Spinal Mobilization of Postpartum Low Back and Pelvic Girdle Pain: An Evidence-Based Clinical Rule for Predicting Responders and Nonresponders

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Objective: To develop a clinical prediction rule (CPR) for identifying postpartum women with low back pain (LBP) and/or pelvic girdle pain (PGP) whose functional disability scores improve with a high-velocity thrust technique (HVTT) conducted by a physical therapist.

Design: Prospective cohort.

Setting: Outpatient physical therapy departments.

Participants: Sixty-nine postpartum women referred to physical therapy with the complaint of LBP and/or PGP.

Methods: Subjects underwent a physical examination and a HVTT to the lumbopelvic region.

Main Outcome Measures: Success with treatment was determined by the use of percent changes in disability scores and served as the reference standard for determining accuracy of the examination variables. Variables with univariate prediction of success and nonsuccess were combined into multivariate CPRs.

Results: Fifty-five subjects (80%) had success with the HVTT. A CPR for success with 4 criteria was identified. The presence of 2 of 4 criteria (positive likelihood ratio = 3.05) increased the probability of success from 80% to 92%. A CPR for treatment failure with 3 criteria was identified. The presence of 2 of 3 criteria (positive likelihood ratio = 11.79) increased the probability of treatment failure from 20% to 75%.

Conclusions: The pretest probability of success (80%) is sufficient to reassure the clinician about the decision to use a HVTT to the lumbopelvic region in postpartum women with LBP and/or PGP. If 2 of 3 criteria for treatment failure are met in the CPR, an alternative approach is warranted. An intervention such as the HVTT is compelling, given the need to minimize pharmaceutical remedies in women who are potentially breast-feeding post partum.

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INTRODUCTION

Low back pain (LBP) and pelvic girdle pain (PGP) are commonly reported to obstetricians and can be debilitating for pregnant and postpartum women, preventing them from performing household and employment activities [1]. From 50% to 70% of women experience some form of low back or pelvic pain during pregnancy, and women who experience severe LBP or PGP are at high risk for back pain for more than 3 to 10 years after delivery [1-5]. The majority of patients recover from LBP or PGP shortly after delivery; however, pain may persist for prolonged periods in some patients, ranging from 6-24 months in more than 20% of the population [6,7]. Despite the apparent need, few treatments have been studied [8,9]. A possible reason for this lack of evidence on the effectiveness of treatments may be the inability to recognize subgroups of patients who are likely to benefit from specific interventions.

Manual therapy, a clinical approach utilizing skilled specific hands-on techniques, can include lumbosacral region high-velocity thrust techniques (HVTTs), which are commonly used for the treatment of LBP and PGP [10,11]. HVTTs, which are also referred to as

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high-velocity low-amplitude thrusts, are manual therapy techniques that move a joint or motion segment beyond the restricted range of the joint and/or related soft tissues [12]. Although the specific target of action with manual therapy approaches is unclear (eg, facet joint or sacroiliac joint [SIJ]), there is demonstrable evidence of benefit with the use of HVTTs for LBP and PGP [13].

Flynn and colleagues [14] developed a clinical prediction rule (CPR) that can be used to identify patients with LBP who are most likely to benefit from HVTT. Patients who met at least 4 of the 5 criteria in the CPR improved their chances of success with HVTT from 45% to 95%. Success was defined as a 50% improvement on the modified Oswestry Disability Questionnaire (ODQ). This CPR was subsequently validated in a randomized clinical trial [15]. These CPR studies served to verify previous reports that patients with acute LBP or PGP are reported to benefit from the HVTT [16,17] without the need to definitively identify impairments such as SIJ dysfunction, for which objective tests and measures lack reliability [18-26]. It is unclear whether these CPRs would be useful for chronic conditions.

The authors of previous CPR studies deliberately excluded postpartum women. Thus a CPR to predict potential benefit of HVTT in postpartum women has not been investigated. Murphy and colleagues [27] studied lumbopelvic pain in pregnant women and found that using a diagnosis-based clinical decision rule yielded favorable outcomes in terms of disability and pain. Developing a CPR to identify postpartum subjects who are likely to respond favorably to a HVTT directed toward the lumbopelvic region would aid clinicians in their decision-making process.

