studies were considered to be of high methodological quality when there was: adequate method of randomisation, concealment of treatment allocation, drop-out rate described and acceptable, intention-to-treat analysis, blinding of observer/outcome assessor, and no co-interventions (Clarke & Oxman 1999).

WG4 Pelvic girdle pain

Introduction and overview of basic studies

Definitions

The last decade saw increasing efforts among clinicians and researchers to study pain and the etiology of pelvic girdle pain. The WG4 proposes a definition for pelvic musculoskeletal pain under the title Pelvic Girdle Pain (PGP), to exclude gynecological and/or urological disorders.

Pelvic girdle pain (PGP) generally arises in relation to pregnancy, trauma, osteo-arthrosis and arthritis. Pain is experienced between the posterior iliac crest and the gluteal fold, particularly in the vicinity of the sacroiliac joints (SIJ). The pain may radiate in the posterior thigh and can also occur in conjunction with/or separately in the symphysis.
The endurance capacity for standing, walking, and sitting is diminished.
The diagnosis of PGP can be reached after exclusion of lumbar causes. The pain or functional disturbances in relation to PGP must be reproducible by specific clinical tests.

Anatomical and biomechanical background information

Although it is possible to focus on pain arising solely from the pelvis, functionally the pelvis can not be studied in isolation.

In all quadrupeds and bipeds the pelvic girdle forms a firm connection between the spine and the lower extremities. In bipeds the pelvis has to serve as a basic platform with three large levers acting on it, i.e. the spine and both legs. To allow bipedal gait in humans, specific adaptations of the pelvis have been necessary through evolution, i.e. changing the shape of the ilia, flaring out into the sagittal plane and, compared to quadrupeds, providing a more optimal lateral attachment for the gluteus medius as an important muscle for hip pelvic stability. In particular, a dramatically increased attachment site for the gluteus maximus muscle has changed this muscle (a relatively minor muscle in the chimpanzee) into one of the largest muscles of the human body (Lovejoy 1988).

Additional evolutionary changes in humans are the muscular and ligamentous connections between the sacrum and ilia: a) muscles like the lower lumbar multifidi inserting to the sacrum and also into the medial cranial aspects of the ilium. b) Changes in the position of the coccygeus and the piriform muscles and the gluteus maximus muscle originating from the sacrum and sacrotuberous ligaments. c) Extensive fibrous connections adapted to the typical anatomy of the SIJ, like the interosseous ligaments, surrounding an iliac protrusion fitting in a dorsal sacral cavity, called the axial joint just behind the auricular surfaces of the SIJ (Bakland & Hansen 1984). d) Ventral and dorsal SIJ ligaments, sacrotuberous and sacrospinous ligaments between sacrum and lumbar spine (anterior longitudinal ligaments). In addition, direct fibrous connections exist between the iliac bone and L4 and L5, the iliolumbar ligaments. A recent study has described the influence of the iliolumbar ligaments on SIJ stability (Pool-Goudzwaard et al. 2003). Due to the above-mentioned muscular and ligamentous connections, movement of the sacrum with respect to the iliac bones, or vice versa, affects the joints between L5-S1 and between the higher lumbar levels. Anatomical and functional disturbances of the pelvis or lumbar region influence each other. Due to the tightness of the fibrous connections and the specific architecture of the SIJ, mobility in the SIJ is normally very limited, but movement does occur and has not been scientifically challenged (Egund et al. 1978, Lavignolle et al. 1983, Miller et al. 1987, Solonen 1957, Sturesson et al.1989, 2000a, b, Vleeming et al. 1990a, b, 1996, Weisl 1955).

The main movements are forward rotation of the sacrum relative to the iliac bones (nutation) and backward rotation of the sacrum relative to the ilia (counternutation). Posterior rotation of the ilium relative to the sacrum is the equivalent of nutation of the sacrum, and anterior rotation of the ilium to the sacrum is the equivalent of counternutation of the sacrum.

It was shown that even at advanced age (over 72 years) that the combined movement of nutation and counternutation of the SIJ can amount up to 4°, although motions are normally less than 2° (Vleeming et al. 1992a'
In the study of Vleeming et al. (1992a) the SIJ with the lowest mobility showed radiologically marked arthrosis. Ankylosis of the SIJ was found to be an exception, even at advanced age. This finding is in agreement with studies of Stewart (1984) and Miller et al. (1987).
In load bearing situations like standing and sitting, nutation is increased. In prone lying positions nutation is also increased compared to supine positions (Egund et al. 1978, Sturesson et al. 1989, 2000 a, b, Weisl 1955). Counternutation normally occurs in unloaded situations like lying down (supine). Counternutation in supine positions can be altered to nutation by maximal flexion in the hips, using the legs as levers to posteriorly rotate the ilia relative to the sacrum, as in a labour position.

Stability of the pelvic girdle
The SIJs are relatively flat, unlike ball and socket joints such as the hip. Flat articular surfaces are less resistant to shear forces and therefore the presence of flat surfaces in the pelvis seems surprising. This anatomical configuration gives rise to three questions: 1) Why did nature create seemingly flat SIJ, 2) What specific adaptations are available to prevent shear in these joints, and 3) Why is the SIJ not perpendicularly orientated to the forces of gravitation?
Regarding the first question, a large transfer of forces is required in the human SIJ, and indeed flat joints are well suited to transfer large forces (Snijders et al. 1993a, b). An alternative for effective load transfer by these flat joints would be a fixed connection between sacrum and iliac bones, for instance by ankylosis of the SIJ. The flat SIJ in humans serve a purpose: to economize gait, to allow shock and shear absorption, and to alleviate birth of (in the evolutionary sense) abnormally large babies. The principal function of the SIJs is to act as important stress relievers, ensuring that the pelvic girdle is not a solid ring of bone that could easily crack under the stresses to which it is subject (Adams et al. 2002).
In relation to the second question, the SIJ are abnormal compared to other joints in the body. The articular cartilage is already extraordinary before birth. Several authors have described cartilage changes, especially at the iliac side of the joint; they were then misinterpreted as evidence for degenerative arthrosis (Bowen & Cassidy 1981, Sashin 1930). These cartilage changes are more prominent in men than in women. According to Salsabili et al. (1995), the sacral cartilage is thicker in females than in males. This gender difference may be related to childbearing and possibly to a different localization of the centre of gravity in relation to the SIJ (Dijkstra et al. 1989, Vleeming et al. 1990a, b). These changes are expected to cause pain or SIJ problems, especially in the elderly. Since this is not the case, these anatomical changes are considered to reflect a functional adaptation (Vleeming et al. 1990 a, b). The features seem to be promoted by the increase in body weight during the pubertal growth spurt (Vleeming et al. 1990 a, b) and concern coarse cartilage texture, and a wedge and propeller like form of the joint surface.
Studies of frontal slides of intact joints of embalmed specimen show the presence of cartilage covered bone extensions protruding into the joint. These protrusions seemed irregular, but are in fact complementary ridges and grooves. Joint samples taken from normal SIJ, with both coarse texture and complementary ridges and grooves, were characterized by the highest friction coefficients (Vleeming et al. 1990b).

All these features are expected to contribute to the highest coefficient of friction of any arthrodial joint, enhancing the stability of the joint against shear, reflecting adaptation to

human bipedality (Vleeming et al. 1990a). As a consequence, less muscle and ligament force is required to bear the upper part of the body.
Also the “keystone-like” bony anatomy of the sacrum further contributes to its stability within the pelvic ring. The bone is wider cranially than caudally, and wider anteriorly than posteriorly. Such a configuration permits the sacrum to become "wedged" cranially and dorsally into the ilia within the pelvic ring (Vleeming et al. 1990 a, b).
To illustrate the importance of friction in the SIJ the principles of form and force closure were introduced (Vleeming et al 1990. a, b). Form closure refers to a theoretical stable situation with closely fitting joint surfaces, where no extra forces are needed to maintain the state of the system, given the actual load situation. If the sacrum would fit in the pelvis with perfect form closure, no lateral forces would be needed. However, such a construction would make mobility practically impossible. With force closure (leading to joint compression) both a lateral force and friction are needed to withstand vertical load. Shear in the SIJ is prevented by the combination of the specific anatomical features (form closure) and the compression generated by muscles and ligaments that can be accommodated to the specific loading situation (force closure).
<u>In answer to the third question</u>; force closure ideally generates a perpendicular reaction force to the SIJ to overcome the forces of gravity (Vleeming et al. 1990b)
This shear prevention system was named the selfbracing mechanism and is not unique for the SIJ.
When a larger lever is applied and/or coordination times become less, the general effect in the locomotor system will be closure or reduction of the kinematic chain’s degrees of freedom, leading to a reduction of the chain’s mobility or a gain of stability by increasing force closure (Huson, 1997). Mechanisms comparable to selfbracing of the SIJ are present elsewhere in the body, e.g. in the foot and carpus
In selfbracing of the pelvis, nutation of the sacrum is crucial. This movement is an anticipation for joint loading. Hodges et al. (2003) use the terminology “preparatory motion” for the same phenomenon in the lumbar spine. Nutation is seen as a movement to prepare the pelvis for increased loading. The altered position in the SIJ increases the tension of the ligaments and therefore the stiffness of the joint.
Nutation tightens most of the SIJ ligaments, among them the vast interosseous ligaments. They are located between sacrum and iliac bones, directly posterior of the main articular surfaces. Due to tension of the interosseous and short dorsal sacroiliac ligaments, the posterior parts of the iliac bones are pressed together. This enlarges the compression of the SIJ.

Defining optimal and non-optimal pelvic girdle stability
Static and dynamic stability throughout the body is achieved when the active, passive and neuromotor control systems work together to transfer load (Panjabi, 1992, Snijders et al 1993a, b). Adequate compression of the joint surfaces must be the result of reaction forces acting across the joint, if stability is to be insured (Vleeming et al. 1990a, b). Adequate means ideally tailored to the existing situation, using the least amount of compression to guarantee stability: in fact, efficient neuromuscular control.
The joint reaction force is modified by gravity, the shape of the articular surfaces, the actual joint position, proprioceptive muscle reflexes, the level of muscle (co)contractions and increased ligament tension, which will determine the level of stiffness of the joint (Vleeming 1990b).

Consequently, the ability to effectively transfer load through joints is a dynamic process and depends on many factors, including:

- optimal function of the bones, joints and ligaments (form closure, joint congruency; Vleeming et al. 1990a, b).
- optimal function of the muscles and fascia (force closure; O'Sullivan et al. 2002, Richardson et al. 2002, Vleeming et al. 1990 a, b, Vleeming 1990, Vleeming et al. 1995) and appropriate neuromotor control (Hodges 1997a, b, Gandavia et al. 2002, Holstege et al. 1996). When neuromotor control is changed this leads to increased or diminished joint compression.

Stability is not merely about how much a joint is moving (quantity of motion) or how resistant structures are, but more about motion control which allows load to be transferred and movement to be smooth and effortless. The WG4 presents a definition of stability for effective joint control, which is the property that the joint returns to its initial position after perturbation (Tullberg et al. 1998). Especially the translational stability is important. Translations are normally small and rotations generally large and mainly limited near the end of the range of motion. For the SIJ, rotations are very small and the translations even smaller (Sturesson et al. 2000 a,b).

Definition of joint stability
The effective accommodation of the joints to each specific load demand through an adequately tailored joint compression, as a function of gravity, coordinated muscle and ligament forces, to produce effective joint reaction forces under changing conditions.
Optimal stability is achieved when the balance between performance (the level of stability) and effort is optimized to economize the use of energy.
Non-optimal joint stability implicates altered laxity/stiffness values leading to increased joint translations resulting in a new joint position and/or exaggerated/reduced joint compression, with a disturbed performance/effort ratio (Vleeming A, Albert HB, van der Helm FCT., Lee D, Ostgaard HC, Stuge B, Sturesson B)*.*

To help understand laxity of the lumbopelvic area, the theoretical concepts of neutral zone and elastic zone are helpful. According to Panjabi (1992), the neutral *zone* is a small range of movement near the joint's neutral position where minimal resistance is given by the osteo-ligamentous structures. The *elastic zone* is the part of the motion from the end of the neutral zone up to the physiological limit. Panjabi notes that a joint has nonlinear load-displacement curves. The non-linearity results in relative laxity in the neutral zone and increased stiffness toward the end of the range of motion.
Laxity in the neutral zone can lead to repositioning of the joint to a position in the elastic zone to seek higher compression forces to stiffen the joint. Panjabi describes that the size of the neutral zone alters with injury, articular degeneration and/or weakness of the stabilizing musculature and that this is a more sensitive indicator (laxity/versus stiffness) than angular range of motion for detecting instability. Panjabi's model does, however, conclude that neutral zone can be influenced by compression.
It was hypothesized (Lee & Vleeming 1998) that the neutral and elastic zone properties are affected qualitatively by altering the compression forces across the joint. Also, neutral zone movement can be influenced by altered compression. This implicates that joint compression can be too much, too little or optimal. In case of ankylosing spondylitis it was hypothesized that too much compression could influence optimal function of the SIJ (Masi et al. 2003 a b).
When the articular surfaces of the sacrum and the ilia fit together with perfect form closure, displacement in the joint would be impossible. However, form closure of the SIJ is not perfect and displacement is possible, albeit small, and therefore stabilization during loading the pelvic joints is required. This is achieved by increasing compression across the joint surface at the moment of loading. The anatomical structures responsible for this are the ligaments and muscles, together with their fascia. Ligaments are tensed when bones move in directions that lengthen them and when muscles that attach to them contract. This tension results in compression and altered joint reaction forces of the joint (Vleeming et al. 1990 a, b, Snijders et al. 1993 a, b). This is seen as a prerequisite in all joints and the effective application of compression is the decisive factor, besides the anatomical factors, for joint stabilization. Compression as a function of effective motor control, reduces the size of the joint's neutral zone and increases the stiffness value of the joint. Shear forces are thereby controlled, facilitating stabilization of the joint.
In all joints, it is the combination of regional and local ligaments, muscles, fascial systems and gravity that contribute to effective joint reaction forces (Vleeming et al. 1990a, b, Snijders et al. 1993 a, b), and not exclusively the deep stabilizing muscles. Also muscles with bigger lever arms to the joint, add to joint reaction forces. When this mechanism works efficiently in the pelvis, the shear forces, between the ilia and sacrum, are adequately controlled and loads can be transferred between the trunk, pelvis and legs (Snijders et al. 1993 a, b).

Studies on optimal and non-optimal pelvic girdle stability
PGP research in the past focused especially on the functional analysis of PGP, mainly in women. This because earlier publications emphasized that pregnancy-related pelvic girdle relaxation is the primary cause for instability of the pelvic ring.
As early as the 1870s, Snelling (ref. Svensson et al. 1990) was of the impression that relaxation of the pelvic articulations becomes apparent suddenly after parturition, or gradually during pregnancy, permitting a degree of mobility which thus hinders locomotion and gave rise in some women to the most distressing and alarming sensations.
Abramson et al. (1934) described pelvic pain and instability, and made the distinction between symptoms related solely to the pubic joint, to the SIJ, or combined. These authors describe pain in the symphyseal region with radiation to the thighs, and SIJ symptoms

presented as posterior pelvic pain. Frequently noted was a waddling gait and a positive Trendelenburg sign. The authors used, among others, screening techniques like X-rays of the pubic symphysis, even in women 8 months pregnant (Abramson et al. 1934). Brooke, 1924) reporting on in vitro studies of women (pregnancy 8-9 month), that SIJ mobility has increased by a factor of two and a half, in comparison to non-pregnant women of comparable age.

