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The active straight leg raising test and mobility of the pelvic joints

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Abstract Objective signs to assess impairment in patients who are disabled by peripartum pelvic girdle pain hardly exist. The purpose of this study was to develop a clinical test to quantify and qualify disability in these patients. The study examined the relationship between impaired active straight leg raising (ASLR) and mobility of pelvic joints in patients with peripartum pelvic girdle pain, focusing on (1) the reduction of impairment of ASLR when the patient was wearing a pelvic belt, and (2) motions between the pubic bones measured by X-ray examination when the patient was standing on one leg, alternating left and right. Twenty-one non-pregnant patients with peripartum pelvic girdle pain in whom pain and impairment of ASLR were mainly located on one side were selected. ASLR was performed in the supine position, first without a pelvic belt and then with a belt. The influence of the belt on the ability to actively raise the leg was assessed by the patient. Mobility of the pelvic joints was radiographically visualized by means of the Chamberlain method. Assessment was blinded. Ability to perform ASLR was improved by a pelvic belt in 20 of the 21 patients (binomial two-tailed P = 0.0000). When the patient was standing on one leg, alternating the symptomatic side and the reference side, a significant difference between the two sides was observed with respect to the size of the radiographically visualized steps between the pubic bones (binomial two-tailed P = 0.01). The step at the symptomatic side was on average larger when the leg at that side was hanging down than when the patient was standing on the leg at that side. Impairment of ASLR correlates strongly with mobility of the pelvic joints in patients with peripartum pelvic girdle pain. The ASLR test could be a suitable instrument to quantify and qualify disability in diseases related to mobility of the pelvic joints. Further studies are needed to assess the relationship with clinical parameters, sensitivity, specificity and responsiveness in various categories of patients. In contrast with the opinion of Chamberlain, that a radiographically visualized step between the pubic bones is caused by cranial shift of the pubic bone at the side of the standing leg, it is concluded that the step is caused by caudal shift of the pubic bone at the side of the leg hanging down. The caudal shift is caused by an anterior rotation of the hip bone about a horizontal axis near the sacroiliac joint.

Key words Diagnostic tests · Low back pain · Pubic symphysis · Sacroiliac joint

Introduction

Pain in the lumbar spine and pelvic region frequently complicates pregnancy and delivery; the reported 9-month prevalence ranges from 48 to 56% [3, 10, 17, 18]. In retrospective studies among young and middle-aged women with chronic low back pain, 10–28% state that their first episode of back pain occurred during pregnancy [4, 23].

Hypotheses on the pathogenesis focus on changed load and decreased stability of the pelvic girdle [1, 2, 22, 25]. Snijders et al. describe instability as an impairment of the ability of the pelvic girdle to transfer loads between trunk and legs [22]. Increase of movement of the sacroiliac joints (SIJs) during pregnancy is well documented by an anatomical study [5], and many radiographic studies [1, 9, 13, 14, 15, 24].

Because peripartum pelvic girdle pain is a main topic of our research many patients, from all over the Netherlands (200,000 births per year) consult us. During the past 6 years we examined about 3000 new patients with peripartum pelvic girdle pain. It was noticed that in the supine position active raising of one or both legs was weak in almost all of them. Many patients report pain during this action, but most describe feeling as though they were paralysed. As early as 1839, the Swedish gynecologist Cederschjöld gave a description of a condition that he called "joint loosening" in pregnant and puerperal women [11]. One of the characteristics that he described was the "difficulty or almost impossibility of even moving the lower limbs." He noted "... an instantaneous relief in the pains and the ability to move the limbs when the hips are pressed hard together with the hands." Because this sign was expected to be related to stress to the ligaments in the pelvis and/or the lumbosacral junction, a study was initiated to investigate whether impairment of active straight leg raising (ASLR) was related to increased mobility of the pelvic joints.