The specific aims of this study were as follows: (1) determine the predictive ability of individual historic and physical examination variables in identifying positive response and nonresponse to treatment among subjects with LBP and/or PGP undergoing a HVTT; and (2) determine the best combination of these variables for predicting positive response and treatment failure. We chose a widely used, nonspecific HVTT that is purportedly directed to the SIJ [10]. However, the specificity of this claim has not been tested, and in all likelihood it also affects portions of the lumbar spine.

METHODS

Subjects

A prospective cohort of postpartum patients reporting pain in the lower back and/or buttocks was recruited. Institutional Review Board approval was obtained from the University of Pittsburgh before the onset of any study activities. Women between 18 and 45 years of age who were within 1 year of giving birth were included in the study. Women with a chief complaint of pain in the areas of the lower back, pelvis, buttock, and legs who were referred for physical therapy by obstetrics and gynecology physicians or who called in response to public advertising were included in the study. Thirty-two percent of the women were categorized as having acute symptoms or recurrent acute symptoms (ie, $<$6 weeks since onset of symptoms/pain). As in previous studies in which the authors used a CPR for LBP, the baseline ODQ score had to be at least 30%. Previous research has shown that an average ODQ score of 40% is found for new patients referred to physical therapy, with a standard deviation (σ) of approximately 10% [28]. Change in disability was used as the reference criterion in this study, and the minimum baseline level of 30% ensured that a wide range of patients were included and extreme low scores of disability were excluded. Any subject presenting with frank nerve root compression signs in a radicular pattern (ie, weakness), a previous history of lumbar/sacral spine surgery, a new pregnancy, or spinal fractures was excluded. The following data were recorded: the subject's age, number of children, type of delivery, duration of symptoms, and whether the pain started during pregnancy.

Subjects completed several validated self-report measures related to pain, including the Visual Analogue Scale [29], the ODQ (which measures function and disability) [30], and the Fear-Avoidance Beliefs Questionnaire (which measures fear avoidance) [31,32]. A standardized history was obtained and a physical examination was performed, followed by an HVTT. Follow-up occurred within 2 to 4 days to categorize the HVTT as a success or failure for each subject as determined by the criterion standard, which was 50% improvement in disability scores as measured by the ODQ.

Examination Procedure

Subjects provided demographic information and completed a baseline examination, which included rating their pain with use of a 10-point numeric scale. Subjects then indicated the location of their pain symptoms on a body diagram [33]. The primary outcome variable was the well-validated and accepted self-report ODQ questionnaire that documents the extent to which LBP restricts a person's functional level [34]. A physical examination was performed that included a neurologic screening to rule out nerve root compression or radiculopathy (ie, weakness), Waddell nonorganic signs [35], and a series of SIJ tests (Appendix 1) [21].

Intervention

All subjects received the same HVTT procedure that targeted the lumbopelvic region. The side to be treated was chosen on the basis of the subject's report of her most symptomatic side. Cibulka et al [10] found that a manipulative procedure of the lumbopelvic region changes innominate tilt bilaterally and in opposite directions. The physical therapist passively sidebent the subject toward the painful side, rotated the upper