Increased mobility and widening of the symphysis were well documented in relation to pregnancy related PGP. Post-mortem anatomical studies in former days, showed increased mobility of the SIJ and an increased amount of synovial SIJ and symphyseal fluid in pregnant women (Brooke, 1924).

Possibly due to these older pelvic studies on pelvic instability in the 19th and 20th century, the scientific focus of pelvic pain shifted towards a functional approach.

In more recent functional pelvic studies, it was again stated that PGP can be related to insufficient stability which, among others, is underpinned by the fact that a pelvic belt normalizes and stiffens the pelvic ring. Vleeming et al. (1992b) describe that a pelvic belt enhances pelvic stability because it stiffens the SIJ.

Mens et al. (1999) developed a new diagnostic test. They studied the relation between impaired active straight leg raising (ASLR) and the mobility of pelvic joints with and without the application of a pelvic belt; thereby testing the hypothesis that the pelvis is the basic bony platform that needs to be stabilized before levers, like the legs and spine, can be effectively used. They conclude that impairment of the ASLR test correlates highly with the level of laxity of the pelvis, since application of a pelvic belt generally reduces the impairment of the ASLR test.

Mens et al. (1999) suggest that after completing the initial provocative pelvic diagnostic tests, to repeat these tests with the application of a pelvic belt in order to study the differences. In these studies, a small tension of 50 N was applied to the belt, just above the greater trochanter. Larger forces did not yield better stabilization (Vleeming et al. 1990a, b). The efficacy of the pelvic belt was primarily determined by the location of the belt, and the mechanical effects of the belt were explained by increased compression, and self-bracing of the SIJ.

Buyruk et al. (1995 a, b, 1999) applied unilateral oscillations to the anterior superior iliac spine in order to measure the laxity of the pelvic joints in vivo. With sono-elasticity, using Doppler Imaging of Vibrations (DIV), they measured the stiffness/laxity ratio of artificially destabilized SIJ and compared them to stabilized pelvises. The new method was objective and repeatable. In vivo studies by Damen et al. (2002a) then followed. The same technology was applied on healthy subjects and showed that pelvic belts are able to alter laxity of the SIJ with an applied force of the pelvic belt of maximally 50 N (Damen et al. 2002a). The authors also showed that the laxity values of the SIJ decreased after application of a pelvic belt to patients with pelvic pain.

In another study, the authors (Damen et al. 2002b) reported that patients with asymmetric SIJ laxity have significantly more pain during pregnancy, compared with patients with symmetric laxity. They concluded that, strictly based on the outcome of the DIV measurements, increased general laxity in itself is not associated with pelvic pain. The variation of pelvic girdle laxity in normal subjects and PGP patients seems to be large.

The conclusion of these recent studies is that a relation exists between asymmetric SIJ laxity and PGP. Buyruk et al. (1999) and Damen et al. (2001, 2002 a, b) describe the relation between severity of the complaints and pelvic asymmetric laxity. Damen and colleagues note that subjects with asymmetric laxity of the SIJ during pregnancy have a threefold higher risk for moderate to severe pelvic pain to persist into the postpartum period, compared to

subjects with symmetric laxity during pregnancy. They also conclude that pelvic belt application can stiffen the pelvis and influence an impaired ASLR test. According to these DIV studies, the asymmetry of laxity correlates with the symptomatic individual.
Mens et al. (1999), using X-rays taken after pregnancy, showed that when the symptomatic pelvic side and leg were freely hanging down, in the standing position, the pubic bone on the symptomatic side shifts caudally relative to the other side. This procedure differs from the classical Chamberlain X-ray method, which screens the symptomatic loaded side. With the procedure of Mens and colleagues (1999), the patient is standing with the asymptomatic side on an increased height, making it possible for the symptomatic leg to hang down. The symphyseal shift noticed by Mens and colleagues (1999) was on average larger than on the reference side. The authors propose that this shift could be the result of an anterior rotation of the ilium relative to the sacrum on the symptomatic side (counter nutation).
Hungerford et al. (2003, 2004) came to the same conclusion. Using an external motion analysis system, they studied three dimensionally the angular and translational displacements of patients with SIJ problems and compared them to asymptomatic subjects. They conclude that posterior rotation of the ilia relative to the sacrum (nutation) occurs on the weight bearing side in asymptomatic subjects. In contrast, the ilia rotated anteriorly relative to the sacrum (counternutation) in the patient group.

Kumar et al. (1996) show that axial rotation of the trunk involves agonistic activity of the contralateral external obliques, and ipsilateral erector spinae and latissimus dorsi as agonistic muscles to rotate the trunk. Mooney et al. (1998) use the anatomical relation of the latissimus dorsi and the contralateral gluteus maximus to study their coupled effect during axial rotation exercises and walking. They conclude that in normal individuals walking a treadmill, the functional relationship between the mentioned muscles could be confirmed. It was apparent that on average, the right gluteus maximus had a lower signal amplitude compared to the left, in a group of 15 subjects of whom 12 were right handed. This reciprocal relationship of muscles correlates with normal reverse rotation of shoulders versus the pelvis in normal gait.
Mooney et al. (2001) showed that during right rotation of the trunk the right latissimus dorsi is significantly more active than the left, but the left gluteus maximus more active than the right gluteus. In patients with SIJ problems, a strikingly different pattern was noticed. The gluteus maximus on the symptomatic side was more active compared with the healthy subjects. The reciprocal relation between latissimus and gluteus maximus, however, was still present. After an intense rotational strengthening training program, the patients showed marked increase of latissimus strength and diminished activity of the gluteus on the symptomatic side.
The importance of these findings could be that rotational trunk muscle training is particularly important for stabilizing the SIJ and lower spine. These findings contradict the conclusion of Bogduk et al. (1998) that the latissimus has no function besides upper limb movement.
Van Wingerden et al. (2004) studied several muscles which could contribute to compression of the pelvic joints and influence the stiffness characteristics. SIJ stiffness was measured using DIV in six healthy women. SIJ stiffness was measured both in a relaxed situation and during EMG recorded isometric voluntary contractions. The biceps femoris, gluteus maximus, erector spinae, and contralateral latissimus dorsi were included in this study whereas the deeper lying muscles were not included. Pelvic stiffness significantly increased after activation of the erector spinae, the biceps femoris and the gluteus maximus muscles. Based on these data it is concluded that optimal function of the pelvic girdle during leg loading is based on tailored force closure/compression of the SIJ due to activation of multiple muscle slings. The study concludes that SIJ stiffness increased even with slight

muscle activity, supporting the notion that effective load transfer from spine to legs is possible when muscle forces actively compress the SIJ preventing shear.
This is in agreement with the work of Cholewicki et al. (2000) that shows that sufficient stability of the spine is achieved in most people with modest levels of co-activation of the paraspinal and abdominal wall muscles. Hodges et al. (2003) demonstrate in porcine experiments that contractions of both the transversus muscle and the diaphragm increases the stiffness of the spine; however, asymmetric contractions did not yield the same effect.
Richardson et al. (2002) further elaborated on the force closure model by showing that contractions of the transversus abdominus muscle significantly decrease SIJ laxity. However, several other muscles that may have influenced the results were not measured.
O'Sullivan et al. (2002) demonstrated how the ASLR test is related to altered motor control and respiratory function in patients with PGP. They measured this in studying bladder movement as a function of pelvic floor activation. Pool-Goudzwaard (thesis 2004) found indications that pelvic floor contractions could enhance stability of the SIJ. Further studies are needed to verify these findings.

With insufficient bracing of the lumbopelvic region, the body can be expected to implement compensation strategies, e.g. tensing the sacrotuberous ligament through activation of the biceps femoris or exaggerated contraction of parts of the gluteus maximus. Although definite experimental data are still lacking, it is presumed that tension of the biceps and other hamstring muscles can be increased over an extended period. Hungerford et al. (2003) showed altered firing patterns of these muscles in SIJ patients. Higher tension of the hamstrings will force the pelvis as a unit to rotate backwards, leading to a flattening of the lumbar spine.
A porcine experiment by Indahl et al. (1999) revealed that stimulation with bipolar wire electrodes in the ventral SIJ capsule initiated a muscular response of the gluteus maximus and the quadratus lumborum. Stimulation directly under the SIJ capsule provoked a response in the deep medial multifidus fascicles lateral to the L5 spinous process. The latter study could help to broaden the knowledge of muscular control of SIJ.

Non-optimal stability and pelvic girdle pain
Damen et al. (2002 a, b) conclude their DIV studies by proposing that the term pelvic instability should not be used, because increased symmetric laxity (based on the DIV methodology) is not properly related to pelvic pain whereas asymmetric laxity is. However, although using a proper method for inclusion of pelvic patients, Damen et al. (2001) did not specify for left or right leg differences of a positive ASLR test and did not specifically study the relation between a positive ASLR test and laxity.
The DIV method was specifically designed to study joint play in vivo, especially the study of neutral zone movement. The DIV method measures stiffness. Therefore it would be a basic mistake to use DIV studies as the sole method to analyze general pelvic girdle mobility and use the outcome of DIV studies to draw overall conclusions about PGP. Another problem of the DIV method is that laxity is strongly influenced by altered muscle tension, as explained by Richardson et al. (2002) and van Wingerden et al. (2004). This implicates that altered motor patterns influence the dynamics of stiffness. For that reason asymmetric laxity/stiffness may shift side when another muscular (defense) strategy is used.
Therefore, the findings of the anatomist and the gynecologist in older studies describing the relation between increased mobility of the SIJ and symphysis, can not be refuted by the outcome of DIV laxity studies. Simply stated, older studies report on overall pelvic girdle motion (Brooke 1924, Abramson et al. 1934). The DIV method in contrast, studies neutral zone laxity.

In this respect, the studies of Sturesson et al. (1989, 2000 a, b) applying a radiostereometric analysis (RSA) to the SIJ, also study overall movements characteristics (elastic zone movements) of the SIJ. In practically all their studies Sturesson and colleagues found that an anterior rotation of the sacrum (nutation) was observed when patients loaded their spine by means of rising from a supine towards a sitting or standing position. Sturesson et al. (2000a) acknowledge that nutation is a prerequisite for the described self-bracing mechanism to stiffen the SIJ through ligament tension. Although Sturesson et al. (1989) conclude that movements measured in the SIJ are not different between the symptomatic and the asymptomatic side, it was shown that movements of the SIJ are reduced by increased loads. Sturesson et al. (1999) note that SIJ movement in most patients can be reduced by applying slight tension to an external Hoffman Slatis frame, resulting in tensioning of the posterior SIJ ligaments and therefore compressing the SIJ (Snijders et al.1993 a,b).
This will increase the functional capacities of the patient and, in all propability, reduce the pain. This is the same finding as presented by studies exploring the effect of a pelvic belt.
A new study by van Wingerden et al. (to be published 2005) found that (based on the study of coupled movements) both LBP and PGP patients show a specific and discriminating movement pattern. In standing, PGP patients already show more backward pelvic tilt combined with a slight flattened lordosis compared to both healthy subjects and LBP patients. During forward bending it was shown that the coupled motion of lumbar spine and pelvis can not only be distinguished from that of healthy subjects, but also differs significantly between both patient groups. It was postulated that this motion is a result of functional compensation strategies of the body, following impaired neuromuscular coordination, possibly caused by specific tissue damage.

In conclusion: To comprehend the movement characteristics of the pelvic girdle, both elastic zone research (RSA, quantitative study of movement, and the outcome of 20th century studies) and research into the quality of movement (DVI, measuring the amount of compression/force closure), is needed. The RSA and DIV methods are used to study pelvic mobility and analyze different characteristics of joint movement. However, both methodologies conclude that increased stiffness correlates with increased stability and reduced motion in the SIJ. The studies by Richardson et al. (2002) and van Wingerden et al. (2004) also illustrate that muscle force directly increases SIJ stiffness. Again, no proper studies are available on a subgroup of PGP patients selected on too much compression of the pelvis.

Etiology

The cause of PGP is multifactorial and PGP may be related to different conditions. Only a few factors are proven to have an impact on development of the condition. Most studies have included women in relation to pregnancy, because the vast majority of patients with PGP are women. A large number of patients have been collected during routine pregnancy controls. In these latter cases there is no disease or trauma to initiate the condition, as there is in ankylosing spondylitis or after trauma. Consequently, there is no obvious explanation for the onset of most cases of PGP. However, during pregnancy the female body is exposed to certain factors that have an impact on the dynamic stability of the pelvis
One such factor is the effect of the hormone relaxin which, in combination with other hormones, affects the laxity of ligaments of the pelvic girdle as well as ligaments in the rest of the body. The effect of increased ligament laxity is a slightly larger range of movement in the pelvic joints. If this is not compensated by altered neuromotor control, pain may result. The exact role of each specific hormone and the reasons for its variations in serum levels is not known, but the primary aim is to maintain pregnancy and to initiate delivery.

Any artificial change in hormone levels during pregnancy would probably jeopardize any ongoing pregnancy and is thus not relevant for treating PGP; therefore, this is not further discussed here. However, more knowledge of hormonal effects on ligaments could provide a better understanding of PGP.

Discussion

Several studies have shown that there is no linear relationship between pain and increased range of motion in the pelvic joints (Damen et al. 2001, Sturesson et al. 1989 Walde 1962); thus, apparently, some women can handle increased range of motion caused by ligament laxity while other women can not. This indicates that decreased joint stability may be compensated for by changed muscle function (O’Sullivan et al. 2002).

Considering red flags, there is no difference between LBP and PGP, except that PGP patients are normally younger than 30 years old (Bjorklund 1997) and therefore are less likely to have malignant diseases as the cause of pain. The role of yellow flags has not been investigated among PGP patients but, based on the present limited knowledge, the impression is that yellow flags are less common among PGP patients than among LBP patients.

Prognosis

It is difficult to compare different studies in the literature because pelvic girdle pain is often included in low back pain. However, in studies where PGP is defined and studied separately, the findings are similar and acceptable. Several studies find that about 20% of all pregnant women develop PGP during pregnancy, and that about 5% have serious problems with pain and disability (Larsen et al.1999, Östgaard et al. 1994b).

After pregnancy the prevalence of PGP rapidly declines to 7% during the first three months (Östgaard et al. 1996 Albert et al., 2001). Women with persisting PGP after delivery often had serious pain during pregnancy and also had pain for a longer period of time (Östgaard et al. 1991a). These figures relate to non-treated populations.

The incidence of PGP in relation to pregnancy differs in that respect from the incidence of LBP, which has been found not to differ from the incidence of LBP in a non-pregnant population (Östgaard et al. 1996).

Summary and conclusions of basic PGP studies

- Pelvic girdle pain (PGP) is a specific form of low back pain (LBP), that can occur separately or in conjunction with LBP; a new definition of PGP is recommended.
- Although it is possible to focus on and specify PGP, functionally the pelvis can not be studied in isolation.
- PGP is related to non-optimal stability of the pelvic girdle joints
- The typical anatomy of the sacroiliac joint (SIJ) (which is characterized by a coarse cartilage texture, cartilage-covered grooves and ridges, a wedge-like shape of the sacrum, and a propeller-like shape of the joint surface) leads to the highest

coefficient of friction of diarthrodial human joints. This friction can be altered according to the loading situation and serves to stabilize the pelvic girdle.