Assessment of mobility of the pelvic joints by palpation appears to be unreliable [6, 12, 16, 20]. In 1930, Chamberlain introduced a method to visualize the mobility radiographically [7]. It was demonstrated that small rotatory displacements of the hip bones about a transverse axis never become apparent on anteroposterior (AP) roentgenograms of the SIJs. Chamberlain suggested that the side of the high pubic bone was the abnormal one. He described a method of determining movements in the SIJs by measuring the movements between the pubic bones when alternately standing on one leg and the other. Experiments to visualize the mobility of the pubic bones in other stress positions failed, and Abramson et al. as well as Death et al. concluded that the Chamberlain technique should remain the procedure of choice [1, 8]. Berezin compared women in the puerperium with and without complaints [2]. He measured a range of motion between the pubic bones of 5.9 ± 3.3 mm in women with complaints and 1.9 ± 2.2 mm in those without (Wilcoxon $P = 0.0000$, statistical analysis by J.M.).

A pelvic belt is a well-established orthosis to treat peripartum pelvic girdle pain [1, 3, 19, 21, 24]. Hypotheses on the mode of action focus on increased stability by compression of the surfaces of the SIJs [22]. In an anatomical study, the mobility of the SIJs was reduced significantly when a pelvic belt was tightened round the pelvic girdle [25].

The goal of the present study was to take a new step in the development of a clinical test to quantify and qualify disability in patients with peripartum pelvic girdle pain. The study focuses on the relationship between ASLR and mobility of the pelvic joints. The mobility of the pelvic joints was modified by a pelvic belt and measured by the Chamberlain method.

Subjects and methods

A group of 21 patients were selected from the outpatient clinic of the Institute of Rehabilitation Medicine of the University Hospital Rotterdam. Included were non-pregnant women with pelvic girdle pain that started during pregnancy or within 3 weeks after delivery and with impaired ASLR. To minimize recall bias, the duration of the post partum period was restricted to 5 years. Pelvic pain was defined as pain experienced between the plane through the four superior iliac spines and the horizontal plane through the inferior border of the pubic symphysis. Pelvic girdle pain was defined as pelvic pain that is influenced by position and locomotion and is located posteriorly as well as anteriorly. Patients were included only if pain and impairment of ASLR were asymmetric and both mainly located on the same side; this side was called the symptomatic side, and the other the reference side.

Patients were asked what percentage of their pelvic girdle pain was felt at the most painful pelvic half. Arbitrarily, 75% or more was classified as asymmetrical pain.

The ASLR was performed in the supine position with straight legs relaxed in lateral rotation, and feet 20 cm apart. The test was performed after the instruction: "Try to raise your legs, one after the other, above the couch for 5 cm without bending the knee." The patient was asked whether she felt weakness, pain or any other unpleasant feelings during the test and whether she noticed any difference between the two sides. The examiner assessed the velocity of raising, the appearance of a tremor of the leg, the amount of rotation of the trunk, and verbal and non-verbal emotional expressions of the patient. Impairment was scored on a four-point scale:

0 The patient feels no restriction
1 he patient reports decreased ability to raise the leg but the examiner assesses no signs of impairment
2 The patient reports decreased ability to raise the leg and the examiner assesses signs of impairment
3 Inability to raise the leg

In a pilot study (25 subjects, two assessors) the intertester reliability of the score was high (Kendall's Tb = 0.81). Arbitrarily, a difference of two points or more between the left and right side was classified as asymmetrical impairment.

Patients with a history of fracture, neoplasm, inflammatory disease or previous surgery of the lumbar spine or pelvis were excluded, as well as patients with signs indicating radiculopathy – asymmetric Achilles tendon reflex, hypesthesia in a radicular pattern, (passive) straight leg raising restricted by pain in the lower leg.