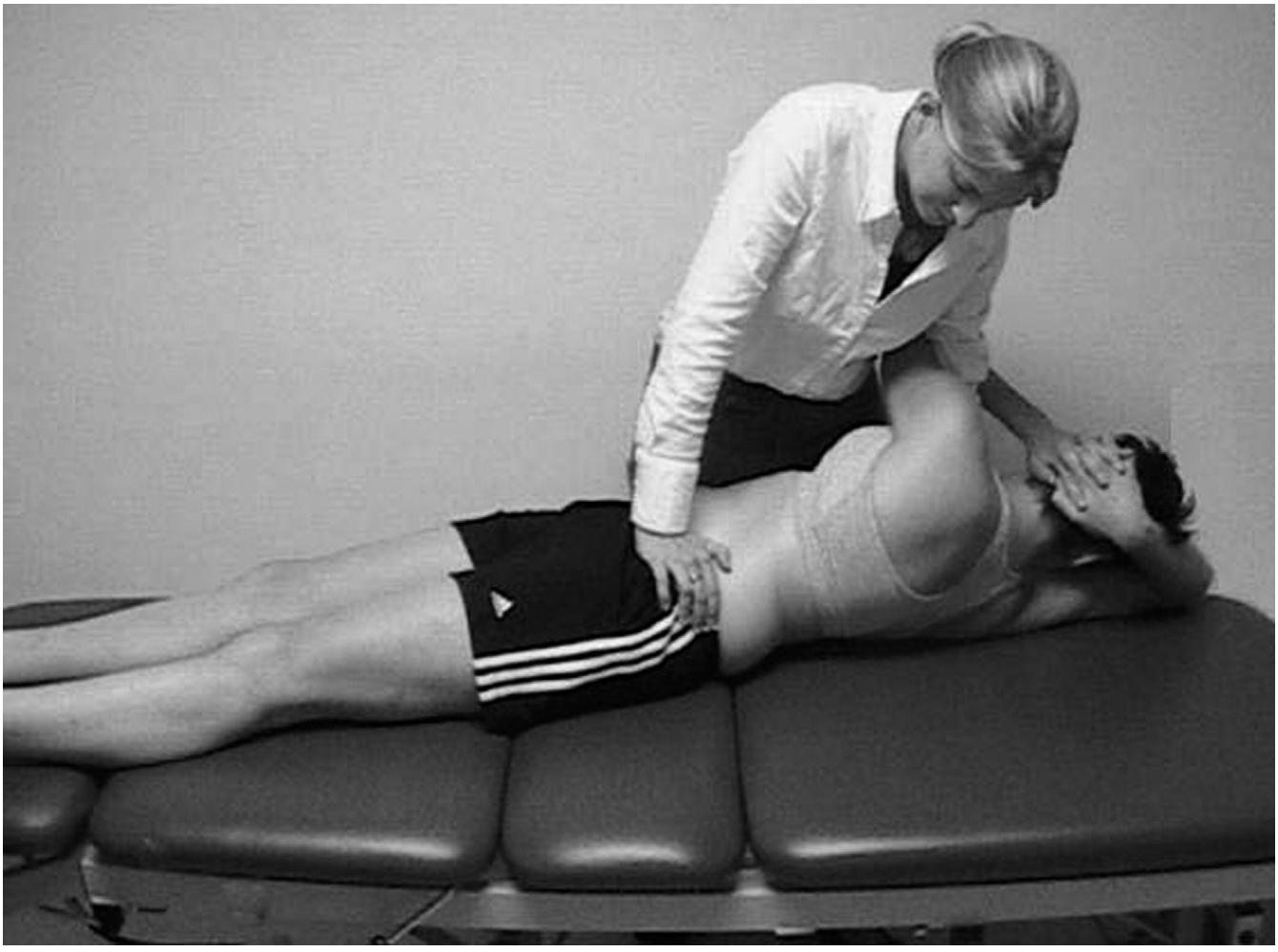

Figure 1. High velocity thrust technique used in the study.

body in the direction opposite to the side bending, and then delivered a quick posterior and inferior thrust at a grade V [36]. *The Guide to Physical Therapy Practice* defines manipulation (grade V mobilization) as a "manual therapy technique comprising a continuum of skilled passive movements to the joints and/or related soft tissues that are applied at varying speeds and amplitudes, including a small-amplitude/high-velocity therapeutic movement" [37].

A maximum of 2 attempts per side was permitted if no pop was heard following the first attempt (Figure 1). According to Flynn et al [38], there is no relationship between an audible pop and improvement in range of motion, pain, or disability when performing a mobilization to the SIJ in persons with nonradicular LBP. The physical therapist then instructed the subject to perform 10 repetitions of the hand-heel rock range of motion exercise. The subject is instructed to assume the quadruped position and distribute weight on her hands and arms equally as the starting position. The forward rock is performed by transferring her weight more to her hands, while not allowing her arms to bend. She is asked to allow her abdomen to sag toward the surface while she holds her head to look up. A pause is held toward the end of the range, and then she is asked to return back toward the starting position. The backward rock is performed as if she were attempting to sit on her heels. She is asked to allow her back to round while her hands drag along the surface to obtain the fully backward position.