- Nutation of the sacrum (flexion of the sacrum relative to the ilia), is generally the result of load bearing and a functional adaptation to stabilize the pelvic girdle.
- More research is needed in patients with PGP to verify whether counternutation of the SIJ (anterior rotation of the ilia relative to the sacrum) in load bearing situations is a typical sign of non-optimal stability of the pelvic girdle.

Epidemiology

Considering the different characteristics of PGP, it is considered necessary to divide the patients into subgroups of non-pregnant patients and those with pregnancy-related pain, before describing the epidemiology.

Pelvic girdle pain in non-pregnant patients

Schwarzer et al. (1995) studied 100 patients with low back pain of whom 43 complained of pain over the SIJ. After intra-articular anesthetic blocks of the SIJ, 13 of these patients had pain relief. In this study the intra-articular injections were used as the diagnostic criteria to determine whether the patients suffered from SIJ pain. The results showed a prevalence of 13% of patients with intra-articular SIJ pain in a population referred to hospital for general low back pain.

In a population of 183 patients with “failed low back pain syndrome” Greenman (1992) found that after classifying the patients into different pelvic syndromes (pubic dysfunction, pelvic tilt syndrome, posterior nutated sacral base, ilium shear dysfunction, non-neutral dysfunction muscle imbalance of lower extremities and pelvic obliquity and sacral base unleveling) that only five patients had none of these SIJ syndromes while 86.3% had two or more. However, this study focused on a highly selected patient group, and the tests used have a very low intra-tester reliability and doubtful validity.

Petersen et al. (2004) investigated a population of 90 patients who came for treatment at a specialist centre due to low back pain. On the basis of the patient history and a thorough clinical examination they concluded that in 13% of the patients the pain focus was actually located in the SIJ.

Discussion

No proper epidemiological studies have been performed. The patient groups examined so far are specially selected and therefore not representative of the normal population. The diagnostic tests used in the studies do not fulfil the criteria of reliability and validity, and most tests do not examine the pelvic girdle as a functional unit (Wu et al , 2004).

Pregnancy-related pelvic girdle pain

Many studies have attempted to describe the incidence and prevalence of PGP in pregnancy. However, obtaining a clear picture is difficult because the reported incidence of pelvic and low back pain in pregnancy in the literature ranges between 4% to 76.4% (Ansari et al. 2003, Berg et al. 1988, Diakow et al. 1991, Endresen 1995, Fast et al. 1990, Golighty 1982, Kogstad 1988, Kristiansson et al. 1996a, Larsen et al. 1999, Mantle et al. 1977, Moon et al 2000, Mousavi 2003). There are several reasons for this large variation. For example, some of the studies are prospective and others are retrospective. Another problem is the diagnostic procedure: in some studies the women diagnose their own condition, in others a history of pelvic pain is declared sufficient to propose a diagnosis, and in others both a pain history and a clinical examination is required before a woman is diagnosed with PGP. Another complicating factor is the lack of definition of the location of pain: some studies specify LBP, some PGP, some do not specify the area, and some describe both. Furthermore, many of the tests used in the studies have not been scientifically tested, or have been found to have low inter-tester reliability and validity.
Due to these basic methodological problems in this report, only those studies are included in which the pain presenting area is within the boundaries of the pelvic area, moreover the

studies must be prospective and the diagnosis has to be confirmed by a pain history and, preferably, a clinical examination.
Four studies with these qualifications have been identified:

Albert et al. (2002) performed the largest study which included 2269 pregnant women who were examined and had their pain history taken in week 33 of gestation. The women, reporting daily pain in the pelvic joints which could be confirmed by clinical examination, were divided according to symptoms into five subgroups; pelvic girdle syndrome (pain in both SIJ and the symphysis, symphysiolysis, one-sided SIJ syndrome, double-sided SIJ syndrome and miscellaneous). Of these pregnant women 20.1% were found to have PGP. In the classification subgroups the incidence was: pelvic girdle syndrome 6.0%, symphysiolysis 2.3%, one-sided SIJ syndrome 5.5% and double-sided SIJ syndrome 6.3%.

Östgaard et al. (1991b) undertook a prospective study of back pain in 855 pregnant women at their regular visits to a maternity care unit. The authors relied on history information only (women identified the location of pain on a pain drawing). Based on their pain drawings, three groups of pain were distinguished; high back pain, low back pain and SIJ pain. In week 30 of gestation the point prevalence of low back pain and sacroiliac pain was about 32% and SIJ pain alone was about 19%. No physical examination was performed to confirm the pain presentation.

In the study by Larsen et al. (1999), 1600 pregnant women filled out a questionnaire six times during pregnancy. If the woman suffered from pelvic pain, and also confirmed that 2 out of 5 fixed ADL activities were painful, examination was made by a rheumatologist to exclude low back pain. In total 238 women reported to have PGP and that 2 or more ADL activities induced pain, whereas 227 fulfilled the criteria of pelvic pain, giving an incidence of 16%. However, because Larsen et al. only examined 14.8% of the pregnant women included in the study, some of the milder cases of PGP may not have been included in the incidence calculations. Only a part of the population was examined, namely the 227 women who fulfilled the criteria of having a minimum of two ADL reduced activities.

Berg et al. (1988) performed a prospective study in which 862 pregnant women completed a questionnaire in weeks 20, 30, and 35 of gestation. Of these women 49% reported that they experienced SIJ pain at some time during the pregnancy, i.e. the *cumulative* incidence. However, only women entitled to sick leave from work (9%) underwent clinical examination.

Discussion
The three studies which report on incidence/point prevalence are: a) prospective, b) have a strictly epidemiological design by studying an unselected group of pregnant women reporting for a maternity check, c) have very large numbers of participants (4724 in total), d) the applied tests to confirm the diagnosis were tested for inter-tester reliability sensitivity and specificity, and e) only patients with PGP were included. The results of the studies show almost the same number of patients with PGP; 20.1% (Albert et al. 2002), 19% (Östgaard et al. 1991b), and 16% (Larsen et al. 1999). The slightly lower number in the Larsen study is probably due to the stricter minimum criteria used.

Conclusion
Based on the above described studies the incidence/point prevalence of pregnant women suffering from PGP is close to 20%. The evidence for this result is strong.

Risk factors

Pregnancy-related pelvic girdle pain
To determine the possible risk factors for developing PGP in pregnancy, only a few epidemiological observational studies have been performed.
Berg et al. (1988) followed 862 women three times during pregnancy. Of these, 72 women complained of severe pain and were referred to an orthopedic surgeon for examination. The risk factors were previous history of low back pain, heavy work and smoking (covariance with heavy work). Contraceptive pills and number of previous pregnancies presented no risk.
Östgaard et al. (1991a, b) followed 855 women 7-9 times during pregnancy. If a woman reported back pain, a pain drawing and a questionnaire was filled out. The authors noticed that the risk factors for developing low back and PGP during pregnancy were previous history of low back pain, pluripara, young age, heavy workload, and if the woman believed her back to be weak. Contraceptive pills, BMI, height and weight increase during pregnancy presented no risk.
Kristiansson et al. (1996a) examined 200 women three times during pregnancy and once 12 weeks after delivery, with a physical examination and a comprehensive questionnaire. They found that the risk factors for developing back pain were previous history of low back pain, pluri para, and increased weight during pregnancy, whereas smoking, age, BMI at first visit, and time since last pregnancy proved to be no risk.
In the study by Larsen et al. (1999), 1600 pregnant women filled out a questionnaire six times during pregnancy. Women suffering from PGP and confirming that two out of five fixed ADL were painful, were examined by a rheumatologist. Of the 238 women who were examined, 227 fulfilled the criteria for PGP. The authors described the following significant risk factors; previous history of low back pain (0.05), pluripara (0.01), PGP in previous pregnancy (0.01), smoking (0.05), heavy work (0.01), not doing regular exercise (once a week) (0.05), and mother or sister with pelvic pain in previous pregnancy (0.01). After logistic regression analysis of these factors, smoking, heavy work, and pluripara were no longer significant. Age, height, weight, parttime or full-time work, being a single or a married mother proved to be no risk.
Albert et al. (submitted) examined 2269 consecutive pregnant women (at week 33 of gestation) over a one-year period with a structured questionnaire and a thorough physical examination. Women who reported daily PGP with corresponding objective findings were allocated, according to symptoms, to four classification groups. This study demonstrates no single dominant risk factor for developing PGP in pregnancy, but does reveal a set of physical and psychosocial factors. After, logistic regression analysis, the risk factors for developing PGP were: history of previous low back pain, trauma of the back or pelvis, pluripara, higher level of stress, and job dissatisfaction.
The following variables were examined but revealed no differences between the healthy and diseased groups in the univariate analysis: age, marital status, full-time work, previous stillbirth, interval between current and previous pregnancy, previous use of contraceptive pills, or hormonal-induced pregnancy, urinary tract infection in the year preceding pregnancy, and less desire to become pregnant. Further more BMI > 30, was excluded in the multivariate analysis.

Van Dongen et al. (1999) examined 509 women post partum and concluded that hypermobility was not a risk factor for postpartum PGP.

Previously the hormone relaxin was thought to be involved in the etiology of pregnancy-related PGP. Early studies, (MacLennan et al. 1986) concluded that an increased concentration of serum relaxin was a risk factor; this was also reported in the study by Kristiansson et al. (1996c) using human relaxin assays. However, this correlation has not been confirmed by subsequent studies using human relaxin assays (Albert et al. 1997, Hansen et al. 1996). Other studies on joint laxity of peripheral joints confirm that there is no proven correlation between the level of serum relaxin and joint laxity (Schauberger et al. 1996).

Discussion

The epidemiological studies reported are all prospective, and follow a strictly epidemiological design by examining an unselected group of pregnant women reporting for a maternity check-up. The studies include a large numbers of participants, 5586 in total. The applied diagnostic tests were tested for inter-tester reliability sensitivity and specificity and only patients with PGP were included. Furthermore, two of the studies (Albert et al. submitted) and Larsen et al. 1999) performed multivariate logistic regression analysis in order to identify possible confounders and interactions. Unfortunately, not all the studies examine the same risk factors.

Conclusion

Risk factors for developing PGP during pregnancy are most probably: a history of previous low back pain and/or previous trauma to the pelvis. There is slight conflicting evidence (one study) against the following risk factors; pluripara and high work load.
There is agreement that non risk factors are: contraceptive pills, time interval since last pregnancy, height, weight, smoking amd most probably age (one study reports that young age is a risk factor).

Non-pregnancy related pelvic girdle pain

No studies have been published on the risk factors for the non-pregnant population to develop PGP, or which women or men are at risk to continue having PGP.

Diagnosis

Grading of evidence and the strength of recommendations is according to the guidelines for the diagnosis of acute low back pain (WG1)

Clinical tests

Evidence (level A)

Test specifically evaluated in *pregnant* women

In an epidemiological study Albert et al. (2000) examined 2269 consecutive pregnant women by means of inspection of pelvic tilt, palpation of muscles, one test for a locked SIJ, nine pain provocation tests for the SIJ and two pain provocation tests for the symphysis. The sensitivity for the 11 provocation tests ranged from 0.11 to 0.93, with a specificity ranging from 0.77-1.00. The kappa values for the inter-tester reliability ranged from 0.34 to 0.89, with 6 tests in the all most perfect group, 3 in the substantial, 2 in the moderate and one in the fair group. The tests with the highest kappa values were palpation of the symphysis, Menell's test, passive hip abduction/ adduction/ flexion test, separation, compression, Posterior Pelvic Pain Provocation test (P4/ thigh thrust test), the modified Trendelenburg test, pelvic topography/positioning, and Patrick's faber test (flexion/ abduction/ extrernal rotation test).
The tests with the highest sensitivity and specificity for the SIJ were the P4, Patrick's faber test and Menell's test. The tests with the highest sensitivity and specificity for the symphysis were palpation of the symphysis and the modified Trendelenburg test.
Östgaard et al. (1994a) examined 342 women before they underwent different treatment programs. All women performed the P4 test and the sensitivity and specificity was reported to be 81% and 80% respectively.
In a prospective cohort study Kristiansson et al. (1996b) examined 200 pregnant women with several tests for the total spine. In the pelvic area they performed palpation of two ligaments, four pain provocation tests for the SIJ, and one pain provocation test for the symphysis. The inter-tester reliability and sensitivity and specificity were tested. The sensitivity of the five provocation tests was highest ranging from 0.12 to 0.87, with a specificity ranging from 0.85 to 0.99. No kappa values were reported.
Hansen et al. (1996) examined 238 women who complained of pain in 2 out of 5 selected ADL activities with palpation of muscles and ligaments, two pain provocation tests for the SIJ and two pain provocation tests for the symphysis. These tests had previously been scrutinized by Wormslev et al. (1994). In the study by Wormslev and colleagues (1994) the inter-tester reliability of several applied tests was thoroughly examined. The tests with the highest kappa values ranging from 0.41 to 0.60 were chosen for use in the next study; these tests were Patrick's test, palpation of the symphysis, the modified Trendelenburg test, palpation of the sacrotuberous ligament and the ilio-psoas muscle.
Only in the four latter studies were the inter-tester reliability, sensitivity and specificity for pregnant women studied. The test for the joints with the highest kappa values were palpation of the symphysis, the modified Trendelenburg test, and Patrick's faber test.

Tests specifically evaluated in *postpartum* women

Evidence (level C)

Kogstad (1988) examined 95 women postpartum with a thorough examination consisting of 120 variables. Inspection of walking was performed, posture and pelvic tilt, palpation of muscles and ligaments, checking of presumed locking of the SIJ with two tests, and four provocation tests for the SIJ. The tests of the pelvic joints are described in detail, but the sensitivity and specificity of the used tests were not reported.

Mens et al. (2001, 2002a) evaluated the Active Straight Leg Raise (ASLR) in postpartum women; this is a functional pelvic girdle test. The test was examined for reliability in 50 patients with varying degree of symptoms scored with a one-week interval. The score was unfortunately only analyzed with correlations coefficients and no kappa. Pearson's correlation coefficient was 0.82 and the ICC was 0.82. In 200 patients the test was evaluated with regard to sensitivity and specificity. It was compared with the P4 test, and a sensitivity of 0.87 and a specificity of 0.94 were reported. In the absence of a gold standard for pelvic pain (Mens 2002a) the validity of the ASLR was evaluated in an extensive set of aspects that is expected to correlate with disease severity, and compared with other tests for pelvic pain such as the P4, pelvic torsion, sacral thrust, lumbar pressure, and tenderness of the long dorsal ligament, and compared with an existing pain disability scale.

Vleeming et al. (2002) evaluated palpation of the long dorsal sacroiliac ligament. The ligament is palpated directly under the posterior superior iliac spine and some training is required to properly locate the ligament. Njoo (1993) examined the reliability and validity of this test and found a high inter-tester reliability with a kappa of 0.76 (0.64-88). Unfortunately no strict distinctions were made between lumbar and pelvic pain.
Vleeming et al. (2002) performed a reliability study of the long dorsal sacroiliac ligament in 178 women with postpartum pelvic pain.
The women were examined with the P4 and the ASLR tests, and palpation of the long dorsal sacroiliac ligament. Patients were included in the study on the basis of history only. Of the patients, 76% indicated that the palpation caused pain; sensitivity was 0.76. If a cut-off score was chosen in which both the P4 and ASLR test had to be positive, the sensitivity of the test increased to 0.86; if only women with severe pain were included the sensitivity of test increased to 0.98.