The patient was asked whether the ability to actively raise the leg changed (more, equal or less) when the test was performed again with a pelvic belt fastened around the pelvic girdle. The belt was adjusted in two different positions: just below the anterior superior iliac spines (high position) and at the level of the symphysis (low position). A belt of non-elastic material was used (model 3221/3300; Rafys, Hengelo, The Netherlands) 5 cm wide at the anterior and 7 cm at the posterior side. The belt was fastened with Velcro to be able to adjust the tension. In a pilot study (ten patients) the minimum force needed to influence ASLR was evaluated. The force was measured with a special belt, which was connected with a digital force measurement apparatus. In most patients 50 N was sufficient. Increased tension (up to 200 N) gave results similar to those at 50 N. In loosening a tightly fixed belt the effect generally disappeared suddenly between 50 and 20 N. In an earlier anatomical study, sagittal rotation in the SIJs was reduced by a belt with forces of the same magnitude [25]. In the present study care was taken that applied tension was amply more than 50 N; this was manually controlled. In a pilot study (ten patients) the applied tension after manual control ranged from 70–95 N. To reduce psychological effects, the influence of six other modifications on ASLR (e.g. contralateral hip flexion, tension of the oblique abdominal muscles, etc) was also assessed. Care was taken not to give any suggestions about possible effects.

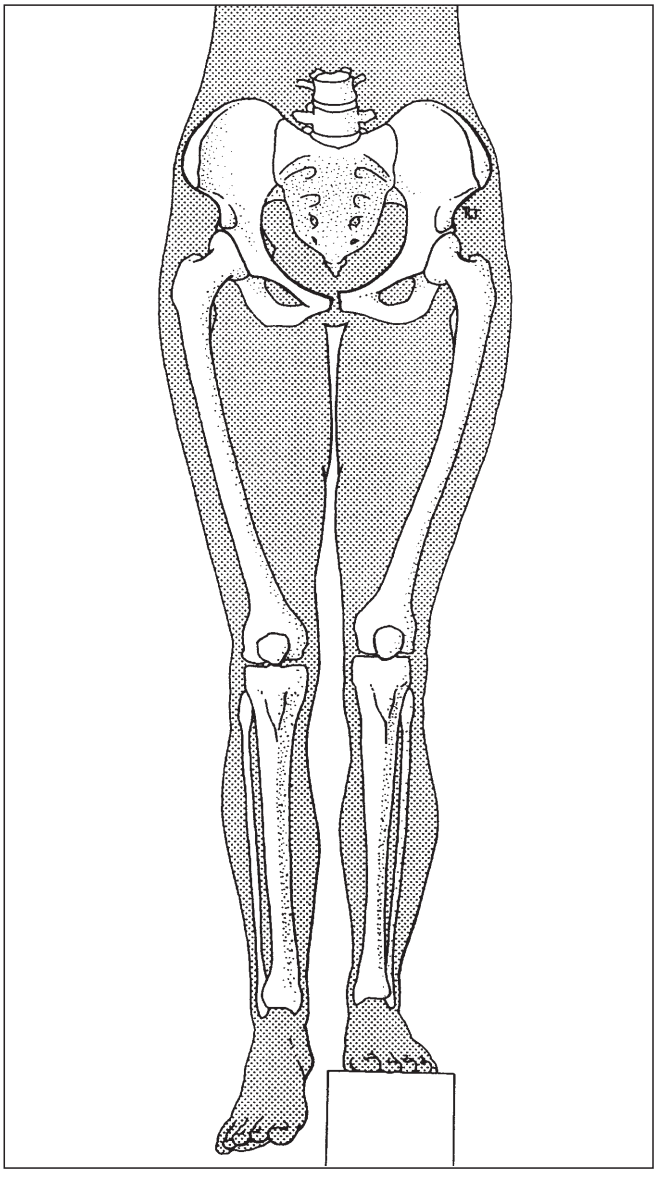

Fig. 1 Position of the patient standing on the left leg. The right leg is hanging passively beside the bench. The os pubis at the right is located a few millimeters caudally of the left one