All subjects were advised to remain as active as possible without aggravating symptoms. The subjects were asked to return 2 to 4 days later to complete the ODQ. Percentage improvement was calculated as follows: ([initial score – final score]/initial score × 100). If the subject showed greater than 50% improvement, the intervention was categorized as a success and participation ended. If the subject showed improvement of 50% or less after the first treatment, the intervention was categorized as a failure, the examination and intervention were repeated, and the subject was asked to return 2 to 4 days later. If the subject then showed greater

Table 1. *Baseline characteristics of study sample*

Variable	All Subjects (n = 69)	HVTT Success (n = 55)	HVTT Nonsuccess (n = 14)	Significance
Age (y)	31 (6) (range, 19-46)	30 (6) (range, 19-42)	34 (5) (range, 26-46)	.018
Body mass index (kg/m^2)	28.9 (7.5)	29 (7.5)	30 (8)	.567
Ethnicity: No. of white subjects (%)	52 (73.9)	55 (83)	14 (17)	.781
No. of children	1 (1) (range, 0-4)	1 (1) (range, 0-2)	1.5 (1) (range, 1-4)	.503
Epidural used: No. of epidurals (%)	52 (74)	42 (76.4)	10 (71.4)	.472
Type of delivery: No. of vaginal births (%)	51 (74)	42 (76.4)	9 (64.3)	.275
Onset of pain: No. per category (%)				
First trimester	3 (4)	3 (100)	0 (0)	.501
Second trimester	17 (25)	13 (76.5)	4 (23.5)	.472
Third trimester	21 (31)	16 (76.2)	5 (23.8)	.428
<1 wk postpartum	14 (20)	10 (71.4)	4 (28.6)	.300
1 wk to 1 mo postpartum	8 (11.6)	7 (87.5)	1 (12.5)	.485
1-3 mo postpartum	5 (7)	5 (100)	0 (0)	.310
>3 mo postpartum	1 (1.4)	1 (100)	0 (0)	.797
Duration of symptoms (wk)	28.88 (17) (range, 2-84)	28.8 (17)	29.3 (18)	.535
Use of oral contraceptives: No. using (%)	10 (14.5)	9 (16.4)	1 (7.1)	.348
Visual Analogue Scale, 0-10				
Pain at present	4.7 (2.1)	4.4 (2.1)	5.9 (2.2)	.040
Pain at worst	6.7 (2.2)	6.5 (2.2)	7.7 (1.9)	.066
Pain at best	3.4 (2.5)	2.8 (2.1)	5.3 (2.7)	.002
Fear avoidance beliefs				
Work	13.1 (9.7)	13.1 (9.1)	12.5 (12.6)	.557
Physical activity	15.4 (4.3)	15 (4.3)	16.9 (4.3)	.227
Edinburgh Postpartum Depression Questionnaire	6.0 (4.5)	5.9 (4.4)	6.9 (4.7)	.717
Oswestry Disability Questionnaire	42.3 (9.2)	42.2 (9.1)	43.1 (9.3)	.436

Values are means (σ) unless otherwise indicated.
HVTT = high-velocity thrust technique.

than 50% improvement, the intervention was categorized as a success, and study participation ended. If the subject showed improvement of 50% or less, the intervention was categorized as a failure, participation in the study ended, and further treatment was administered as needed (ie, modalities, strengthening exercises, and postural re-education).

Data Analysis

Descriptive statistics (means and SDs) were calculated for the baseline variables with use of SPSS 14.0 (SPSS Inc, Chicago, IL). A sample size of 68 was chosen on the basis of calculations from sensitivity and specificity values of 0.8 and a positive likelihood ratio (+LR) of 2.0 with use of techniques described by Simel et al [39]. Subjects were dichotomized on the basis of success or failure of the treatment, which was the reference standard. Individual variables from the self-reports, history, and physical examination were investigated for their univariate association with the reference standard by calculating point and confidence interval values for test sensitivity, specificity, and LRs calculated from a 2 × 2 contingency table.