Tests specifically evaluated on patients with *non pregnancy* related pelvic girdle pain
Evidence (level A)
Van der Wurff (2000 a,b) performed a thorough systematic literature review of both the reliability and validity of SIJ tests and published two papers.

Reliability
In their reliability paper, van der Wurff et al. (2000 a) scrutinized the methodological quality of the included studies. Of the 11 studies reviewed, 9 had an acceptable methodological quality. Even though it was not an exclusion criterion, they did not include any studies on pregnant women. The studies included were: Van de Wurff et al. 1996, Maigne et al. 1998, Carmichael 1987, Strender et al. 1997, Potter and Rothstein 1985, Laslett and Williams 1994, McCombe et al. 1989, Dreyfuss et al. 1996, Deursen et al. 1990, Herzog et al. 1989, and Wiles 1980. They are presented here with the highest quality first.

Concerning the palpatoric/mobility *test* of the SIJ, the following tests were described in the review: The Overtake (Vorlauf) phenomenon, spine test, lateroflexion test, Gillet test, sitting flexion test, long sitting test, flexion-adduction test, translation SIJ, prone knee flexion test, and the Maitland test. Of the 19 evaluations in the literature, 16 judged these tests to be unreliable. Only three tests were judged to be reliable; 2 of these 3 reliable scores were in the studies with the lowest methodological quality (<50 on a 0-100 scale).

The pain provocation tests evaluated were; gapping or distraction test, compression test, Gaenslen test, sacral thrust, P4/thigh thrust, cranial shear test, Patrick's faber sign test, flexion-adduction hip.

The reliability in these tests was higher. Of the 18 evaluations, 7 were found to be reliable and these studies also had an acceptable methodological score. Agreement exists on the reliability of the P4/thigh thrust and Gaenslen test, while there is disagreement concerning Patrick's faber test, and the gapping and compression test. There is agreement on the unreliability of sacral thrust, cranial shear and flexion-adduction hip.
Following this review by van der Wurff and colleagues several new studies on the subject have been published.

Vincent-Smith et al. (1999) selected nine experienced examiners who then underwent a training session to familiarize themselves with the protocol and methods. They then performed the standing flexion test on 9 subjects. The inter-examiner reliability was low with a kappa of 0.052. The intra-examiner reliability was reasonable with an average of 0.46.
Toussaint et al. (1999), examined 480 construction workers with six tests for the SIJ. They used three palpatoric tests and three pain provocation tests and compared these tests painwise. No individual reliability test was performed on each test. The general agreement of the pairwise tests was a kappa of 0.30 to 0.68. The authors emphasise the difficulties in using palpatoric test in the diagnosis. Toussaint et al. advocate that it is necessary to promote overall uniform examination procedures in the future..

Riddle et al. (2002) investigated the inter-tester reliability of 4 tests in 65 patients: 34 physiotherapists performed the tests for SIJ regional joint dysfunction. These physiotherapist regularly treated patients with low back pain (⅓ of the patients), and on average had 10.1 years experience with treating low back patients. The therapists were given written descriptions and photographs of the procedure. They investigated: the standing flexion test, prone knee flexion test, supine long sitting test, sitting PSIS test and found kappa values ranging from 0.19 to 0.37. They conclude that the reliability of measurements obtained with these four tests is too low for clinical use. The reasons for these low kappa values are probably due to two factors: the usual difficulties in performing tests which rely on observation or palpation, and that the physiotherapists were given the instruction in writing with photographs and no practice sessions were organised.

Two studies propose that the diagnosis of pelvic pain has to be based on a cluster of tests, selected from a specific test battery.
Cibulka and Koldehoff (1999) had two experienced examiners who examined 219 patients with and without low back pain and with and without SIJ pain, to evaluate whether the examiners could establish the diagnosis SIJ dysfunction. The patients were classified as having SIJ dysfunction if 3 out of 4 palpatoric tests were positive. The four palpatoric tests evaluated were: the standing flexion test, sitting posterior-superior iliac spine palpation, supine long-sitting test, and prone knee flexion test. They found 13 patients without low back pain and SIJ dysfunction; 86 patients with low back pain had SIJ dysfunction. They reported a sensitivity of 0.82 and a specificity of 0.88 for a cluster of SIJ tests.
Kokmeyer et al. (2002) had two examiners who examined 59 patients with symptoms and 19 patients without symptoms. They used the gapping test/distraction test, compression test, thigh thrust/P4, Gaenslen's test and Patrick's faber test. The reliability of the individual tests ranged from a kappa of 0.45 to 0.67.
They also evaluated whether the examiners could agree on a diagnosis, and report slightly higher kappa values for the diagnosis ranging from 0.63 to 0.74 if the tests were pooled. The difference in agreement depending on the number of positive tests required was low; the kappa value was 0.66 with the requirement that the examiners had to agree in all 5 tests, whereas the highest kappa value was 0.74 when the examiners agreed on a diagnosis

based on only two tests. It is therefore surprising that the authors conclude that 3 positive tests are the threshold to propose a diagnosis, while their own results show that 2 tests yield the highest agreement values.

Validity
The validity of SIJ tests are difficult to describe due to the lack of a gold standard. Maigne et al. (1996) claim that (double) anesthetic block procedures of the SIJ are the gold standard. But there are serious problems with this approach; they are only effective in diagnosing pathological afflictions within the SIJ. Therefore this procedure is probably valid only if the pain problem is intra-articular. These intra-acticular anesthetic block procedures neglect pain arising from the ligamentus apparatus surrounding the joint, i.e. the long dorsal ligament and the interosseseous SIJ ligaments and other dorsally located ligaments of the joint, which are probably an important source of pain. This is illustrated in the study by Schwarzer et al. (1995) where 43 of their patients complained of pain over the SIJ but only 13 had relief after an anesthetic block. Therefore, it is difficult to make clear statements regarding the validity of tests against a so-called gold standard that fails to include all the extra-articular structures.

Discussion
A review of the literature reveals that a wide variety of examinations, procedures and tests have been used to investigate pregnant and non-pregnant patients.
In the studies where the examination procedures of pregnant women are described, a combination of methods for diagnosis has been used: inspection of walking, posture and pelvic tilt, palpation of ligaments and muscles, tests for a locked SIJ, and pain provocation tests for the SIJ and the symphysis. The early studies focused more on the inspection and palpatoric findings, whereas the later studies have focus more on pain provocation tests, probably due to the higher reliability and specificity of these latter tests. The pain provocation tests with the highest reliability and most frequently used for SIJ pain are the P4/thigh thrust test and Patrick’s faber test. For pain in the symphysis these tests are palpation of the symphysis, and the modified Trendelenburg test used as a pain provocation test.

Recommendation
The following tests are recommended for clinical examination of PGP:
SIJ Pain
Posterior pelvic pain provocation test (P4/thigh thrust), Patrick’s faber test, palpation of the long dorsal SIJ ligament, and Gaenslen´s test.
Symphysis
Palpation of the symphysis and the modified Trendelenburg function test of the pelvic girdle
Functional pelvic test
Active straight leg raise test (ASLR).

It is strongly recommended that a pain history be taken with special attention paid to pain-arising during prolonged standing walking and/or sitting. To ensure that the pain is in the pelvic girdle area, it is important that the precise area of pain be indicated: the patient should either point out the exact location on his/her body, or preferably shade in the painful area on a pain location diagram

Imaging Techniques

Imaging of the SIJ is mainly based on the diagnosis sacroiliitis. Sacroiliitis can be differentiated in: ankylosing spondylitis (AS), reactive arthritis, psoriatric arthritis, arthritis of chronic inflammatory bowel disease, and undifferentiated spondyloarthropathy (Braun et al. 2000).

Conventional Radiography *(Level C)*

Evidence: There are limited indications for using conventional radiography due to the poor sensitivity in detecting the early stages of degeneration and arthritis of the SIJ (Ohen et al. 1967). In a review, Braun et al. (2000) stated that other modalities such as CT and MRI had a much higher sensitivity to detect early degenerative changes around the SIJ. It was also concluded that there was no consensus about the ideal projection angles to effectively analyze the complex anatomy of the SIJ.

Dijkstra et al. (1989) showed that there is a large variation in the configuration of the SIJ. Based on plain radiography 6 patients, and on frontal tomography 5 patients, in a total of 56 AS patients with 72 imaged joints, were diagnosed as normal. However, based on oblique tomography, tailored to the individual joints of the same patients, 31 joints were now diagnosed as normal. Obviously, individually tailored oblique tomography of the SIJ is necessary to gather trustworthy information.

Osteitis condensans ilii (OCI) is a poorly defined roentgenological abnormality, with no known clinical explanation of the origin of the roentgenological appearances (Julkunen and Rokkanen 1969; Rojko and Farkas 1959; Soucy et al. 1969; Withrington et al. 1985). The term OCI should be regarded with suspicion when applied to young people with a history of backache and needs further evaluation.

Recommendation: We can not recommend conventional radiography.

Computer Tomography (CT) *(Level C)*

Evidence: One CCT of reasonable methodological quality showed positive findings (subchondral sclerosis, non-uniform joint width, osteophytes) in 57.5% of patients with relief of pain in the SIJ, after application of an anesthetic block under CT guidance (Elgafy et al. 2001). In this study the differentiation between lumbar and pelvic pain was made without the use of specific sensitive test of the SIJ; however, lumbar spinal disease was excluded by MRI. In another study, a group of patients with undefined lowest back pain (below L5-S1) (Hodge and Bessette 1999) showed with CT that 75% of the patients had findings of osteoarthritis of the SIJ.

Degenerative changes were found in 60% of SIJ among healthy people between 20 and 29 years and 94% in the SIJ in the 40-49 year group (Shibata et al. 2002). In women, the birth of the first child had the greatest impact on changes in the SIJ (Shibata et al. 2002).

Discussion: Degenerative findings are found already in the young age among healthy individuals. The question in these studies is whether normal development of symmetrical grooves and ridges, as have been demonstrated by Vleeming et al. (1990 a) and Dijkstra et al. (1989) can be regarded as osteoarthritis. The relation between roentgenological visible changes and symptoms is not sufficiently clarified to propose CT as a standard procedure for PGP patients, also because the radiation dosage of this method is high.

Recommendation: Do not use CT.

Magnetic Resonance Imaging (MRI) *(Level B)*
Evidence: Several reviews report that MRI enables detection of early diagnosis of ankylosing spondylitis (Braun et al. 2000, Gugliemi et al. 2000, Oostveen and van de Laar 2000). MRI shows early inflammatory changes in the bone marrow and in the SIJ joint capsule (Braun et al. 2000). One study reveals postpartum lesions in the pelvic joints in symptomatic patients (Wurdinger et al. 2002). Puhakka et al. (2003) showed that MRI and CT had equal efficacy, but were superior to radiography in the classifying of erosions and osseous sclerosis. Only MRI allowed visualization and grading of active inflammatory changes in the subchondral bone and surrounding ligaments of the SIJ.
Discussion: MRI is an important tool for excluding early ankylosing spondylitis and severe traumatic (postpartum) injuries.
Recommendation: Consider using MRI for discriminating changes most effectively in and around the SIJ; Early ankylosing spondylitis (AS) as well as tumors can be easily detected. To establish the diagnosis of PGP normally imaging techniques are only needed in AS, or for patients showing “red flag” signs and when surgical intervention procedures are considered.

Scintigraphy *(Level C)*
Evidence: One study (Maigne et al. 1998) shows 90% specificity for increased uptake over the SIJ with a quantitative radionuclide bone scanning, correlated to a positive intra-articular block (indicating PGP) in a group of patients with more than 7 weeks of unilateral low back pain. Another study (Yildiz et al. 2001) concluded that scintigraphy was neither specific nor sensitive enough in the detection of sacroiliitis.
One study (Slipman et al. 1996) showed very low sensitivity with only 4 positive scintigrams out of 31 patients with pain relief after an intra-articular SIJ anesthetic block. In two studies (Dequeker et al. 1978, Ho et al. 1979) the radionuclide uptake in patients with sacroiliitis was not above the range for controls. The authors conclude that the results are non-specific due to the high bone turnover in general in the region of the SIJ.
Discussion: Scintigraphy is not suitable to make distinctions between PGP and healthy controls based on the present literature.
Recommendation: Do not use scintigraphy for PGP.

Pain Referral Maps *(Level C)*
Evidence: A pain referral map was generated using provocative injections into the right sacroiliac joint in 10 healthy volunteers. Out of 54 patients with low back pain, two independent examiners identified 16 and 17 (the same 16 plus one) patients respectively with a positive pain mapping according to the pain referral map. Ten out of 16 patients reported more than 50% relief on the visual analogue scale (Fortin et al. 1994 a, b).
In a cross-sectional study Sturesson et al. (1997) found that 171 out of 338 pregnant women tested positive for the P4 test. A typical pain pattern was identified. Women with a unilateral positive P4 test result had gluteal and posterior thigh pain more often than the other pregnant women, with a stabbing pain sensation. Women testing positive for a bilateral P4 test more often also had lumbar, lumbosacral, symphyseal or groin pain than women testing negative. Women with a negative P4 result, rarely had pain in the gluteal area or the symphysis.
Discussion: Pain mapping as a tool for differentiating between lumbar and pelvic pain can be used as a diagnostic tool in assessing PGP. There are indications for using pain referral maps with the concentration of pain directly under the posterior superior iliac spine, in the gluteal area, the posterior thigh and groin, as a typical pain drawing for PGP.
Recommendation: We recommend pain referral maps.

Diagnostic Injection Techniques *(Level C)*
Evidence: One RCT (Broadhurst and Bond 1998) shows 100% specificity and a range of sensitivity of 77-87% for three PGP provocation tests (Patrick's faber test, posterior pelvic pain provocation test and resisted leg abduction test from a supine position) when using lignocaine 1% intra-articularly in the SIJ compared to injection of normal saline in the SIJ. None of the saline-injected patients showed substantial relief of pain on these tests in contrast to the lignocaine group. The authors conclude that the indicated tests are substantially reliable and they prefer clinical functional assessment of SIJ patients with these tests.
However, Dreyfuss et al. (1996) used the same techniques in 85 patients to compare 12 SIJ tests with intra-articular block injections, including Patrick's faber test, the thigh thrust test (P4), as in the Broadhurst and Bond study. The authors state that in their study none of the 12 physical examination tests proved to be diagnostically sound, which is in sharp contrast to the findings of the Broadhurst and Bond study. Also, Dreyfuss et al. (1996) regard intra-articular blocks as the gold standard without realizing that the procedure mainly has an effect on the intra-articular part of the SIJ.

In a study by Pulisetti & Ebraheim (1999), 90 % of the patients had a pain relief effect of the anesthetic block for 2-14 days. Maigne et al. (1996) studied the effect of several sacroiliac pain provocations tests with a double block anesthetic technique and questioned the accuracy of the tests. However, Maigne et al. (1996) used a mixture of tests, some with low sensitivity and specificity.