After inclusion and clinical examination of the patients, radiographs were made according to Chamberlain [7]. The patient was standing on one leg, alternating left and right, on a small bench and the other leg hanging passively beside the bench (Fig. 1). To reduce X-ray magnification, the tube film distance was 2 m and the X-ray direction was posteroanterior. By means of these precautions, magnification was reduced to approximately 5% and was practically the same in every patient. Because of the inclined position of the symphysis pubis relative to the frontal plane of about 45° the real vertical dimensions of the pubic bones are about 1.4 times larger than their X-ray projections. In the analyses this magnification was neglected, because when comparing various radiographs of one patient, magnification is irrelevant with respect to conclusions about left-right differences.

Two assessors judged the radiographs. In case of disagreement a second assessment in a common session followed. The assessors were blinded with respect to clinical signs and symptoms and gave their interpretation, during the first measurement, independent of each other. If the upper margins at the pubic bones were not in line, a judgment was given about the side with the largest step (standing on the leg at the symptomatic side or at the reference side). The step was defined as the distance between the lines through the upper margins of both pubic bones. A step was expressed as a positive value if the pubic bone was higher at the symptomatic side and as negative if the symptomatic side was lower than the reference side.

To gain more information about the possible mechanism of the test, additional radiographs were made in supine position without leg raising if the steps standing at the symptomatic side as well as at the reference side were both positive or negative, or if the step was largest when the patient was standing on the leg at the symptomatic side. Moreover, in four patients with a large step additional radiographs were made in the supine position during ASLR.

Results

The ages of the 21 women ranged from 24 to 41 years (mean 31.9 SD 4.4 years). Six women had one child, 15 had between two and four children. The latest delivery ranged from 2.5 months to 4.5 years previously, with a median of 8 months. The percentage pain at the most painful side ranged from 75 to 100%, with a mean of 87.0%. In 11 patients the symptomatic side was the left and in 10 patients the right.

ASLR with a belt

ASLR performed with a belt reduced the impairment in 20 patients (positive effect against negative or no effect binomial two-tailed $P = 0.0000$) (Table 1). One patient felt increase of pain in the symphysial region as soon as the belt was tightened. Ten patients preferred the low position of the belt, seven the high position and three had no preference.

Table 1 Influence of a pelvic belt on active straight leg raising (ASLR): ability to perform ASLR with a pelvic belt in the high and the low position (+ more ability compared to ASLR without modification, – less ability, 0 no change, ++ more ability compared to ASLR with the belt in the other position)

Patient no.	Belt high	Belt low
1	0	+
2	0	+
3	+	–
4	+	++
5	+	–
6	+	+
7	++	+
8	++	+
9	+	++
10	+	++
11	0	+
12	+	+
13	0	–
14	+	++
15	0	+
16	+	–
17	+	++
18	0	+
19	++	+
20	+	0
21	+	+

Radiography

In 14 patients the step was largest standing on the leg at the reference side and in three patients at the symptomatic side (Table 2). In four patients the steps were identical (binomial two-tailed $P = 0.01$). Both assessors were in 100% agreement on this question after their first judgment.

Additional radiography

In four patients additional radiographs were made in supine position without leg raising. In three patients this was done because, in contrast to the other patients, the absolute value of the step was larger when standing on the leg at the symptomatic side than on the leg at the reference side, and in one patient because both steps were negative. In each of these four patients a step could be demonstrated in supine position (Table 3). If the radiographs in supine position were used as baseline, the shift standing on the leg at the reference side was larger than when standing on the leg at the symptomatic side.

In four patients [5, 8, 12, 14] with a large step, additional radiographs were made in supine position during ASLR (Fig. 2). In all those cases ASLR at the symptomatic side produced the same step as standing on the leg at the reference side and vice versa.