For continuous independent variables such as age, weight, and modified ODQ, and for categorical variables, a cut point was determined to dichotomize the variables for use in the 2 × 2 contingency table. The dichotomization was performed with the use of a receiver operating characteristic curve. The point on the curve nearest to the upper left corner represents the value with the best diagnostic accuracy and was used as the cutoff for a positive test [40]. To determine which variables had predictive ability, a sensitivity or specificity value of 0.7 or greater was used

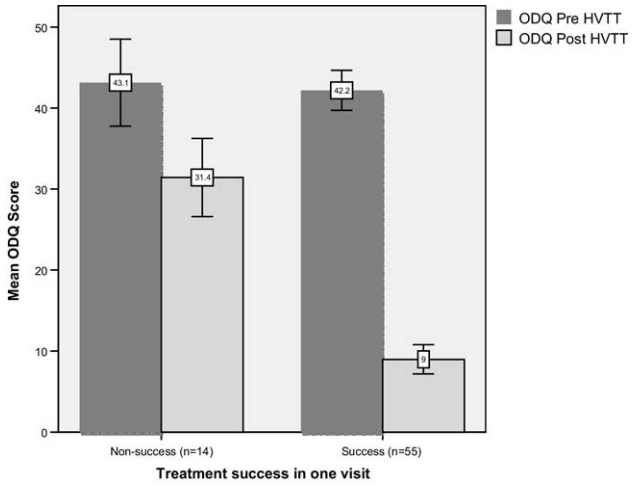

Figure 2. Initial and final ODQ scores for the success and nonsuccess groups. *Nonsuccess represents subjects who had less than 50% improvement in the ODQ after the first visit.

Table 2. *Diagnostic test properties of patient history and self-report variables used for prediction of positive response to mobilization*

Variable	SN (95% CI)	SP (95% CI)	−LR (95% CI)	+LR (95% CI)
Pain not extending below knee	0.84 (0.71-0.92)	0.57 (0.3-0.81)	0.29 (0.14-0.58)	1.95 (1.05-3.61)
Best position (standing)	0.01 (0.03-0.21)	1 (0.73-1)	0.91 (0.84)	–
Worst position (lying down)	0.07 (0.02-0.18)	1 (0.73-1)	0.93 (0.86-0.99)	–
Best time (midday)	0.11 (0.05-0.23)	1 (0.73-1)	0.89 (0.81-0.98)	–
Traumatic onset	0.07 (0.02-0.18)	1 (0.73-1)	0.93 (0.86-0.99)	–
Multiple gestation	0.04 (0.01-0.14)	0.93 (0.64-0.99)	1.04 (.098-1.1)	0.51 (0.05-5.22)
Use of oral contraceptives	0.16 (0.08-0.29)	0.93 (0.64-0.99)	0.90 (0.79-1.02)	2.29 (0.32-16.61)
Vaginal delivery	0.76 (0.63-0.86)	0.36 (0.14-0.64)	0.66 (0.32-1.37)	1.19 (0.78-1.8)

Positive state of the variable for this analysis is enclosed in parenthesis after the variable name.
95% CI = 95% confidence interval; −LR = negative likelihood ratio, +LR = positive likelihood ratio; SN = sensitivity; SP = specificity.

to ensure a minimum level of confidence that a specific condition can be ruled in or out.

On the basis of previous research [16,17,41], we anticipated that approximately half of the subjects would be categorized as intervention successes. Given this prevalence, a sample size of 100 subjects would provide a 95% confidence interval (CI) ranging between 0.7 and 0.9 for a true sensitivity or specificity value of 0.8. Therefore, to be certain that the CI would be sufficient to make the results definitive, the lower bound should not fall below 0.6 [41]. Positive LR values of 2.0 or more and negative LR values of 0.5 or less were considered acceptable. This shift was a small but possibly meaningful one in probability. A CI of 95% was used to identify variables that had a definitive level of acceptability in terms of prediction.