Another study (Rosenberg et al. 2000) shows that when SIJ injections are performed without image guidance, only in 22% of the patients is the injected fluid localized intra-articularly and in 24% of the patients the fluid is localized in the epidural space. Dussault et al. (2000) however, showed that with fluoroscopy-guided SIJ injections the success rate was 97%. According to the authors fluoroscopy-guided SIJ injections are safe, rapid, and reproducible (Dussault et al. 2000).
Discussion: Injection with a local anesthetic block in the SIJ relieved the pain (Broadhurst and Bond 1998), experienced by three different PGP provocation tests. This indicates that positive tests most likely reflect intra-articular pain arising from the SIJ. However, a negative test is not able to exclude extra-articular causes of PGP, such as superficial ligament pain.
In the study by Dreyfuss et al. (1996) the patients had to experience a 90 to 100% reduction of the pain to obtain a positive diagnosis of SIJ pain. Such a high threshold for pain relief probably strongly influenced the results of their study.
The studies also show that SIJ anesthetic blocks should only be performed under fluoroscopic guidance and only performed by specifically trained physicians. However, a combination of simple manual diagnostic tests, with high sensitivity and specificity, as proposed in the diagnosis section, probably analyses a broader spectrum of PGP complaints. More research is necessary, in which studies on fluoroscopic guided intra-articular anesthetic block studies, are combined with superficial injections of extra-articularly orientated SIJ ligaments and related to manual diagnostic tests, as in the study of Broadhurst and Bond (1998).
Recommendations: Do not use local SIJ injections as a diagnostic tool for PGP.

Outcome measures

The aims of treatment for PGP are to relieve pain, to improve functional ability, and to prevent recurrence and chronicity. Relevant outcomes for PGP are pain intensity, functional status, health-related quality of life, general improvement, impact on employment and physical parameters. Intervention-specific outcomes may also be relevant. Until now, no ideal set of measures specifically designed and validated for PGP has been established. (Mens et al. 2000b). Since there seem to be grounds for classifying low back and pelvic girdle pain as two different conditions, outcome measures validated for LBP are not necessarily the most sensitive for PGP. Therefore, outcome measures that are sensitive to change in clinical trials for the specific patient group studied are needed (Beaton 2000). Future studies should therefore address the challenge of developing suitable outcome measures to assess functional status for pelvic girdle pain. The Quebeck Back Pain Disability Scale (QBPDS) (Kopec et al. 1995), Oswestry Low Back Pain Disability Questionnaire (Fairbank et al. 1980) and Disability Rating Index (Salèn et al. 1994) are used in intervention studies of PGP. Mens et al. (2000b) have shown that when a global impression of improvement scored by the patient was used as criterion standard, the QBPDS, hip adduction strength and ASLR test were the most useful outcome measures for PGP. In addition, the SCL-90-R, assessing psychological distress in chronic patients, may be applied to PGP patients (Arrindell, submitted).

Treatment for Pelvic Girdle Pain

The recommendations for treatment of pelvic girdle pain (PGP) are based on the general methods as defined by the Cost Action B13 working group on PGP (WG4). The following treatments were evaluated: physical therapy, exercises, individual treatment, massage, modified back schools, water gymnastics, acupuncture, the use of a specially shaped pillow, information, mobilization/manipulation, electrotherapy, pelvic belt, external fixation, surgery and injection therapy.

Only 3 RCT´s were identified that focused specifically on PGP during (Nilsson-Wikmar et al. 2003) and after pregnancy (Mens et al. 2000; Stuge et al. 2004a). These studies are of high methodological quality. Nilsson-Wikmar et al. (2003) and Mens et al. (2000) found no difference between exercises and information during and after pregnancy. Stuge et al. (2004a) demonstrated that an individualized treatment program focusing on specific stabilizing exercises had a highly significant effect on pain, disability, health-related quality of life and physical outcome measures, with long-lasting effects one and two years postpartum (Stuge et al. 2004b). These studies will be discussed in the following section.

Physical therapy in general

Recommendation: Consider using physical therapy during pregnancy, it is not possible to recommend any particular treatment modality based on these studies.

Evidence (Level B): One systematic review evaluated the effectiveness of physical therapy interventions for pregnancy-related low back and pelvic pain (Stuge et al. 2003). Of the 17 studies found, 9 were clinical controlled trials, 4 were randomised and 3 were considered high methodological quality studies (Kihlstrand et al. 1999; Mens et al. 2000; Nilsson-Wikmar et al. 2003). One study investigated postpartum women (Mens et al. 2000).

Discussion: Because of the heterogeneity and the varying quality of the studies included in the systematic review, there is no strong evidence concerning the effect of physical therapy interventions on the prevention and treatment of back and pelvic pain related to pregnancy.

Evidence was often related to multifactor programs which include a variety of modalities, such as information, specific exercises, ergonomic advice and mobilisation. The effectiveness of the various components of these programs remains unclear.

Exercises

Exercises for PGP in pregnancy

*Recommendation***:** Consider using exercises in pregnancy.

Evidence (Level C): Six studies have examined the effect of exercises in pregnancy with inconsistent results (Dumas et al. 1995; Kihlstrand et al. 1999; Nilsson-Wikmar et al.2003; Noren et al. 1997; Östgaard et al. 1994b; Suputtitada et al. 2002).

Discussion: The interventions were heterogeneous with regard to type and duration of exercises, whether performed individually or in groups. One study was of high methodological quality, showing an effect of water gymnastics on pain and sick-leave (Kihlstrand et al. 1999). However, the control group was given no attention, which may have biased the results.

Two trials of moderate to low methodological quality studying individualized physical therapy with exercises show significant positive effects on pain intensity and sick leave (Noren et al. 1997; Östgaard et al.1994b). Only one study (Nilsson-Wikmar et al. 2003) used specific inclusion criteria for PGP. The patients were randomized into three different treatment groups; information, home exercises, and an in-clinic exercise group. There was no significant difference between the groups during pregnancy or at the follow-up (3, 6 and 12 months postpartum) regarding pain intensity and activity.

Exercises for PGP postpartum

Recommendation: We recommend is the use of an individualized treatment program including specific stabilizing exercises as part of a multifactorial treatment for PGP postpartum.

Evidence (Level C): Two RCTs with high methodological quality have studied PGP postpartum (Mens et al. 2000; Stuge et al. 2004a); specific inclusion criteria for PGP were used in both studies. Mens et al. (2000) compared video instructed exercises for diagonal trunk muscle system with placebo exercises and no exercises. The exercises were not individualized and supervised. No significant differences were found between the groups after 8 weeks of intervention. In the study of Stuge et al. (2004a), a treatment program focusing on specific stabilising exercises was compared with physical therapy without specific stabilizing exercises. A treatment program focusing on specific stabilising exercises had statistically and clinically a significantly better effect on pain, functional status, health-related quality of life and physical tests than physical therapy without specific stabilizing exercises, measured after 20 weeks of intervention and 1 year postpartum.

A two year follow-up study showed persisting low levels of pain and disability in the exercise group and significant differences between the comparison groups (Stuge et al. 2004b).

Discussion: These two studies differ in type of intervention, individualization, dosage, duration and guidance, and in the number of subjects studied. In the study of Mens et al. (2000), 25% of the subjects terminated their exercise program due to pain, probably because of too heavy exercises. A treatment program with specific exercises that include local and global muscle systems, individually adapted and guided by a physical therapist showed best effects. Further investigation is needed to identify the most effective elements in this type of individual intervention program.

Comment on exercises in pregnancy and postpartum
Compose and start an individual training program, emphasizing and starting with activation and control of local deep lumbopelvic muscles. Gradually include the training of more superficial muscles in dynamic exercises to improve control mobility, strength, and endurance capacity. A pelvic belt can be fitted to test for symptomatic relief, but should only be supplied for short periods.

Individual treatment
Recommendation: We recommend individualized physical therapy in pregnancy.
Evidence (Level C): Two moderate to low methodological quality studies investigated individualized physical therapy (Noren et al. 1997; Östgaard et al. 1994b). The two studies had no specific inclusion criteria, except from being pregnant. Östgaard et al. (1994b) compared individual physical therapy with two classes of modified back- school education with training and a control group. They found that individual physical therapy showed significantly higher reduction in sick leave and lower pain intensity 8 weeks postpartum compared to the control group. Noren et al. (1997) compared individualized physical therapy with no specific treatment. Pain intensity and sick leave was significantly reduced. However, no comparison between groups was performed for pain intensity, and the control group received less attention.
Discussion: Based on these findings individually tailored programs were more effective than general group training or no treatment. In our opinion treatment should be based on the findings in an individual examination.

Massage
Recommendation: We can not recommend massage as a stand-alone treatment for PGP in pregnancy.
Evidence (Level C): One quasi-randomized controlled trial studying pregnant women, compared massage therapy with progressive muscle relaxation therapy and found significantly less back pain intensity, reduced anxiety, improved mood and better sleep in the massage group. No comparisons between the groups were made (Field et al. 1999). There were no specific inclusion criteria, apart from being pregnant.
Discussion: Massage might be helpful as part of a multidisciplinary individualized treatment.

Modified back school classes
Recommendation: We can not recommend back school classes as a treatment for PGP in pregnancy.
Evidence (Level C): Two moderate to low methodological quality studies investigated back school classes (Mantle et al. 1981; Östgaard et al.1994b). There were no specific inclusion criteria, except from being pregnant. No significant effect was found on pain intensity or sick leave (Östgaard et al. 1994b). A significantly higher proportion of the control group experienced “troublesome” or “severe” backache, compared with the treated group; however, compliance was very low (Mantle et al.1981).
Discussion: Both studies examined an intervention with only two classes of modified back school education with training and ergonomic back care advice. The amount of therapy may have been too smalll to expect a realistic change, or group treatment may not be sufficient for effective treatment.

Watergymnastics
Recommendation: Consider using water gymnastics during pregnancy.
Evidence (Level C): One RCT of high methodological quality compared water gymnastics with a control group receiving no treatment, and showed a significant effect of water gymnastics on sickleave and pain intensity at its worst the first week postpartum (Kihlstrand et al. 1999). There were no specific inclusion criteria, apart from being pregnant.
Discussion: Even though there was a significant effect of the water gymnastics, the intensity of back pain increased during pregnancy in both groups. The control group was given no attention, which may have biased the results.

Acupuncture
Recommendation: Consider using acupuncture during pregnancy.
Evidence (level C): Two studies have investigated acupuncture in the treatment of LBP and PGP during pregnancy (Kvorning et al. 2004; Wedenberg et al. 2000). There were no specific inclusion criteria, apart from being pregnant. One study of moderate to low methodological quality compared acupuncture with physical therapy (Wedenberg et al. 2000). A significant effect on pain and functional status, in favor of acupuncture, was found. The results may be biased by high drop-out rates and because the groups differed with regard to pain location (LBP and PGP). Furthermore, individual acupuncture treatment was compared to physical therapy given mainly as group treatment. Another study (Kvorning et al. 2004) compared acupuncture with no treatment. Acupuncture patients were significantly less bothered by pain compared with the control group. However, the study was of moderate to low methodological quality because of high drop-out, no intention-to-treat analysis, and lack of attention given to the control group.
One study (Elden et al. 2004) of high methodological quality, showed significant effect of acupuncture on pain compared to standard treatment. No differences were found regarding sickleave.
Discussion: There are indications that acupuncture may be helpful, but more high quality studies are needed.

Using specially shaped pillows to reduce back pain
Recommendation: We can not recommend a specific pillow as a treatment for PGP during pregnancy. *Evidence* (Level C): One crossover trial compared the use of a specially shaped pillow to fit under the woman`s abdomen (Ozzlo pillow) with a standard pillow (Thomas et al. 1989). There were no specific inclusion criteria, apart from being pregnant. Lower scores for backache at night were recorded the week women used the Ozzlo pillow; there were no differences in sleeping scores.
Discussion: A crossover study with no separate control group is considered to be a weaker design than an RCT. Moreover, because there is no theoretical rationale behind this intervention, and because the tested pillow is not commercially available, the results of this study are of minor interest here.

Information
Recommendation: Communicate the condition in such a way that the patient understands and acknowledges his or her specific problem. The purpose of this information is to reduce fear and to enable patients to become active in their own treatment and rehabilitation. It is essential that the information and treatment are consistent across professions to preclude unnecessary anxiety about the condition.
Give adequate advice concerning activities of daily living.

Ensure that the patient understands and respects the relation between impairment, load demand and the actual loading capacity of the patient so that sufficient time for recuperation will be made.
Evidence (Level D): No RCT or CCT investigating information as a single treatment has been found. Several studies have included information as part of their interventions.
Discussion: The purpose of information is mainly to reduce fear and to help patients to take active part in their treatment and/or rehabilitation. To give adequate information and ergonomic advice is considered useful. It is important that information and treatment are consistent across professions, and that all healthcare providers closely collaborate with each other. Information and skilled communication is needed to help the patient understand the condition and increase the patient`s understanding of their problem. It is essential that the patient is taken seriously and that their suffering be acknowledged by a skilled physician. General information on PGP needs to be presented (anatomy, biomechanics, motor control) and the patient reassured that their problems are not dangerous to them or their child and that they will most likely improve/recover. The patient needs encouragement to enjoy physical activity and manage and combine this with periods of rest to recuperate (considering their overall loading capacities).

Manipulation and Mobilization
Recommendation: We can not recommend manipulation and mobilization
Evidence (Level D): No RCT or CCT investigating manipulation or mobilisation has been found. Four studies, however, have examined manipulation (Daly et al.1991; Diakow et al. 1991) or mobilisation for PGP in pregnancy (Berg et al. 1988; McIntyre & Broadhurst 1996).
Discussion: The results of the studies indicate that manipulation and mobilisation might be a possible treatment for PGP. However, the studies had few participants and no control group. Manipulation of the SIJ has been shown to normalize clinical test results without altering the position of the SIJ (Tullberg et al. 1998). The results of the studies may be based on a positive soft tissue response.

Pelvic belt
Recommendation: We can not recommend a pelvic belt
Evidence (Level D): No RCT or CCT investigating the use of a pelvic belt has been found.
Discussion: Several studies have included the use of a pelvic belt as part of their interventions but without investigating it as a single treatment (Mens et al. 2000; Nilsson-Wikmar et al.2003; Östgaard et al. 1994b) (Berg et al.1988; Wedenberg et al. 2000). The results show that a pelvic belt may reduce mobility/laxity of the SIJ (Damen et al. 2002a; Vleeming et al. 1992b). Effective load transfer through the pelvis, measured by Active Straight Leg Raising (ASLR) has been improved by application of a pelvic belt (Mens et al. 1999). A pelvic belt may be fitted to test for symptomatic relief, but should only be applied for short periods.

Electrotherapy
Recommendation: We can not recommend electrotherapy.
Evidence. No study has been identified.

