Effect of Foot Manipulation on Pregnancy-Related Pelvic Girdle Pain: A Feasibility Study

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ABSTRACT

Objective: The objective of this study was to investigate if the research process to evaluate the effect of foot manipulation on pregnancy-related pelvic girdle pain (PPGP) is feasible.

Methods: A randomized, single-blind (patients and evaluators) pilot trial was performed to compare foot manipulation to a comparative group at 6-weekly treatment sessions at 5 physiotherapy outpatient clinics in Skaraborg primary care (Skövde, Sweden). Women at 12 to 31 weeks of pregnancy with well-defined PPGP ($n = 97$) and joint dysfunction or decreased range of movement in the feet were included. Women with a twin pregnancy, low back pain, rheumatoid arthritis, or other serious diseases and those who had previous foot manipulation were excluded. Visual analog scale scores were recorded before study start, before and after each treatment session, and 3 months after delivery.

Results: One-hundred and two women were eligible, and 97 were included (group 1: foot manipulation, $n = 47$; group 2: comparative treatment, $n = 50$); 40 and 36 in the foot manipulation and comparative treatment groups, respectively, completed the study. The foot manipulation group had a nonsignificant pain relief score compared with that of the comparative group, which had higher pain relief scores. The difference was most pronounced at the first and second treatment sessions. A power analysis showed that at least 250 individuals would be needed in each group to confirm the effect of foot manipulation.

Conclusions: This study showed that it is feasible to assess the effect of foot manipulation on PPGP in a multicenter physical therapy outpatient clinic setting. A new larger study should choose a different comparative method and test this hypothesis in a full-scale trial. (*J Chiropr Med* 2017;16:211-219)

Key Indexing Terms: *Primary Health Care; Physiotherapy; Osteopathic Manipulation; Ankle Joint; Pregnancy Pelvic Girdle Pain; Randomized Clinical Feasibility Study*

INTRODUCTION

Pregnancy-related pelvic girdle pain (PPGP) is a common problem caused by changes in mechanical loading conditions during pregnancy.¹ The hormone relaxin increases the elasticity of the pelvic joints to facilitate the birth of the infant. It is thought that the increase in elasticity, which seems to be greater in women with PPGP,² may elicit pain as a result of mechanical stress from load on the tissues around the vertebrae of the lumbar spine and pelvic joints. The pain is localized around the posterior pelvic crest, pelvic joints, and buttocks and can radiate as far as the knee joints. Pregnancy-related pelvic girdle pain causes pain and mobility problems during pregnancy and can lead to sick leave.^{3,4}

Pregnant women with PPGP are at risk of becoming physically inactive, and this could cause other medical problems during pregnancy. In most women, PPGP spontaneously disappears soon after delivery, but some continue to have residual problems in the pelvis and lower back for a long time.⁵

It is important to distinguish between lumbar pain and PPGP because the conditions are treated differently. The prevalence rates of PPGP, lumbar pain, and the combination of PPGP and lumbar pain vary greatly among reports because currently no clear definitions of the different conditions exist.⁶ Lumbar pain in pregnant women has been shown to be similar to lumbar pain in nonpregnant women, suggesting that PPGP is a condition of other pathogenesis.⁷ In the European guideline on pelvic girdle pain (PGP), the conclusion was that PGP can occur separately or in conjunction with low back pain (LBP) and is a specific form of LBP.⁸ There are descriptions of tests for PGP, such as pain provocation tests of the sacroiliac joint and of the symphysis as well as a functional test of the pelvic girdle. A pain location diagram is recommended for the localization of pain areas and for a more distinct diagnosis.