Table 2 Differences between the heights of the upper margins of the pubic bones when standing on one leg, both at the reference side and at the symptomatic side (+ a step with the pubic bone high at the symptomatic side, – a step with the pubic bone low at the symptomatic side, 0 no step, the upper margins of the pubic bones are in line with each other)

Patient no.	Step standing at reference side	Step standing at symptomatic side	Largest step standing at reference side (R) or at symptomatic side (S)
1	–	0	R
2	–	0	R
3	–	0	R
4	–	0	R
5	–	+	S
6	–	0	R
7	–	0	R
8	–	–	R
9	0	0	R=S
10	–	+	R=S
11	–	+	R=S
12	0	+	S
13	–	0	R
14	–	0	R
15	–	+	R
16	–	0	R
17	–	0	R
18	0	0	R=S
19	–	0	R
20	0	+	S
21	–	+	R

Table 3 Results of additional radiographs in supine position: movements of the pubic bones from supine to standing on one leg (+ a step with the pubic bone high at the symptomatic side, or cranial shift at the symptomatic side, – a step with the pubic bone low at the symptomatic side, or caudal shift at the symptomatic side)

Patient no.	Step in supine position	Shift from supine to standing on the leg at the reference side	Shift from supine to standing on the leg at the symptomatic side	Largest shift from supine to standing on the leg at the reference side (R) or at the symptomatic side (S)
5	+	–	+	R
8	–	–	+	R
12	+	–	+	R
20	+	–	+	R

Discussion

Tightening a belt round the pelvic girdle reduced the impairment of ASLR in all but one patient. Thus, measured

Fig. 2 A, B Radiographs during active straigth leg raising (ASLR) of patient 8. **A** ASLR of the left leg (reference side). A step of about 1 mm is seen at the upper margins of the pubic bones. **B** ASLR of the right leg (symptomatic side). A step of about 5 mm is seen at the upper margins of the pubic bones. The projection of the right pubic bone is smaller than the left one, indicating a rotation of the right hip bone

by this criterion standard, impairment of ASLR parallels pelvic mobility.

When the patient was standing on one leg, alternating the symptomatic side and the reference side, a significant difference between the two sides was observed with respect to the size of the radiographically visualized steps between the pubic bones. At the symptomatic side the caudal shift of the pubic bone when the leg was hanging down was on average larger than at the reference side. Thus, by this criterion standard too, impairment of ASLR parallels pelvic mobility.

Figure 2B illustrates the phenomenon that in most patients with a large step projection of the pubic bone at the side of the raised leg during ASLR at the symptomatic side was smaller in the craniocaudad direction than that of the other three presented pubic bones. This leads to the conclusion that on the side of the raised leg, the hip bone was rotated anteriorly, about a horizontal axis near the sacroiliac joint. Since the same pattern was seen during standing on one leg at the side of the leg hanging down we conclude that standing on one leg produces a caudal displacement at the side of the leg hanging down instead of a cranial displacement of the pubic bone at the standing side. It makes a difference for many therapeutic interventions (e.g. manual therapy and operative fusion of an SIJ) whether problems arise from anterior rotation of a hip bone or posterior rotation of the opposite one.

In four patients (indicated in Table 2) the motion pattern appeared to be different. If the radiographs in supine position were used as baseline, the movement pattern in these patients was the same as in the other 17 patients: the hip bone rotated anteriorly at the side of the leg hanging down, and this movement was larger at the symptomatic side than at the reference side.

Chamberlain suggested that the side of the high pubic bone was the abnormal one. If the step on both radiographs had the same value, he classified the situation as “a fixed slip” and stated that this was caused by an abnormal position of the hip bone at the side of the high pubic bone and manipulation was indicated [7]. In our study no case was found in which both steps were high (positive values) at the symptomatic side. The discrepancy with our study possibly could be explained by the difference in the study population. Chamberlain mainly studied patients with acute low back pain. Since herniation of the nucleus pulposus had not yet been described in those days, it might be expected that a part of his population consisted of patients with a radiculopathy because of herniation. He stated:

We cannot claim to have proved that the so-called “slip” is the primary factor in the acute low back episode... Our definite demonstration of innominate bone [hip bone J.M.] rotation in these cases could be equally well explained by assuming certain muscle spasms, pulling the rotated innominate bone from its usual position. No attempt is made, at the present time, to decide which is cause and which is effect. [7]

It could be that in peripartum pelvic girdle pain enlarged mobility is primary and in acute low back pain changed mobility of the hip bones is secondary.