SIJ Therapeutic Injection Therapy and Radiofrequency Denervation
Recommendations: Consider using Intra-articular SIJ injections (under image guidance) for ankylosing spondylitis.
Evidence (Level B): In two RCTs (Luukkainen et al. 2002, Maugars et al. 1996), local anesthetics in combination with corticosteroids were applied to the SIJ in patients suffering

predominantly from non-specific spondyloarthropathies and AS; the procedure led to pain relief after 1 to 6 months in 60 to 88% of the patients. Two CCTs (Ferrante et al. 2001, Gevargez et al. 2002) reported that after application of local anesthetics and radiofrequency denervation of nerve endings, between 36 to 65% of the patients had pain relief after 3 months to one year. In one RCT (n=110) (Yelland et al. 2004) it was stated that after lumbopelvic ligament injection of 20% glucose and 0,2% lignocaine or normal saline injection that both groups reported sustained reductions in pain and disability irrespective of the injected substance.
Discussion: Different guiding techniques for intra-articular injections in the SIJ were used either under fluoroscopy or with CT or MR guidance. All studies showed immediate pain relief with decreasing effects over time. The therapeutic effect in inflammatory diseases is longer compared with osteoarthritis. Local injection appears promising with in patients with inflammatory diseases. However, proper studies are lacking to clarify whether additional SIJ injections are necessary besides medication for AS. There is a substantial effect of injection therapy independent of the used injection. Prolotherapy showed no benefit with local saline injections. Further studies are needed to confirm that intra-articular injections are essential, besides general medication. There is no evidence for non-AS PGP patients to use local injections as treatment. Radiofrequency denervation needs further research before recommendations can be made.

External fixation

Recommendations: Do not use an external frame fixator.
Evidence (Level D): The external fixation with a trapezoid Hoffman frame was introduced by Slätis and Karaharju (1975) for instable pelvic fracture treatment. In two studies with in PGP patients the external fixator reduced and relieved pain and improved the walking ability (Wahlheim 1984a, Slätis & Eskola 1989). In a radiostereometric analysis the external fixator reduced the movements in the SIJ in 10 patients to about 50% (Sturesson et al. 1999).
Discussion: Three independent studies showed that the preoperative application of an external frame fixation before fusion surgery can be helpful for decision-making concerning surgery. Application of the frame should not be used as an alternative for belts and should only be considered when all other treatment modalities applied by specialized professionals have failed. Randomized trials are needed.

Surgery

Recommendations: Do not use sacroiliac fusion.
Evidence: (Level D). No RCTs or CCT´s were identified. Eleven cohort studies on fusion surgery of the SIJ have been found (Smith-Petersen and Rogers 1926, Gaenslen 1927, Hagen 1974, Olerud & Wahlheim 1984, Waisbrod et al. 1987, Moore 1995, Keating 1995, Belanger and Dall 2001, Berthelot et al. 2001, van Zwienen et al, 2004, Giannikas et al. 2004). In most studies intraarticular SIJ anesthetic blocks were used as a preoperative inclusion criterion. Three studies advocate an external preoperative test, before surgery (Wahlheim 1984, Slätis and Eskola 1989, Sturesson et al. 1999).
Discussion:
Severe traumatic cases of PGP can be an exception to this recommendation, but only when other non-operative treatment modalities have failed by professionals with expert knowledge of the condition.
In that case, preoperative assessment with an external fixator for three weeks to evaluate longer lasting effects of fixation, is recommended.

Both clinical and biomechanical data support the use of an external fixator prior to surgery (Wahlheim1984, Slätis and Eskola 1989, Sturesson et al.1999).

In all reports of fusion surgery (Smith-Petersen and Rogers 1926, Gaenslen 1927, Hagen 1974, Olerud & Wahlheim1984a, Waisbrod et al. 1987, Moore 1997, Keating 1995, Belanger and Dall 2001, Berthelot et al. 2001, van Zwienen et al. 2004, Giannikas et al. 2004) preoperative evaluation was thorough and an operation took place only on patients in whom non-operative treatment had been unsuccessful.

The studies included 2 up to 77 patients and the results were assessed by the authors as fair to excellent in 50 to 89% of the patients. In a case report by Berthelot et al. (2001) two patients were operated and had total pain relief. Different techniques are described, but the transiliac technique described by Smith-Petersen & Rogers (1926) with some modifications was most widely used.

Intra-articular sacroiliac injections may also be a useful preoperative tool, but will probably only be an indicator in patients with intra-articular pathology.

In two studies additional symphysiodesis is advocated (Olerud & Wahlheim 1984, van Zwienen 2004). However from a biomechanical viewpoint this is highly questionable. Van Zwienen et al. (2004) reported that 15% of pseudarthrosis in the symphysis and 9% of nerve root injury was due to posterior instrumentation.

No evidence-based criteria exist for surgery of PGP and it is strongly recommended that physicians with extensive knowledge of the condition perform sacroiliac fusions within a scientific protocol.

Prevention

Evidence: Three RCTs of moderate to low quality investigated the effect of treatment for preventing PGP and LBP during pregnancy (Dumas et al.1995; Östgaard et al.1994b). No effect was found on prevention of incidence of LBP or PGP. No specific prevention study has been identified

Discussion: The interventions studied aimed both at prevention and treatment of pregnant women with or without PGP or LBP.

Recommendation: We can not recommend any prevention

Acknowledgement
The authors are grateful for the important contribution made by Diane Lee (PT) and Prof. Dr. F.C.T van der Helm to the basic part of this manuscript; especially in relation to the definition of joint stability.

References

1. Abramson D, Roberts SM, Wilson PD (1934) Relation of the pelvic joints in pregnancy. Surg Gynecol Obstet 58:595-613
2. Adams MA, Dolan P, Burton K, Bodguk N (2002) The biomechanics of back pain. Edinburgh:Churchill Livingstone
3. Albert H, Godskesen M, Westergaard J (2000) Evaluation of clinical tests used in classification procedures in pregnancy-related pelvic joint pain. Eur Spine J 9:161-166
4. Albert H, Godskesen M, Westergaard J (2001) Prognosis in four syndromes of pregnancy-related pelvic pain. Acta Obstet Gynecol Scand 80: 505-510
5. Albert H, Godskesen M, Westergaard JG, Chard T, Gunn L (1997) Circulating levels of relaxin are normal in pregnant women with pelvic pain. Eur J Obstet Gynecol Reprod Biol 74:19-22
6. Albert HB, Godskesen M, Westergaard JG (2002) Incidence of four syndromes of pregnancy-related pelvic joint pain. Spine 27:2831-2834
7. Albert H, Godskesen M, Westergaard JG. Risk factors in pregnancy-related pelvic joint pain. (Submitted)
8. Ansari N, Keyhani S, Jalaie S (2003) Low back pain during pregnancy, incidence and risk factors. WCPT congress Barcelona, Abstract
9. Arrindell WA, Janssen ICM (2004) Replication of SCL-90-R factors of symptom distress in patients with peripartum pelvic pain syndrome (submitted)
10. Bakland O, Hansen J H (1984) The axial sacroiliac joint. Anat Clin 6: 29–36
11. Beaton, DE (2000) Understanding the relevance of measured change through studies of responsiveness: Spine 25: 3192-3199
12. Belanger TA, Dall BE (2001) Sacroiliac arthrodesis using a posterior midline fascial splitting approach and pedicle screw instrumentation: a new technique. J Spinal Disord 14:118-124
13. Berg G, Hammar M, Möller-Jensen J, Linden U, Thorblad J (1988) Low back pain during pregnancy. Obstet & Gynecol 1:71-75
14. Berthelot JM, Gouin F, Glemarec J, Maugars Y, Prost A (2001) Possible use of arthrodesis for intractable sacroiliitis in spondylarthropathy: report of two cases. Spine 26:2297-2299
15. Bjorklund K, Lindgren PG, Bergstrom S, Ulmsten U (1997) Sonographic assessment of symphyseal joint distention intra partum. Acta Obstet Gynecol Scand 76:227-232
16. Bogduk N, Johnson G, Spalding D (1998) The morphology and biomechanics of the latissimus dorsi. Clin Biomech 13:377-385
17. Bowen V, Cassidy JD (1981) Macroscopic and microscopic anatomy of the sacro-iliac joints from embryonic life until the eighth decade. Spine 6:620-628
18. Braun J, Sieper J, Bollow M (2000) Imaging of sacroiliitis. Clin Rheumatol 19:51-57
19. Broadhurst NA, Bond MJ (1998) Pain provocation tests for the assessment of sacroiliac joint dysfunction. J Spinal Disord 11:341-345

20. Brooke R (1924) The sacroiliac joint. J Anat 58:299-305
21. Buyruk HM, Snijders CJ, Vleeming A, Laméris JS, Holland WPJ, Stam HJ (1995b) The Measurements of Sacroiliac Joint Stiffness with Colour Doppler Imaging: a Study on Healthy Subjects. Eur J Radiol 21:117-121
22. Buyruk HM, Stam HJ, Snijders CJ, Lameris JS, Holland WP Stijnen WP (1999) Measurement of Sacroiliac Joint Stiffness in Peripartum Pelvic Pain Patients with Doppler Imaging of vibrations (DIV). Eur J Obstet Gynecol Reprod Biol 83 2: 159-163
23. Buyruk HM, Stam HJ, Snijders CJ, Vleeming A, Laméris JS, Holland WPJ (1995a) The Use of Colour Doppler Imaging for the Assessment of Sacroiliac Joint Stiffness: a Study on Embalmed Human Pelvises. Eur J Radiol 21:112-116
24. Carmichael JP (1987) Inter- and intra-examiner reliability of palpation for sacroiliac joint dysfunction. J Manipulative Physiol Ther 10:164-171
25. Cholewicki J, Simons APD, Radebold A (2000) Effects of external trunk loads on lumbar spine stability. J Biomech 33:1377-1385
26. Cibulka MT, Koldehoff R (1999) Clinical usefulness of a cluster of sacroiliac joint tests in patients with and without low back pain. J Orthop Sports Phys Ther; 29:83-92
27. Clarke M, Oxman AD (1999), Cochrane Reviwers`Handbook 4.0, Oxford,England: The Cochrane Collaboration, In: Review Manager (RevMan)(Computer program). Version 4
28. Daly J, Frame PS, Rapoza PA (1991) Sacroiliac subluxation: A common treatable cause of low-back pain in pregnancy. Fam Practice Res J 11:149-159
29. Damen L Buyruk HM, Guler-Uysal F, Lotgering FK, Snijders CJ, Stam HJ (2001) Pelvic pain during pregnancy is associated with asymmetric laxity of the sacroiliac joints. Acta Obstet Gynecol Scand 80: 1019-1024
30. Damen L, Spoor CW, Snijders CJ, Stam H J (2002a) Does a pelvic belt influence sacroiliac laxity? Clin Biomech 17: 495-448
31. Damen L, Buyruk HM, Guler Uysal F, Lotgering FK, Snijders CJ, Stam HJ (2002b) The prognostic value of asymmetric laxity of the sacroiliac joint in pregnancy related pelvic pain. Spine 27: 2820-2824
32. Dequeker J, Goddeeris T, Walravens M, De Roo M (1978) Evaluation of sacro-iliitis: comparison of radiological and radionuclide techniques. Radiology 128:687-689
33. Deursen van LLJM, Patijn J, Ockhuysen A, Vortman BJ (1990) The value of some clinical tests of the sacroiliac joint. J Man Med 5:96-99
34. Diakow PR, Gadsby TA, Gadsby JB, Gleddie JG, Leprich DJ, Scales AM (1991) Back pain during pregnancy and labor. J Manip Physiol Ther 14:116-118
35. Dijkstra PF, Vleeming A, Stoeckart R (1989) Complex motion tomography of the sacroiliac joint: an anatomical and roentgenological study. Fortschr Geb Rontgenstr Nuklearmed. 150:635-642
36. Dreyfuss P, Michaelsen M, Pauza K, McLarty J, Bogduk N (1996) The value of medical history and physical examination in diagnosing sacroiliac joint pain. Spine 21:2594-602
37. Dumas GA, Reid JG, Wolfe LA, Griffin MP, McGrath MJ (1995) Exercise, posture, and back pain during pregnancy. Part 2. Exercise and back pain, Clinical Biomechanics 10:104-109
38. Dussault RG, Kaplan PA, Anderson MW (2000) Fluoroscopy-guided sacroiliac joint injections. Radiology 214:273-277
39. Egund N, Olson TH, Schmid H, Selvik G (1978) Movements in the sacroiliac joints demonstrated with roentgen stereophotogrammetry. Acta Radiol Diagn 19: 833-846

40. Elden H, Ladfors L, Olsèn MF, Östgaard HC, Hagberg H (2004) Effects of acupuncture and stabilizing exercises among women with pregnancy-related pelvic pain: a randomised single blind controlled trial, submitted
41. Elgafy H, Semaan HB, Ebraheim NA, Coombs RJ. (2001) Computed tomography findings in patients with sacroiliac pain. Clin Orthop 382:112-118
42. Endresen EH (1995) Pelvic pain and low back pain in pregnant women – an epidemiological study. Scand J Rheumatol 24:135-141
43. Fairbank JCT, Davies JB, Couper J, O`Brien JP (1980) The Oswestry Low Back Pain Disability Questionnaire, Physiotherapy 66: 271-273
44. Farbrot E (1952) The relationship of the effect and pain of pregnancy to the anatomy of the pelvis. Acta Radiol 38:403-417
45. Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG (1990) Low back pain in pregnancy. Spine 1:28-30
46. Ferrante FM, King LF, Roche EA, Kim PS, Aranda M, Delaney LR, Mardini IA, Mannes AJ (2001) Radiofrequency sacroiliac joint denervation for sacroiliac syndrome. Reg Anesth Pain Med 26:137-142
47. Field T, Hernandez-Reif M, Hart S, Theakston H, Schanberg S, Kuhn C (1999) Pregnant women benefit from massage therapy, J Psychosom Obstet Gynecol 20: 31-38
48. Fortin JD, Dwyer AP, West S, Pier J (1994a) Sacroiliac joint: pain referral maps upon applying a new injection/arthrography technique. Part I: Asymptomatic volunteers. Spine 19:1475-1482
49. Fortin JD, Aprill CN, Ponthieux B, Pier J (1994b) Sacroiliac joint: pain referral maps upon applying a new injection/arthrography technique. Part II: Clinical evaluation. Spine 19:1483-1489
50. Gaenslen FJ. (1927) Sacro-iliac arthrodesis. J Am Med Assoc 89:2031-2035
51. Gandavia SC, Butler JE, Hodges PW, Taylor JL (2002) Balance acts: respiratory sensations, motor control and human posture. Clin Exp Pharmocol Physiol 29:118-121
52. Gevargez A, Groenemeyer D, Schirp S, Braun M (1992) CT-guided percutaneous radiofrequency denervation of the sacroiliac joint. Eur Radiol 12:1360-1365
53. Giannikas KA, Khan AM, Karski MT, Maxwell HA (2004) Sacroiliac joint fusion for chronic pain: a simple technique avoiding the use of metalwork. Eur Spine J 13:253-256
54. Golighty R (1982) Pelvic arthropathy in pregnancy and the puerperium. Physiotherapy 68:216-220
55. Greenman PE (1992) Sacroiliac dysfunction in the failed low back pain. In: Vleeming A, Mooney V, Snijders C J, Dorman T (eds) First interdisciplinary world congress on low back pain and its relation to the sacroiliac joint. San Diego, CA, 5-6 November, 329-352
56. Guglielmi G, De Serio A, Leone A, Cammisa M (2000) Imaging of sacroiliac joints. Rays. 25:63-74
57. Hagen KB, Hilde G, Jamtvedt G, Winnem MF (2000) The Cochrane review of bed rest for acute low back pain and sciatica. Spine 25: 2932-2939
58. Hagen R (1974) Pelvic girdle relaxation from an orthopaedic point of view. Acta Orthop Scand 45:550-563
59. Hansen A, Jensen DV, Larsen E, Wilken-Jensen C, Pedersen LK (1996) Relaxin is not related to symptom-giving pelvic girdle relaxation in pregnant women. Acta Obstet Gynecol Scand 75:245-249