To our knowledge, the role of foot position in PPGP has been reported before, but one author (C.M.) has considerable experience in treating pregnant women with satisfying results,

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although this has not been tested in a clinical trial. The association between foot position and back pain in nonpregnant individuals has been demonstrated previously,⁹ including an interaction between the feet and pelvic positions.^{10,11} For instance, one-leg standing in 28 healthy males in different calcaneal wedges of 0°, 5°, and 10° eversion produced a significant increase in hip flexion and medial rotation, as well as pelvic anterior tilt.¹² Pelvic joints are also linked in this interaction, and movements in the talocrural and subtalar joints and in the more distal transverse tarsal joints in the foot have an important impact on pelvic position.^{7,9-12} Asymmetric pronation in the subtalar joints, as well as asymmetric rotation of the feet and hips, results in an asymmetric pelvis and leads to asymmetric movements and locking of the sacroiliac joints. The transverse tarsal joints rotate in opposition to the subtalar joint,¹³ and mobility in these joints is crucial for foot stability in standing and weight bearing and for mobility during walking.¹⁴ Decreased mobility in all 3 joints leads to external hip and foot rotation to perform the swing phase of the gait circle. Furthermore, internal rotation of the feet causes anterior tilting of the pelvis, and external rotation causes posterior tilting of the pelvis.¹⁵ Rotation of the foot also results in a functionally shorter leg and pelvic tilts in the coronal plane.¹⁶ If asymmetric, these tilting movements could elicit pain in the pelvic joints and may contribute to PPGP. However, some studies have suggested that there are fewer cases of LBP related to the pes cavus¹⁷ and some others have suggested that flat feet are not the reason for LBP.^{18,19}

In a Cochrane review²⁰ of pelvic pain and back pain during pregnancy, it was found that acupuncture reduced pelvic pain better compared with exercise, and that compared with usual care, both acupuncture and training were better. However, 1 of the studies showed that compared with nonpenetrating acupuncture, acupuncture did not have a significant difference in effect on pain but improved the performance of daily activities.²¹ Pelvic belt, physiotherapy, osteopathic manipulative treatment and multimodal intervention also seemed to relieve pelvic pain or back pain better than usual care.²⁰ Some outcomes had low quality of evidence, and the effect on pain was variable. One conclusion of the Cochrane report was that further research on prevention or treatment of pelvic pain and back pain during pregnancy is likely to change the results.

Osteopathic manipulative treatment of back pain and related symptoms during the third trimester of pregnancy seems to lower or halt the deterioration of back-specific functioning.²² Chiropractic high-velocity, low-amplitude manipulation on female athletes with talocrural joint dysfunction has been shown to result in an increase in vertical jump height.²³

Pregnancy-related pelvic girdle pain is a common condition during pregnancy and causes suffering for the patient and her family and sometimes results in disability and absence from work. Only around 50% of women get treatment to relieve the pain.⁴ Treatments for pain relief have shown inconsistent results. There is a need for treatments that can be easily accessed and applied in the

care of pregnant women. Therefore, the purpose of this study was to investigate the feasibility of the research process to evaluate the effect of foot manipulation on PPGP in a multicenter physical therapy outpatient clinic setting.

METHODS

Study Population

The study included cases from September 2009 to August 2011, and comprised women with suspected PPGP who had been referred by midwives or physicians or who had contacted physiotherapists directly. Inclusion criteria were Swedish-speaking women in weeks 12 to 31 of pregnancy who had PPGP as determined by specific provocation tests, including the posterior pelvic pain provocation test, Patrick (FABERE [flexion, abduction, external rotation]) test, active straight leg raise test, modified Trendelenburg test, and palpation of the symphysis pubis.⁶ The precise area of pain was indicated on an anatomic pain drawing, and women with only LBP were excluded. Women with twin pregnancies, lumbar pain, rheumatic disease, or other serious diseases; non-Swedish-speaking women; and those who had been treated with foot manipulation earlier were also excluded. The feet were inspected with the patient in the standing position to estimate whether they were straight, whether they were rotated outward or inwards from the hip, and if the load was flat, pronated, or supinated. Movement in the subtalar joints, as well as the mobility of the tarsal bones and the lateral malleoli, was investigated manually. All movements between the right foot and the left foot were compared both visually and manually. However, a goniometer was not used. Those participants with identified joint dysfunction or decreased range of movement (ROM) in the feet were included in this study.