Two binary logistic regression models were created for the 2 variable types (historical and physical examination). The 2 regression models helped identify the best cluster for each variable type. Any variable with a P value of .05 was eligible to enter the model and a P value of .15 was required to remove the variable from the model, which ensured that any potentially helpful variable would not be excluded because of the strict criteria. The best cluster that remained in the separate regression analyses were then entered together. All variables that remained in the final regression equation ($P < .15$) were considered significant predictors of a positive response to the HVTT when used as a cluster of tests.

When the final regression model was established, sensitivity, specificity, and LRs were calculated for the cluster of tests. Each cluster was treated as one single variable, and test properties were examined at different levels of positive findings. For example, if there were 5 items in the final cluster of tests, a score of 1 was given if one or more variables in the cluster were positive and a score of 0 was given if there were no positive findings for any individual variable in the cluster. Calculation of sensitivity, specificity, and LRs was then performed for the cluster.

In the next level of scoring, a score of 1 was given if there were 2 or more positive findings and a score of 0 was given if there were fewer than 2 positive findings. The process continued until all the appropriate levels were examined. The same procedure was repeated for the identification of clusters for nonresponse to the HVTT. The variables entered into the model were determined on the basis of sensitivity and specificity values for prediction of nonresponse calculated in the first aim.

RESULTS

A total of 70 subjects were recruited between January 2006 and January 2007. One subject was ineligible for the study after signing the consent because of nerve root compression signs in a radicular pattern (ie, weakness). As a result of this dropout, the analyses are based on data from 69 subjects. Baseline characteristics of the study sample, including demographics, patient history, and self-report variables, are listed in Table 1.

The mean functional disability score (ODQ) at baseline was 42.26 ± 9.21, and after the first intervention it was

Table 3. *Diagnostic test properties of physical examination variables used for prediction of positive response to mobilization*

+ Variable	SN (95% CI)	SP (95% CI)	−LR (95% CI)	+LR (95% CI)
Iliac crest symmetry in standing	0.91 (0.79-0.97)	0.14 (0.03-0.44)	0.64 (0.12-3.39)	1.06 (0.84-1.33)
Standing flexion test	0.89 (0.77-0.95)	0.14 (0.03-0.44)	0.76 (0.15-3.76)	1.04 (0.82-1.31)
Gillet test	0.76 (0.63-0.86)	0.29 (0.1-0.58)	.83 (.36-1.89)	1.07 (0.74-1.54)
PSIS symmetrical in sitting	0.29 (0.18-0.43)	0.93 (0.64-0.99)	0.76 (0.64-0.91)	4.07 (0.59-28.15)
Seated flexion test	0.85 (0.72-0.93)	0.4 (0.17-0.67)	0.37 (0.16-0.85)	1.42 (0.93-2.83)
Hip IR	0.75 (0.61-0.85)	0.14 (0.03-0.44)	1.78 (0.49-6.49)	0.87 (0.67-1.13)
ASLR	0.78 (0.65-0.88)	0.07 (0-0.36)	3.05 (0.3-31.09)	0.84 (0.69-1.03)
Prone knee bend test	0.79 (0.70-0.89)	0.6 (0.38-0.83)	0.34 (0.18-0.63)	1.99 (1.06-3.75)

ASLR = active straight leg raise; 95% CI = 95% confidence interval; IR = internal rotation; −LR = negative likelihood ratio, +LR = positive likelihood ratio; PSIS = posterior superior iliac spine; SN = sensitivity; SP = specificity.

Table 4. *Clinical prediction rule for positive response to mobilization*

No. of Predictor Variables Present	Sensitivity	Specificity	Positive LR	Probability of Success, %
4+	0.12 (0.05-0.24)	0.97 (0.7-1)	3.48 (0.21-58.39)	93
3+	0.12 (0.05-0.24)	0.97 (0.7-1)	3.48 (0.21-58.39)	93
2+	0.65 (0.51-0.77)	0.79 (0.49-0.94)	3.05 (1.1-8.48)	92
1+	0.85 (0.73-0.93)	0.36 (0.14-0.64)	1.33 (0.89-1.99)	84

Final model included these 4 variables: (1) seated flexion; (2) prone knee bend test; (3) posterior superior iliac spine symmetrical in sitting; and (4) pain not extending below the knee.