It is tempting to suggest that impairment of ASLR is provoked by isolated pathology of the SIJ on the tested side; however, it seems to be more complicated. In normal circumstances, when a hip bone is forced into forward rotation by an external force, reaction forces are generated not only in the SIJ but also in the iliolumbar ligaments and the pubic symphysis. In this way, forward rotation of the

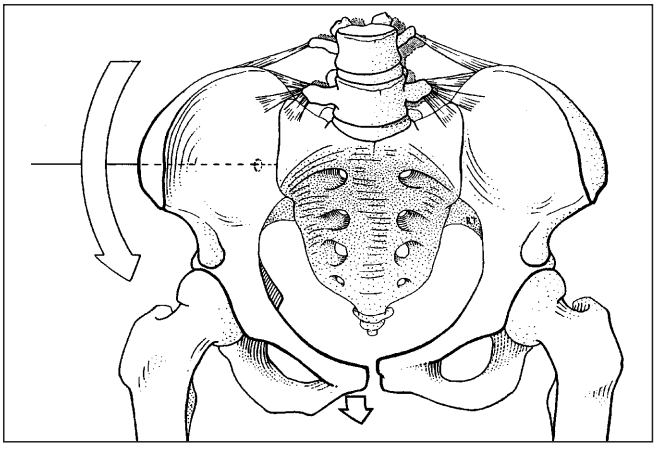

Fig. 3 Possible sequence of events during ASLR of the right leg. The right hip bone is rotated anteriorly about a horizontal axis near the sacroiliac joint. The right iliolumbar ligaments pull L4 and L5 to left rotation and right side flexion

right hip bone during ASLR of the right leg could pull L4 and L5 in side flexion to the right and rotation to the left (Fig. 3). The way the various reaction forces are distributed between sacrum, lumbar spine and contralateral hip bone is dependent on the solidity of the involved connections and the mobility of the bones to which they are attached. Through that, mobility of the lumbar spine and the contralateral SIJ is also involved. In general, every part of this complex chain of motions could be influenced by ASLR and vice versa.

ASLR could also be used to test the usefulness of a pelvic belt in an individual patient and to evaluate the best position and the required tension. It is worthwhile to investigate whether the test can be used to predict the effect of other therapeutic measures, such us exercises, by analyzing the effect of muscle tension and body position on ASLR. Knowledge about the mechanism of peripartum pelvic girdle pain could be valuable for better understanding of non-specific low back pain. In case of weakness of the load transfer system between spine and leg, it is obvious that this weakness has to be treated, and not just the resultant signs and symptoms.

Conclusion

A step has been taken on the path to develop a new clinical test to quantify and qualify disability in patients with peripartum pelvic girdle pain. The results show a clear correlation between impairment of ASLR and mobility of the pelvic joints in patients with peripartum pelvic girdle pain. Though the results are promising, additional studies are needed to reveal the definitive value of the test. Further studies should assess the relationship with clinical parameters, sensitivity, specificity and responsiveness in various categories of patients.

In contrast with the opinion of Chamberlain, that a radiographically visualized step between the pubic bones is caused by cranial displacement of the pubic bone at the standing side, it is concluded that the step during standing on one leg is caused by caudal displacement of the pubic bone at the side of the leg hanging down. The caudal displacement is caused by an anterior rotation of the hip bone about a horizontal axis near the sacroiliac joint.

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