Study Procedure

Patients were randomized to either a foot manipulation group or a comparative treatment group, by using sealed envelopes ($n = 150$; 75 for each treatment). The opaque envelopes, concealing the allocation to foot manipulation or comparative treatment, were mixed centrally and distributed to the physiotherapy clinics in appropriate numbers, depending on the size of the clinic. Ten physiotherapists participated pair-wise in the treatments—1 of them drew the sealed envelope and treated the patient according to the allocation (physiotherapist not blinded, patient blinded), and the other physiotherapist was blinded to the allocation of the patient and made the evaluation (both physiotherapist and patient blinded). The patient's treatment allocation was concealed throughout the study, and the study documentation was kept in separate locked drawers by both physiotherapists. All patients received the same information about PPGP, 6 visits once a week for 6 weeks, and follow-up visits 1 week after end of treatment and 3 months after delivery. All patients

were instructed not to talk to the other pregnant women in the study or to the evaluating physiotherapists about the details of their treatment to keep the patient and the evaluating physiotherapist blinded to the treatment allocation.

Data were recorded in documents separate from the medical records, were not accessible to the evaluators, and included group assignment, results of diagnostic tests, and visual analog scale (VAS) scores for pain (ie, 0–100 mm without number at sessions and in diaries). The blinded evaluator administered the follow-up 3 months after delivery. The allocation of patients was revealed after analysis of data had been completed.

Foot Manipulation

The author who used the foot manipulation technique (C.M.) had received training from Laurie Hartman, DO MRO, Associated Professor of Osteopathic Technique, at the British School of Osteopathy. The other physiotherapists were trained by this author (C.M.).

Asymmetry of the feet was treated once with a high-velocity thrust²⁴ of the cuboid bone, with the patient in the supine position and the leg on a psoas pillow to help the pregnant patient relax. With crossed thumbs under the cuboid, maintaining dorsiflexion at the ankle, the leg was passively pushed in a small flexion and allowed to come back at a small angle. This was repeated until the foot recoiled, and the thrust was given midway through the movement, with the fingers producing inversion, adduction, and compression. This is similar to the snap technique used by Jennings and Davies,²⁵ but here Laurie Hartman's technique was used. The subtalar joint was treated once with a gapping thrust,²⁴ with the patient lying on the affected side and the knee flexed. The foot was fixed in dorsiflexion to stabilize the ankle, and the calcaneum was fixed to the table. The other hand inverted the foot by fixing on the navicula; the foot was then rocked between the hands until the optimal barrier was sensed, and the thrust of the whole foot to the table was given with gapping force. With the patient placed in the squatting position, mobilization with movement of the distal tibia–fibula²⁶ was performed, with the thenar eminence placed ahead of the patient's distal fibula, pushing dorsally and making the fibula glide on the tibia. This movement was repeated 10 times.²⁶ Home training programs to maintain mobility of the joints were provided, and mandatory morning exercises and additional exercises were encouraged. Patients were encouraged to routinely apply the same pressure on the balls of the big toe and the little toe, as well as the middle of the heel. Four types of exercises, each with 8 repetitions, were recommended¹: mobility training of the feet (sitting or lying, with straight legs doing pronation and supination of the feet from maximal dorsal flexion to maximal plantar flexion)²; mobility training of the joints between the tarsal bones by “caterpillar walk” (sitting with the feet, knees, and hips aligned along a vertical line, extending the toes and bending

them while lifting the heels)³; training of take-off of the big toes along a normal walking line to increase the ability to walk with straight feet; and⁴ mobility training of lateral malleoli and the talocrural joint by dorsal flexion of feet while bending the knees forward as far as possible, maintaining normal lordosis.

Comparative Treatment

Comparative treatment included downsizing (a massage technique) the section underneath the heel from the back forward with 4 grips and light palpation of the 5 metatarsal bones with the patient in the supine position on a psoas pillow. Moreover, a grip was taken around the ankle with a ventral, very light pressure on the Achilles tendon with the patient standing against a wall with the feet 40 cm off the wall in light plantar flexion and slightly bent knees to simulate the tibiofibular mobilization in the foot manipulation but without the feet in dorsal flexion. The comparative treatment was repeated 10 times. This group was also advised to perform home exercises in the mornings, repeating them 8 times¹: supine position, spreading and squeezing the toes²; sitting position, lifting of heel and forefoot, with the feet remaining in plantar flexion³; walking with small steps along a line with pelvis aligned over the feet, forward and backward; and⁴ tiptoeing in the erect position while maintaining normal lordosis.