60. Helm van der FCT (2004): March. Personal communications with the WG4 in relation to definition of stability in this report
61. Herzog W Read LJ, Conway PJ, Shaw LD, McEwen MC (1989) Reliability of motion palpation procedures to detect sacroiliac joint fixations. J Manipulative Physiol Ther 12:86-92
62. Ho G Jr, Sadovnikoff N, Malhotra CM, Claunch BC (1979) Quantitative sacroiliac joint scintigraphy. A critical assessment. Arthritis Rheum 22:837-844
63. Hodge JC, Bessette B (1999) The incidence of sacroiliac joint disease in patients with low-back pain. Can Assoc Radiol J. 50:321-323
64. Hodges PW (1997b) Feed forward contraction of transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res 114: 362-370
65. Hodges PW, Kaigle Holm A, Holm S, Ekstrom L, Cresswell A, Hansson T, Thorstensson A (2003) Intervertebral stiffness of the spine is increased by evoked contraction of transversus abdominus and the diaphragm in in vivo porcine studies. Spine 28:2594-2601
66. Hodges PW, Richardson CA (1997a) Contraction of the abdominal muscles associated with movement of the lower limb. Phys Ther 77: 132-144
67. Holstege G, Bandler R, Saper CB (1996) The Emotional Motor System. Elsevier Science
68. Hungerford B, Gilleard W, Hodges PW (2003) Evidence of altered lumbo-pelvic muscle recruitment in the presence of sacroiliac joint pain. Spine 28:1593-1600
69. Hungerford B, Gilleard W, Lee D (2004) Altered patterns of pelvic bone motion determined in subjects with posterior pelvic pain using skin markers. Clin Biomech 19:456-464
70. Huson A (1997). Kinematic models and the human pelvis. In: Movement stability and low back pain. Eds. Vleeming A, Mooney V, Dorman T, Snijders C J, Stoeckart R. Churchill Livingstone 123-131
71. Indahl A, Kaigle A, Reikeras O, Holm S (1999) Sacroiliac joint involvement in activation of the porcine spinal and gluteal musculature. J Spinal Disord 12:325-330
72. Julkunen H, Rokkanen P (1969) Ankylosing spondylitis and osteitis condensans ilii. Acta Rheumatol Scand. 15:224-231
73. Keating JG, Avillar MD, Price M (1997) Sacroiliac joint arthrodesis in selected patients with low back pain. In: Movement, stability & Low Back Pain, Churchill Livingstone 573-586
74. Kihlstrand M, Stenman B, Nilsson S, Axelsson O (1999) Water-gymnastics reduced the intensity of back/low back pain in pregnant women. Acta Obstet Gynecol Scand 78:180-185
75. Kogstad O (1988) Bækkenløsning - en kontroversiel diagnose. Tidsskr Nor Lægeforen 14:1115-1119
76. Kokmeyer DJ, van der Wurff P, Aufdemkampe G, Fickensher TCM (2002) The realibility of multiregimens wiht sacroiliac pain provocation tests. J Manip Physiol Ther 25:42-48
77. Kopec JA, Esdaile JM, Abrahamowicz M, Abenhaim L, Wood-Dauphinee S, Lamping DL, Williams JI (1995) The Quebec Back Pain Disability Scale. Measurement properties. Spine 20:341-352
78. Kristiansson P, Svärdsudd K, von Schoultz B (1996a) Back pain during pregnancy. Spine 6:702-709
79. Kristiansson P, Svärdsudd K (1996b) Discriminatory power of tests applied in back pain during pregnancy. Spine 20:2337-2344

80. Kristiansson P, Svärdsudd K, von Schoultz B (1996c) Serum relaxin, symphyseal pain and back pain during pregnancy. Am J Obstet Gynecol 5:1342-1347
81. Kumar S, Narayan BS, Zedka M (1996) An electromyographic study of unresisted trunk rotation with normal velocity among healthy subjects. Spine 21:1500-1512
82. Kvorning N, Holmberg C, Grennert L, Aberg A, Akeson J (2004) Acupuncture relieves pelvic and low-back pain in late pregnancy. Acta Obstet Gynecol Scand 83: 246-250
83. Larsen EC, Wilken-Jensen C, Hansen A, Jensen DV, Johansen S, Minck H, Wormslev M, Davidsen M, Hansen TM (1999) Symptom-giving pelvic girdle relaxation in pregnancy. I: Prevalence and risk factors. Acta Obstet Gynecol Scand 78:105-110
84. Laslett M, Williams M (1994) The reliability of selected pain provocation tests for sacroiliac joint pathology. Spine. 19:1243-1249
85. Lavignolle B, Vital JM, Senegas J, Destandau J, Toson B, Bouyx P, Morlier P, Delorme G, Calabet A (1983) An approach to the functional anatomy of the sacroiliac joints in vivo. Anat Clin 5:169-176
86. Lee D, Vleeming A (1998) Impaired load transfer through the pelvic girdle. A new model of altered neutral zone function. In: Proceedings of the Third interdisciplinary world congress on low back and pelvic pain. Vienna. Editors: Vleeming A, Mooney V, Tilscher H, Dorman T, Snijders C J. ISBN 90-802551-2-2
87. Lovejoy CO (1988) Evolution of human walking. Sci Am 259:118-125
88. Luukkainen RK, Wennerstrand PV, Kautiainen HH, Sanila MT, Asikainen EL (2002) Efficacy of periarticular corticosteroid treatment of the sacroiliac joint in non-spondylarthropathic patients with chronic low back pain in the region of the sacroiliac joint. Clin Exp Rheumatol 20:52-54
89. MacLennan A, Nicolson R, Green R, Bath M (1986) Serum relaxin and pelvic pain of pregnancy. Lancet 2:243-244
90. Maigne JY, Aivaliklis A, Pfefer F (1996) Results of sacroiliac joint double block and value of sacroiliac pain provocation tests in 54 patients with low back pain. Spine 21:1889-1892
91. Maigne JY, Boulahdour H, Chatellier G (1998) Value of quantitative radionuclide bone scanning in the diagnosis of sacroiliac joint syndrome in 32 patients with low back pain. Eur Spine J 7:328-331
92. Mantle MJ, Greenwood RM, Currey HLF (1977) Backache in pregnancy. Reumatol Rehab 16:95-101
93. Mantle MJ, Holmes J, Currey HL (1981) Backache in pregnancy II: prophylactic influence of back care classes: Rheumatol Rehab 20:227-232
94. Masi AT, Dorsch JL, Cholewicki J (2003b) Are adolescent idiopathic scoliosis and ankylosing spondylitis counter-opposing conditions? A hypothesis on biomechanical contributions predisposing to the spinal disorders. Clin Exp Rheumatol 21:573-580
95. Masi AT, Walsh EG (2003a) Ankylosing spondylitis: integrated clinical and physiological perspectives. Clin Exp Rheumatol 21:1-8
96. Maugars Y, Mathis C, Berthelot JM, Charlier C, Prost A (1996) Assessment of the efficacy of sacroiliac corticosteroid injections in spondylarthropathies: a double-blind study. Br J Rheumatol 35:767-770
97. McCombe PF, Fairbank JC, Cockersole BC, Pynsent PB (1989) 1989 Volvo award in clinical sciences. Reproducibility of physical signs in low-back pain. Spine 14:908-918
98. McIntyre IN, Broadhurst NA (1996) Effective treatment of low back pain in pregnancy. Aust Fam Phys 25:65-67

99. Mens JM, Snijders CJ, Stam HJ (2000) Diagonal trunk muscle exercises in peripartum pelvic pain: a randomized clinical trial. Phys Ther 80:1164-1173
100. Mens JM, Vleeming A, Snijders CH, Stam HJ (2002b) Responsiveness of outcome measurements in rehabilitation of patients with posterior pelvic pain since pregnancy. Spine 27:1110-1115
101. Mens JM, Vleeming A, Snijders CJ, Koes BW, Stam HJ (2001) Reliability and validity of the active straight leg raise test in posterior pelvic pain since pregnancy. Spine 26:1167-1171
102. Mens JM, Vleeming A, Snijders CJ, Koes BW, Stam HJ (2002a) Validity of the active straight leg raise test for measuring disease severity with posterior pelvic pain after pregnancy. Spine 27:196-200
103. Mens JM, Vleeming A, Snijders CJ, Stam HJ, Ginai AZ (1999) The active straight leg raising test and mobility of the pelvic joints. Eur Spine J 8:468-473
104. Mens JMA, Stam HJ, Stoeckart R, Vleeming A, Snijders CJ (1992) Peripartum pelvic pain: a report of the analysis of an inquiry among patients of a Dutch patient society. In: Vleeming A, Mooney V, Snijders C J, Dorman T (eds) First interdisciplinary world congress on low back pain and its relation to the sacroiliac joint. San Diego, CA, 5–6 November, 521–533
105. Mens JMA, Vleeming A, Stoeckart R, Stam HJ, Snijders CJ (1996) Understanding peripartum pelvic pain: implications of a patient survey. Spine 21: 1303-1369
106. Miller JA, Schultz AB, Andersson GB (1987) Load displacement behavior of sacroiliac joints. J Orthop Res 5: 92-101
107. Mixter WJ, Barr JS (1934) Rupture of the intervertebral disc with involvement of the spinal canal. New Engl J Med 211:210-215
108. Moon WN, Kin MY, Oh HJ (2000) Incidence and risk factors of pelvic pain in pregnancy. J Korean Spine Surg 7:259-263
109. Mooney V, Pozos R, Vleeming A, Gulick J, Swenski D (2001) Exercise treatment for sacroiliac joint pain. Orthopedics , vol 24, no 1, 24:29-32
110. Moore MR (1997) Surgical treatment of chronic painful sacroiliac joint dysfunction. In Movement, stability & Low Back Pain, Vleeming et al. Churchill Livingstone 563-572
111. Mousavi SJ (2003) Low back pain and posterior pelvic pain during pregnancy in a middle East population. WCPT congress Barcelona, Abstract
112. Nilsson-Wikmar L, Holm K, Oijerstedt R, Harms-Ringdahl K (2003) Effect of three different physical therapy treatments on pain and functional activities in pregnant women with pelvic girdle pain: A randomised clinical trial with 3, 6, and 12 months` follow-up postpartum. PhD Thesis Karolinska Institutet, Stockholm, Sweden
113. Njoo KH (1993) Non specific low back pain in general practice: a delicate point. PhD Thesis, Erasmus University Rotterdam, The Netherlands
114. Noren L, Östgaard S, Nielsen TF, Östgaard HC (1997) Reduction of sick leave for lumbar back and posterior pelvic pain in pregnancy. Spine 22:2157-2160
115. Ohen AS, McNeill JM, Calkins E, Sharp JT, Schubart A (1967) The "normal" sacroiliac joint. Analysis of 88 sacroiliac roentgenograms. Am J Roentgenol Radium Ther Nucl Med 100:559-563
116. Olerud S, Walheim GG (1984) Symphysiodesis with a new compression plate. Acta Orthop Scand 55: 315-313
117. Oostveen JC, van de Laar MA (2000) Magnetic resonance imaging in rheumatic disorders of the spine and sacroiliac joints. Semin Arthritis Rheum 30:52-69

118. O'Sullivan PB, Beales DJ, Beetham JA, Cripps J, Graf F, Lin IB, Tucker B, Avery A (2002) Altered motor control strategies in subjects with sacroiliac pain during the active straight leg raise test. Spine 27: E1-8
119. Östgaard HC Back pain and Pregnancy (1991) PhD Thesis. Department of Orthopaedics, University of Göteborg, Sweden 1991
120. Östgaard HC, Andersson GBJ (1991) Post partum low back pain. Spine 16:549-552
121. Östgaard HC, Andersson GJ (1991a) Previous back pain and risk of developing back pain in future pregnancy. Spine 16:432-436
122. Östgaard HC, Andersson GJ, Karlsson K (1991b) Prevalence of back pain in pregnancy. Spine 16:549-552
123. Östgaard HC, Andersson GBJ, Schultz AB, Miller JAA (1993) Influence of biomechanical factors on low back pain in pregnancy. Spine 18:54-58
124. Östgaard HC, Zetherström G, Roos-Hansen E, Svanberg G (1994a) The posterior pelvic pain provocation test I pregnant women. Eur Spine J 3:258-260
125. Östgaard HC, Zetherström G, Roos-Hansson E, Svanberg B (1994b) Reduction of back and posterior pelvic pain in pregnancy. Spine 19:894-900
126. Östgaard HC, Zetherström G, Roos-Hansson E (1996) Regression of back and posterior pelvic pain after pregnancy. Spine 21:2777-2780
127. Panjabi MM (1992) The stabilizing system of the spine. Part I: Function, dysfunction, adaptation, and enhancement. J Spinal Dis 5: 383-389
128. Petersen T, Olsen S, Laslett M, Thorsen H, Manniche C, Ekdahl C, Jacobsen S (2004) Inter-tester reliability of a new diagnostic classification system for patients with non-specific low back pain. Aust J Physiother 50:85-94
129. Pool-Goudzwaard A, Hoek van Dijke G, Mulder P, Spoor C, Snijders CJ, Stoeckart R (2003). The iliolumbar ligament: its influence on stability of the sacroiliac joint. Clin Biomech 18:99-105
130. Pool-Goudzwaard A, Kleinrensink G J, Snijders CJ, Entius C, Stoeckart R (2001) The sacroiliac part of the iliolumbar ligament. J Anat 199:457-463
131. Pool-Goudzwaard A (2004) Biomechanics of the sacroiliac joints and the pelvic floor. PhD Thesis, Erasmus University Rotterdam, The Netherlands
132. Potter NA, Rothstein JM (1985) Intertester reliability for selected clinical tests of the sacroiliac joint. Phys Ther 65:1671-1675
133. Puhakka KB, Jurik AG, Egund N, Schiottz-Christensen B, Stengaard-Pedersen K, van Overeem Hansen G, Christiansen JV (2003) Imaging of sacroiliitis in early seronegative spondylarthropathy. Assessment of abnormalities by MR in comparison with radiography and CT. Acta Radiol 44:218-229
134. Pulisetti D, Ebraheim NA (1999) CT-guided sacroiliac joint injections. J Spinal Disord 14:310-312
135. Richardson CA, Snijders CJ, Hides JA, Damen L, Pas MS, Storm J (2002) The relationship between the transversus abdominus muscle, sacroiliac joint mechanics and low back pain. Spine 27: 399-405
136. Riddle DL, Freburger JK (2002) Evaluation of the presence of sacroiliac joint dysfunction using a combination of tests: A multicenter intertester reliability study. Phys Ther 82:772-781
137. Rojko A, Farkas K (1959) Osteitis condensans ossia ilii. Acta Orthop Scand. 29:108-120
138. Rosenberg JM, Quint DJ, de Rosayro AM (2000) Computer tomographic localization of clinically –guided sacroiliac joint injections. Clin J Pain 16:18-21