13.54 ± 11.47. The mean percentage improvement in the ODQ during the study period was 69 ± 25.25% (range, 10.5%-100%). For 55 subjects (80%) the intervention was categorized as a success (50% improvement in 48-72 hours after one intervention session), and for 14 subjects (20%) the intervention was categorized as a failure. The mean improvement in the success group was 33.2 ± 8.78 points, with a mean percentage improvement of 79 ± 11.64%. The mean improvement in the treatment failure group was 11.71 ± 5.37 points, with a mean percentage improvement of 27.14 ± 11%. The initial and final ODQ scores in the success and nonsuccess groups are shown in Figure 2. In no case was a subject determined to have greater disability or pain after the intervention.

Prediction of Positive Response to the HVTT Intervention

Nine patient history and self-report variables met the criteria to be retained as potential predictor variables (Table 2). Eight variables were retained from the physical examination (Table 3). Among the patient history and self-report variables, the use of oral contraceptives was most predictive of success (+LR = 2.29). Among the physical examination variables, symmetrical posterior superior iliac spine (PSIS) test in the seated position was most predictive of success (+LR = 4.07).

The 17 variables were entered into the 2 separate binary logistic regression models to identify the best cluster of variables. One historic variable (pain not extending below the knee) and 3 physical examination variables (symmetrical PSIS test in the seated position, a seated flexion test, and a prone knee bend test) remained in their respective regression models. The 4 variables were retained in the final model and formed the CPR. Only 6 subjects were positive for all 4 variables at baseline in the CPR, and they were all in the success group.

Accuracy statistics were calculated for each level of the CPR (ie, when one variable was present in the CPR, when 2 were present, when 3 were present, and so on). On the basis of the pretest probability of success with mobilization found in this study (80%) and the positive LR values calculated, a subject with 4 variables present at baseline increases her probability of success with the HVTT from 80% to 93% (Table 4). When different combination of variables were analyzed, it was found that when variables 3 and 4 (symmetrical PSIS test in the seated position and symptoms not extending below the knee) were present (+LR = 7.23), posttest probability of success with the HVTT increased from 80% to 97%.

Prediction of Treatment Failure With the HVTT Intervention

Five patient history and self-report variables met the criteria to be retained as potential predictor variables (Table 5). Eight variables were retained from the physical examination (Table 6). Among the patient history and self-report variables, age was most predictive of nonresponse to the intervention (+LR = 3.06). Among the physical examination variables, a positive PSIS symmetry test in the seated position and a positive SIJ stiffness test [40] were most predictive of nonresponse (+LR = 4.1).

The 13 variables were entered into the 2 separate binary logistic regression models. Two historic variables (age >35 years and Visual Analogue Scale (VAS)-Best in the past 24

Table 5. *Diagnostic test properties of patient history and self-report variables used for prediction of nonresponse to mobilization*

Variable	SN (95% CI)	SP (95% CI)	−LR (95% CI)	+LR (95% CI)
Age (>35 y)	0.5 (0.24-0.76)	0.84 (0.71-0.92)	0.6 (0.35-1.0)	3.06 (1.38-6.67)
VAS-worst (≥7)	0.93 (0.64-1)	0.44 (0.31-0.58)	0.16 (0.02-1.13)	1.65 (1.25-2.17)
VAS-best (>3)	0.86 (0.60-0.97)	0.67 (0.53-0.79)	0.21 (0.05-0.78)	2.62 (1.7-4.05)
Oral contraceptives	0.07 (0-0.36)	0.84 (0.71-0.92)	1.11 (0.95-1.29)	0.44 (0.06-3.16)
Multiple gestation	0.07(0.003-0.36)	0.96 (0.86-0.99)	0.96 (0.83-1.11)	1.96 (0.19-20.14)

Positive state of the variable for this analysis is enclosed in parenthesis after the variable name.
95% CI = 95% confidence interval; −LR = negative likelihood Ratio, +LR = positive likelihood ratio; SN = sensitivity; SP = specificity; VAS = Visual Analogue Scale; worst = worst pain experienced in the past 24 hours; best = least amount of pain experienced in the past 24 hours.