Visual Analog Scales and Home Diaries

The patients used a specifically prepared diary (Appendix 1 Pain Diary) with VAS graded from 0 to 100 mm on a horizontal line to rate pain (in the pelvis, sacroiliac joint [SIJ] and symphysis pubis) marked with an “X” on the line each morning and evening for 6 weeks. One author (C.M.) measured the VAS in millimeters and recorded the scores. Patients also indicated daily whether they were on sick leave 25%, 50%, 75%, or 100% of the time in their full-time jobs. This procedure was calculated to take 5 to 10 minutes per day. Net days of sick leave were calculated as the number of days multiplied by the degree of sick leave.

Participating Physiotherapists and Evaluation

One year before study start, an investigation of the prevalence of PPGP and how the condition was treated in Skaraborg by physiotherapists and midwives was performed using inquiries. It was not possible to estimate the prevalence, but 13% to 35% of all pregnant women were treated by physiotherapists. Sixty-one (65%) of the physiotherapists answered that they had treated PPGP.²⁷ Physiotherapists interested in taking part in the study were recruited among the participants whose time in practice varied from 4 to 35 years. The study was performed at physiotherapy clinics at 5 primary health care centers in Skaraborg. The physiotherapists performing the study participated in 3 full-day meetings on different occasions before study start to learn the manipulation

Fig 1. Foot manipulation for pregnancy-related pelvic pain (PPGP) in primary care, CONSORT flow-chart of study subjects and dropout during treatment and follow-up.

and comparative techniques. Intertherapist reliability of treatment technique and evaluation of treatment was measured by using VAS and was checked by one author (C.M.) at these meetings. The blinded evaluations, including VAS measurements, were performed at all visits before and after each treatment by the physiotherapists. The extra time allotted to this procedure was estimated to be 30 minutes.

Statistics

The intention was to include 150 patients because the study was rather demanding for the patients because of the daily

training program and having to keep diaries. A dropout rate of 30% was expected. A power calculation was performed on the basis of the results in the study to evaluate risk for type 2 error in the material. All analyses were performed using SPSS version 19 (SPSS Inc., Chicago, IL). The *t* test and the χ^2 test were used to compare continuous variables, numbers, and frequencies. Differences in VAS scores were calculated using a sign test with binomial approximation and with adjustment for differences in baseline pain on the VAS. The effects of treatment were classified according to Cohen in small effects less than 10% of the scale, medium effects 10% to 20%, and large effects more than 20%.²⁸ In addition, as the rate of

Table 1. Clinical Characteristics of Women With Pregnancy-Related Pelvic Girdle Pain at Inclusion

	Comparative Treatment (n = 50), Mean ± SD	Foot Manipulation (n = 47), Mean ± SD	P
Age, y	28 ± 6	30 ± 6	.13
Parity	1.8 ± 0.8	2.0 ± 1.5	.36
Gestational age, wk	23 ± 6	24 ± 6	.52
Former girdle pain	n = 22 (63%)	n = 13 (37%)	.07
Foot trauma	n = 30 (48%)	n = 33 (44%)	.28

Data are mean ± standard deviation; number and percent in the last 2 rows. SD, standard deviation.

dropout during the study was high, an intention-to-treat analysis was performed, with multiple imputation for missing data comparing the VAS scores between the first and second treatment sessions. A difference was considered significant if the *P* value was below 0.05.

Ethics and Funding

The regional ethics review board at the University of Gothenburg (No. 319-09) approved the study, and a written consent was obtained from all the participants. The study was funded by grants from the Skaraborg Research and Development Council and the Skaraborg Primary Care Research and Development Council. The trial was registered at ClinicalTrials.com (No. NCT01894009).