139. Salèn BA, Spangfort EV, Nygren ÅL, Nordemar R (1994) The Disability Rating Index: An instrument for the assessment of disability in clinical settings. J Clin Epidemiol 47:1423-1434
140. Salsabili N, Valojerdy MR, Hogg DA (1995) Variations in thickness of articular cartilage in the human sacroiliac joint. Clin Anat 8:388-390
141. Sashin D (1930) A critical analysis of the anatomy and the pathological changes of the sacroiliac joints. J Bone Joint Surg 12:891-910
142. Schauberger CW, Rooney BL, Goldsmith L, Shenton D, Silva P, Schaper A (1996) Peripheral joint laxity increases in pregnancy but does not correlate with serum relaxin. Am J Obstet Gynecol 174:667-671
143. Schwarzer AC, Aprill CN, and Bogduk N (1995) The sacroiliac joint in chronic low back pain. Spine 20:31-37
144. Shibata Y, Shirai Y, Miyamoto M (2002) The aging process in the sacroiliac joint: helical computed tomography analysis. J Orthop Sci 7:12-18
145. Slätis P, Eskola A (1989) External fixation of the pelvic girdle as a test for assessing instability of the sacro-iliac joint. Ann Med 21:369-372
146. Slätis P, Karaharju EO (1975) External fixation of the pelvic girdle with a trapezoid compression frame. Injury 7:53-56
147. Slipman CW, Sterenfeld EB, Chou LH, Herzog R, Vresilovic E (1996) The value of radionuclide imaging in the diagnosis of sacroiliac joint syndrome. Spine 21:2251-2254
148. Smith-Petersen MN, Rogers WA (1926) End-result study of arthrodesis of the sacroiliac joint for arthritis – traumatic and nontraumatic. J Bone Joint Surg 8:118-136
149. Snijders CJ, Vleeming A, Stoeckart R (1993a) Transfer of lumbosacral load to iliac bones and legs. 1: Biomechanics of self-bracing of the sacroiliac joints and its significance for treatment and exercise. Clin Biomech 8:285-294
150. Snijders CJ, Vleeming A, Stoeckart R (1993b) Transfer of lumbosacral load to iliac bones and legs. 2: Loading of the sacroiliac joints when lifting in a stooped posture. Clin Biomech 8:295-301
151. Solonen KA (1957) The sacroiliac joint in the light of anatomical, roentgenological and clinical studies. PhD Thesis. Acta Orthop Scand (suppl 27)
152. Soucy JC Jr, Pitts WH Jr, Soucy JC Sr, Smyth CJ (1969) Osteitis condensans ilii. JAMA 207:1145-1147
153. Stewart TD (1984) Pathologic changes in aging sacroiliac joints. Clin Orthop183:188-196
154. Strender LE, Sjoblom A, Sundell K, Ludwig R, Taube A (1997) Interexaminer reliability in physical examination of patients with low back pain. Spine. 22:814-820
155. Stuge B, Hilde G, Vollestad N (2003) Physical therapy for pregnancy-related low back and pelvic pain: a systematic review. Acta Obstetet Gynecol Scand 82: 983-990
156. Stuge B, Lærum E, Kirkesola G, Vøllestad N (2004a) The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy. A randomized controlled trial. Spine 29: 351-359
157. Stuge B, Veierød MB, Lærum E, Vøllestad N (2004b) The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy. A two-year follow-up of a randomized clinical trial. Spine 29: E197-E203
158. Sturesson B, Selvik G, Udén A (1989) Movements of the sacroiliac joints. A roentgen stereophotogrammetric analysis. Spine 14:162-165

159. Sturesson B, Udén A, Önsten I (1999) Can an external frame fixation reduce the movements of the sacroiliac joint? A radiostereometric analysis. Acta Orthop Scand 70:37-41
160. Sturesson B, Uden A, Vleeming A (2000a) A radiostereometric analysis of movements of the sacroiliac joints during the standing hip flexion test. Spine 25:364-368
161. Sturesson B, Uden A, Vleeming A (2000b) A radiostereometric analysis of the movements of the sacroiliac joints in the reciprocal straddle position. Spine 25: 214-217
162. Sturesson B, Udén G, Udén A (1997) Pain pattern in pregnancy and "Catching" of the leg in pregnant women with posterior pelvic pain. Spine 22:1880-1891
163. Suputtitada A, Wacharapreechanont T, Chaisayan P (2002) Effect of the "sitting pelvic tilt exercise" during the third trimester in primigravidas on back pain. J Med Assoc Thai 85: S170-S179
164. Svensson HO, Andersson GBJ, Hagstad A, Jansson PO (1990) The relationship of low-back pain to pregnancy and gynaecologic factors. Spine 15:371-375
165. Thomas IL, Nicklin J, Pollock H, Faulkner K (1989) Evaluation of a maternity cushion (Ozzlo Pillow) for backache and insomnia in late pregnancy. Aust NZ J Obstet Gynaecol 29:133-138
166. Toussaint R, Gawlik CS, Rehder U, Rüther W (1999) Sacroiliac joint diagnostics in the Hamburg construction workers study. J Manip Physiol Ther 22:139-143
167. Tullberg T, Blomberg S, Branth B, Johnnson R (1998) Manipulation does not alter the position of the sacroiliac joint. A Roentgen stereophotogrammetric analysis. Spine 23:1124-1128
168. van Dongen PW, de Boer M, Lemmens WA, Theron GB (1999) Hypermobility and peripartum pelvic pain syndrome in pregnant South African women. Eur J Obstet Gynecol Reprod Biol 84:77-82
169. van Wingerden J P , Vleeming A, Snijders C J, Stoeckart R (1993) A functional-anatomical approach to the spine–pelvis mechanism: interaction between the biceps femoris muscle and the sacrotuberous ligament. Eur Spine J 2:140-144
170. van Wingerden J P, Vleeming A, Buyruk H M, Raissadat K (2004) Stabilization of the Ssacroiliac joint in vivo: Verification of muscular contribution to force closure of the pelvis. Eur Spine J 13: 199-205
171. van Wingerden JP, Vleeming A, Ronchetti I (2005) Physical compensation strategies during standing and forward bending in female patients with chronic low back pain and chronic pelvic girdle pain. Submitted
172. van Zwienen CM, van den Bosch EW, Snijders CJ, van Vugt AB (2004) Triple pelvic ring fixation in patients with severe pregnancy-related low back and pelvic pain. Spine 29:478-484
173. Vincent-Smith B, Gibbons S (1999) Inter-examiner and intra-examiner reliability of the standing flexion test. Man Ther 4:87-93
174. Vleeming A, Stoeckart R, Snijders CJ (1989a) The sacrotuberous ligament: a conceptual approach to its dynamic role in stabilizing the sacroiliac joint. Clin Biomech 4:201-203
175. Vleeming A, Wingerden van J P van, Snijders CJ, Stoeckart R, Stijnen T (1989b) Load application to the sacrotuberous ligament: influences on sacroiliac joint mechanics. Clin Biomech 4:204-209
176. Vleeming A (1990) The sacroiliac joint. A clinical-anatomical, biomechanical and radiological study. PhD Thesis, Erasmus University Rotterdam, The Netherlands

177. Vleeming A, Stoeckart R, Volkers ACW, Snijders CJ (1990a) Relation between form and function in the sacroiliac joint. 1. Clinical anatomical aspects. Spine 15: 130-132
178. Vleeming A, Volkers ACW, Snijders CJ, Stoeckart R (1990b) Relation between form and function in the sacroiliac joint. 2. Biomechanical aspects. Spine 15: 133-136
179. Vleeming A, Wingerden JP van, Dijkstra P, Stoeckart R, Snijders CJ, Stijnen T (1992a) Mobility in the SI-joints in old people: a kinematic and radiologic study. Clin Biomech 7:170-176
180. Vleeming A, Buyruk HM, Stoeckart R, Karamursel S, Snijders CJ (1992b) An integrated therapy for peripartum pelvic instability: a study of the biomechanical effects of pelvic belts. Am J Obstet Gynecol166:1243-1247
181. Vleeming A, Pool-Goudzwaard AL, Stoeckart R, Wingerden JP van, Snijders CJ (1995) The posterior layer of the thoracolumbar fascia: its function in load transfer from spine to legs. Spine 20:753-758
182. Vleeming A, Pool-Goudzwaard A, Hammudoghlu D, Stoeckart R, Snijders CJ, Mens JM (1996) The function of the long dorsal sacroiliac ligament: its implication for understanding low back pain. Spine 21: 556-562
183. Vleeming A, de Vries HJ, Mens JM, van Wingerden JP (2002) Possible role of the long dorsal sacroiliac ligament in women with peripartum pelvic pain. Acta Obstet Gynecol Scand 81:430-436
184. Vleeming A, Albert H B, van der Helm F C T, Lee D, Östgaard HC, Stuge B, Sturesson B (2004) A definition of joint stability. In European guidelines on the diagnosis and treatment of pelvic girdle pain. Cost Action B13; Low back pain: guidelines for its management. Working group 4 (this report)
185. Wahlheim GG (1984a) Stabilization of the pelvis with the Hoffman frame. An aid in diagnosing pelvic instability. Acta Orthop Scand 55:319-324
186. Walheim GG, Selvik G (1984b) Mobility of the pubic symphysis. In vivo measurements with an electromechanic method and a roentgen stereophotogrammetric method. Clin Orthop Rel Res 191: 129-135
187. Waisbrod H, Krainick JU, Gerbershagen HU (1987) Sacroiliac joint arthrodesis for chronic lower back pain. Arch Orthop Trauma Surg. 106:238-240
188. Walde J (1962) Obstetrical and gynaecological back and pelvic pains, especially those contracted during pregnancy. Acta Obstet Gynecol Scand (Suppl) 2:1-52
189. Wedenberg K, Moen B, Norling A (2000) A prospective randomized study comparing acupuncture with physiotherapy for low-back and pelvic pain in pregnancy. Acta Obstet Gynecol Scand 79:331-335
190. Weisl H (1955) The movements of the sacroiliac joints. Acta Anatomica 23:80-91
191. Wiles M (1980) Reproducibility and inter-examiner correlations of motion palpation findings of the sacroiliac joints. J Can Chiro Ass 24:59-69
192. Withrington RH, Sturge RA, Mitchell N (1985) Osteitis condensans ilii or sacro-iliitis? Scand J Rheumatol 14:163-166.
193. Wormslev M, Juul AM, Marques B, Minck H, Bentzen L, Hansen TM (1994) Clinical examination of pelvic Insufficiency during pregnancy. Scand J Rheumatol 23:96-102
194. Wu W, Meijer OG, Uegaki K, Mens JA, van Dieën JH, Wuisman PIJM, Östgaard HC (2004) Pregnancy-related Pelvic Girdle Pain I. Eur Spine J (in press)
195. Wurdinger S, Humbsch K, Reichenbach JR, Peiker G, Seewald HJ, Kaiser WA (2002) MRI of the pelvic ring joints postpartum: normal and pathological findings. J Magn Reson Imaging 15:324-9
196. Wurff Pvd, Hagmeijer RHM, Kuhlmann P (1996) Het sacroiliacaal gewricht getest. Nederlands Tijdschrift voor Fysiotherapie 106:178-184

197. Wurff Pvd, Hagmeijer RHM, Meyne W (2000a) Clinical tests of the sacroiliac joint. A systematic methodological review. Part 1: Reliability. Manual Therapy 5:30-36
198. Wurff Pvd, Hagmeijer RHM, Meyne W (2000b) Clinical tests of the sacroiliac joint. A systematic methodological review. Part 2: Validity. Manual Therapy 5:89-96
199. Yelland MJ, Glasziou PP, Bogduk N, Schluter PJ, McKernon M (2004) Prolotherapy injections, saline injections, and exercises for chronic low-back pain: a randomized trial. Spine 29: 9-16
200. Yildiz A, Gungor F, Tuncer T, Karayalcin B (2001) The evaluation of sacroiliitis using 99mTc-nanocolloid and 99mTc-MDP scintigraphy. Nucl Med Commun 22:785-94

Appendix 1

Definitions of pelvic girdle pain tests

Active straight leg raise test (ASLR)
The test is performed with patients in a supine position with straight leg and feet 20 cm. apart. The test is performed after the instruction" try to raise your legs, one after the other, above the couch for 20 cm without bending the knee". The patient is asked to score impairment on a 6 point scale not difficult at all =0; minimally difficult = 1; somewhat difficult; difficult =2; fairly difficult =3; very difficult =4; unable to do= 5. The scores on both sides are added, so that the sum score range from 0 to 10 (Mens 2001, Spine).

Gaenslen test
The patient, lying supine, flexes the knee and hip of the same side, the thigh being crowded against the abdomen with the aid of both the patient's hands clasped about the flexed knee. The patient is then brought well to the side of the table, and the opposite thigh is slowly hyper extended by the examiner with gradually increasing force by pressure of the examiners hand of the top of the knee. With the opposite hand, the examiner assists the patient in fixing the lumbar spine and pelvis by pressure over the patient's clasped hands. The test is positive if the patient experience pain, either local or referred on the provoked side (Gaenslen 1927).

Long dorsal sacroiliac ligament test (LDL test)
The patient is lying prone and tested on tenderness on bilateral palpation of the LDL , directly under the caudal part of the posterior superior iliac spine. A skilled examiner scores the pain as positive or negative The LDL test is scored on a scale from; no pain = 0, mild =1; moderate=2; unbearable= 3. Both sides are added so that the sum score range from 0-6. Studied on post partum women Vleeming 2002.

Instruction for the LDL test on pregnant woman: The subject lies on her side with slight flexion in both hip and knee joints. If the palpation causes pain, that persists more than 5 seconds, after removal of the examiner's hand, it is recorded as pain. If the pain disappears within 5 seconds it is recorded as tenderness." Studied on pregnant women Albert et al. 2000

Pain provocation of the symphysis by Modified Trendelenburgs test.
The patient stands on one leg, flexes the other at 90° in hip and knee. If pain is experienced in the symphysis the test is positive. Albert et al 2000.

Patrick's faber test
The subject lies supine. One leg is flexed, abducted, and externally rotated (*faber*, abbreviation of flexion abduction and external rotation) so that the heel rests on the opposite knee. If pain is felt in the SI joints or in the symphysis the test is considered positive. (test described by Wormsley 1994, Broadhurst and Bond 1998, Albert et al. 2000)

Posterior pelvic pain provocation test
The test is performed with the woman supine and the hip flexed to an angle of 90 degree on the side to be examined: a light manual pressure is applied to the patients flexed knee along the longitudinal axis of the femur while the pelvis is stabilized by the examiners other hand

resting on the patients contralateral superior anterior iliac spine. The test is positive when the patient feels a familiar well localized pain deep in the gluteal area on the provoked side. Østgaard et al. 1994.
A similar test is described as posterior shear or “thigh trust”. Laslett and Williams1994.

Symphysis pain palpation test
The subject lies supine. The entire front side of the pubic symphysis is palpated gently. If the palpation causes pain, that persists more than 5 seconds, after removal of the examiner’s hand, it is recorded as pain. If the pain disappears within 5 seconds it is recorded as tenderness. Albert et al 2000.

APPENDIX 2

Recommended Flowchart for Pelvic Girdle Pain