RESULTS

All women included were found to have asymmetric position of one or both feet. A flow chart including the number of patients in the study process is presented in [Figure 1](#). Of 150 total women, 102 were recruited (47 in the foot manipulation group and 50 in the comparative treatment group, of whom 5 did not meet the inclusion criteria). Twenty-one patients withdrew during the study for different reasons. The attrition rate varied during treatment, and according to voluntary comments from the patients, this could be attributed to not having a babysitter, lack of time, and difficulty to take leave from work.

The clinical characteristics of the patients are shown in [Table 1](#). There were no differences in age or gestational week between the 2 groups. Previous girdle pain was more common, although not significantly, in the comparative group. The group receiving comparative treatment had higher scores on the VAS at baseline.

Visual Analog Scale

The completeness of the VAS and the patients' diaries was very good; only 3 diaries were missing, the internal dropout was low, and few items were left out. Completeness of the VAS documentation from the physiotherapists differed, with the time for evaluation ranging from 2% to 5%. Pain in the

SIJ, according to VAS scores after treatment, diminished a couple of scale points or remained at same level in the foot manipulation group, whereas it increased in the comparative treatment group. Comparison of pain scores showed that there was a nonsignificant trend of pain reduction in the foot manipulation group compared with the comparative treatment group during the treatment period ([Fig 2](#)). The effect was most pronounced at the first and second treatment sessions ([Table 2](#)). Pain in the symphysis pubis and the SIJ did not differ between the groups. An intention-to-treat analysis of treatment effect was performed between the first and second sessions because this was the time when the effect was most apparent, but this did not change the result ([Table 3](#)).

Sick Leave

Twelve pregnant women were on sick leave because of PPGP and 12 for other causes. There was no difference in sick leave (net days) between the groups (data not shown). In both groups, none of the patients on sick leave because of PPGP returned to work during pregnancy.

Power Calculation

A power calculation based on the effect of treatment (VAS scoring; mean and standard deviation) after the first session (foot manipulation 17 ± 19, n = 36; and comparative treatment 26 ± 23, n = 34, respectively) and second session (foot manipulation 21 ± 15, n = 38; and comparative treatment 31 ± 22, n = 33, respectively) ([Table 2](#)), showed that 250 patients would be needed in each group to confirm the effect of foot manipulation compared with comparative treatment. Also, as the dropout rate was 22% after randomization ([Fig 1](#)), an additional 140 individuals would have to be included to account for the dropout.

DISCUSSION

The main result of this study was that foot manipulation for PPGP was feasible in a multicenter physiotherapist outpatient clinic setting. A larger study would be feasible as the treatment can readily be performed by physiotherapists in primary care, provided they have appropriate education. The prevalence of the condition is high enough to recommend this, and the completeness of patient diaries and VAS evaluation in the present study was satisfactory.

There seem to be no publications regarding the effect of foot manipulation in the treatment of PPGP, but it has been shown that the foot position affects the position of the pelvis.^{10,11} Furthermore, the effect of foot manipulation on the function of the ankle has been studied in young healthy athletes after they sustained ankle sprain.²³ According to that pilot study, foot manipulation rather than sham treatment increased the female athletes' jump range. Unfortunately, no data on changes in ankle ROM before

Fig 2. Pain scoring according to the visual analog scale (VAS) before and after each treatment session with comparative treatment or foot manipulation for pregnancy-related pelvic pain (PPGP). Data are mean $\pm$ 95% confidence interval (CI). A, Upper panels show patients who attended all treatment sessions ($n = 22$). B, Lower panels show patients who attended each treatment session, number of patients are stated above the bars. VAS before treatment sessions in dotted bars, VAS after treatment sessions in plain bars. There was no statistical difference between the scores in the 2 groups.

Table 2. Pain in Pelvic Region, Sacroiliac Joint, and Symphysis Pubis Recorded by Visual Analogue Scale (100 mm) During Treatment of Pregnancy-Related Pelvic Girdle Pain

	Comparative Treatment		Foot Manipulation		
	n	Mean ± SD	n	Mean ± SD	P
Pain in Pelvic Region					
<i>Morning</i>					
1st session	40	24 ± 23	35	19 ± 16	.24
2nd session	41	24 ± 19	35	18 ± 14	.77
6th session	39	29 ± 26	31	20 ± 20	.64
<i>Evening</i>					
1st session	41	45 ± 29	36	39 ± 23	.33
2nd session	42	41 ± 25	35	34 ± 17	.90
6th session	33	47 ± 27	29	29 ± 21	.28
Pain in SIJ					
<i>Before Treatment</i>					
1st session	50	23 ± 27	47	21 ± 23	.68
2nd session	34	26 ± 23	36	17 ± 19	.05
3rd session	33	31 ± 22	38	21 ± 15	.08
4th session	32	27 ± 24	31	19 ± 17	.58
5th session	33	23 ± 23	30	18 ± 16	.95
6th session	28	22 ± 21	28	16 ± 17	.70
<i>After Treatment</i>					
1st session	48	27 ± 27	47	22 ± 19	.33
2nd session	34	27 ± 23	35	15 ± 15	.04
3rd session	32	29 ± 23	37	20 ± 14	.18
4th session	31	27 ± 22	31	18 ± 16	.60
5th session	30	28 ± 28	30	16 ± 16	.72
6th session	28	24 ± 23	28	14 ± 15	.68
Pain in Symphysis					
<i>Before Treatment</i>					
1st session	50	9 ± 19	47	9 ± 17	.95
2nd session	33	13 ± 20	35	11 ± 19	.36
6th session	27	12 ± 18	28	12 ± 18	.27
<i>After Treatment</i>					
1st session	47	11 ± 20	46	8 ± 17	.34
2nd session	33	11 ± 20	32	11 ± 19	.62
6th session	27	12 ± 18	28	9 ± 14	.92

Data are mean ± standard deviation; the *P* values were adjusted for differences in VAS at baseline; first sessions are the baseline. *SD*, standard deviation; *SIJ*, sacroiliac joint; *VAS*, visual analog scale.

and after treatment could be obtained in the current study. This could have added to the knowledge about the effect of foot manipulation on ankle joints and shed more light on the effect of treatment. Measurement of ankle ROM should be included in a larger clinical trial.

Another issue to be addressed in a future study is the clinical significance of the treatment effect. The minimal important change on the VAS on frequently used measures of pain and the functional status of LBP was 15.²⁹ The VAS is an arbitrarily set scale, where the distance between the steps cannot be considered standardized and can vary among individuals. The reduction in VAS scores in the foot manipulation group was small (from 21 to 15) and below the reduction estimated as clinically relevant (ie, a minimal important change of 15 points). It is also important to note that the increase in pain in the comparative treatment group

Table 3. Comparisons Between the Groups Based on Change in Pain in the SIJ After the First and Second Treatment Sessions^a

	Comparative Treatment		Foot Manipulation		P
	n	Mean ± SD	n	Mean ± SD	
Original Data					
<i>Before Treatment</i>					
1st session	50	23 ± 27	47	21 ± 23	
2nd session	34	26 ± 23	36	17 ± 19	
<i>After Treatment</i>					
1st session	48	27 ± 27	47	22 ± 20	.71
2nd session	34	27 ± 23	35	15 ± 16	.52
First Imputation ^b					
<i>Before Treatment</i>					
1st session	50	23 ± 27	47	21 ± 23	
2nd session	50	33 ± 24	47	18 ± 17	
<i>After Treatment</i>					
1st session	50	27 ± 26	47	22 ± 20	.58
2nd session	50	31 ± 22	47	16 ± 15	.56
Second Imputation ^c					
<i>Before Treatment</i>					
1st session	50	23 ± 27	47	21 ± 23	
2nd session	50	26 ± 21	47	18 ± 18	
<i>After Treatment</i>					
1st session	50	27 ± 26	47	22 ± 20	.72
2nd session	50	27 ± 21	47	16 ± 15	.24

Data are mean ± standard deviation.

^a Intention to treat with multiple imputation data (2 imputations) for missing values.

^b Comparison between the groups with respect to change after first treatment session, by Mann-Whitney test.

^c Comparison between the groups with respect to change after second treatment session, by Mann-Whitney test. *SD*, standard deviation.

should have been accounted for in the current comparison. In a future trial, in addition to measure of relief of pain, evaluation of function and quality of life could be included.

All patients included in this study were shown to have joint dysfunction and decreased ROM, which may explain the PPGP. To what extent pregnant women without PPGP have joint dysfunction and decreased ROM is not known and was not investigated in this study. The prevalence of joint dysfunction and decreased ROM and their association with pelvic girdle pain would be important to study because such a study could contribute to better understanding of the etiology of PPGP. Furthermore, data could be used in the evaluation of foot manipulation not only for PPGP but also for other conditions suspected to be related to joint dysfunction and decreased ROM.

In addition to a training program for the evaluators, other advantages of the current study were that the evaluators were blinded and that a control group of patients had received comparative treatment and were followed up in a way similar to the foot manipulation group. This is as close to a randomized double-blind study as possible because treatment involves actions from a nonblinded caregiver. Furthermore, in the comparative treatment, much effort was put into avoiding manipulation by physiotherapists. The

treatment at the clinic was only slight palpation to ensure that no mobilization of the foot joints occurred.

Although the effect of foot manipulation on PPGP could not be demonstrated in the current study, an effect cannot be ruled out because the relief of pain in this group was nonsignificant; this would be interesting to evaluate further. As indicated by the results of the current study, the sample size needed to confirm or reject a statistical and clinical significant effect of foot manipulation would be 250 in each group in a further trial. This would probably include more clinics, which makes it crucial to ensure introductory education of the physiotherapists in manipulation and evaluation of effect, as well as continuous control of the treatment techniques and reliability in evaluation of treatment over time. Involving osteopathic experts could be valuable in future studies.

Limitations

The small difference in pain relief and the slight reduction in PPGP in both groups could be attributed to the fact that the home exercises performed by the comparative treatment group could have increased the ROM of feet and thus had an effect on the pelvic position and possibly PPGP. Other studies have shown that exercises given to patients with PPGP have a pain-relieving effect compared with the usual treatment without exercises.³⁰

Another limitation of the current study was the low number of participants. The dropout rate has to be accounted for in planning a larger study as well as the varying rates of attrition to treatment and evaluation. Facilitation, for instance, by offering babysitting services during treatment sessions and flexibility in appointments could increase the attrition rate.

Finally, all women with PPGP had asymmetric position in one or both feet. This finding should have prompted us to investigate pregnant women without PPGP to further evaluate the association between foot position and PPGP.

Future Studies

A new comparative treatment that would not have an effect on the ROM of feet should be designed. The treatment by the physiotherapist in the clinic should not mobilize the foot joints and could be used in a future study. However, home exercises should be altered to avoid mobilization, especially lifting of heel and forefoot and tip-toeing in the erect position. Instead, walking on a line, spreading of toes, and stepping in the erect and sitting positions could be used.

Furthermore, new studies should address the issue of high rate of dropout after inclusion in the study by offering babysitting services during treatments as well as more variable time for treatment than done in this study. The participants' midwives should be proactively and regularly engaged to further encourage the participants to complete

the study. To confirm or rule out an effect of treatment, 250 individuals should be included in each group.

Future studies should include foot posture evaluation in pregnant women without PPGP as well. It is important to compare their foot posture to that of women with PPGP to further strengthen or disprove the hypothesis of PPGP caused by different foot postures. A new study should choose a different comparative method because this was found to be a main drawback of the present study. Also, the rates of attrition to treatment and evaluation could be decreased by offering support at the appointments to the participants.

CONCLUSIONS

This study showed that the investigation of the effects of foot manipulation on PPGP is feasible. Thus, a full-scale trial with modification of the program should be considered.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.jcm.2017.05.003>.

Practical Applications

- Foot manipulation might reduce PPGP but needs to be studied in comparison with a suitable control treatment.
- A larger clinical trial is warranted to evaluate the role of foot manipulation for treatment of PPGP.
- A new clinical study should include patients with and without normal foot posture as this could add knowledge of the role of foot posture in pain in the pelvis.

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