Table 6. *Diagnostic test properties of physical examination variables used for prediction of nonresponse to mobilization*

Variable	SN (95% CI)	SP (95% CI)	−LR (95% CI)	+LR (95% CI)
PSIS asymmetry in sitting	0.29 (0.18-0.43)	0.93 (0.64-0.99)	0.76 (0.64-0.91)	4.1 (0.59-28.15)
Hip IR	0.25 (0.15-0.39)	0.86 (0.60-0.97)	0.87 (0.73-1.04)	1.8 (0.46-6.95)
ASLR	0.22 (0.12-0.35)	0.93 (0.64-0.99)	0.84 (0.72-0.98)	3.05 (0.43-21.55)
SIJ stiffness	0.29 (0.18-0.43)	0.93 (0.64-0.99)	0.76 (0.64-0.91)	4.1 (0.59-28.15)
Distraction	0.82 (0.7-0.9)	0.14 (0.03-0.44)	1.27 (0.31-5.16)	.95 (0.75-1.22)
Patrick test	0.27 (0.17-0.41)	0.93 (0.64-0.99)	0.78 (0.66-0.93)	3.82 (0.55-26.5)
Prone knee Bend/negative test†	0.57 (0.3-0.81)	0.8 (0.67-0.89)	0.54 (0.29-0.99)	2.86 (1.42-5.73)
Long dorsal SI ligament provocation	0.33 (0.21-0.47)	0.86 (0.60-0.97)	0.78 (0.64-0.97)	2.3 (0.60-8.73)

ASLR = active straight leg raise; 95% CI = 95% confidence interval; IR = internal rotation; −LR = negative likelihood ratio, +LR = positive likelihood ratio; PSIS = posterior superior iliac spine; SI = sacroiliac; SIJ = sacroiliac joint; SN = sensitivity; SP = specificity; IR = internal rotation.
†No change in relative leg length between starting and ending position of test.

hours >3) and one physical examination variable (a negative prone knee bend test) remained in their respective final regression models. The 3 variables were retained in the final model and formed the CPR. No subjects in the success group were positive for all 3 retained prediction variables at baseline. Three subjects in the treatment failure group were positive for all 3 variables.

Accuracy statistics were calculated for each level of the CPR for failure of the intervention. On the basis of the pretest probability of nonsuccess with the HVTT observed in this study (20%) and the positive LR values calculated, subjects with 3 variables present at baseline increased their probability of nonsuccess from 20% to 87% (Table 7).

DISCUSSION

Eighty percent of the subjects in our study improved with one HVTT intervention. The authors of previous studies who examined the general LBP population found that 45% of subjects improved with use of the HVTT. A CPR for success and a CPR for nonsuccess with the HVTT was developed. These CPRs allow a mechanism to predict a priori the likelihood of success (50% improvement in 48-72 hours) or failure with the HVTT in postpartum patients. Knowing the factors that are associated with a positive response is beneficial to physicians as well as patients as they seek relief for postpartum backache or pelvic pain. In the past, tests and measures that required palpatory skills were used as indicators for use of the HVTT, all of which required specialized manual skills that are beyond the everyday practice skills of clinicians most likely to evaluate postpartum patients. These palpatory tests had limitations with regard to reliability and predictive validity [20-22, 24-26, 42-44]. Although the authors of some studies report acceptable reliability, methodologic limitations still exist that impede the clinical use of these tests [21,45,46]. Although some studies have shown that combining some of the SIJ tests are beneficial in identifying such patients [18,47,48], others have questioned the reliability of these tests [44]. In addition, provocative tests used in different studies were not uniform. By combining patient history and physical examination variables, we were able to develop 2 CPRs that may be useful for clinicians in classifying patients who are likely and unlikely to be responsive to HVTT.

The authors of previous studies that examined CPRs for HVTT studied the general LBP population. In our unique patient population, subjects were post partum. One of the strongest predictors of success in the general LBP population was duration of symptoms less than 15 days. In this unique population of postpartum women with LBP, the success of HVTT was not dependent on duration of LBP. The only shared significant variable between the CPRs of our study and that of Flynn and colleagues was symptoms not extending below the knee [14].

The CPR for women who responded less favorably to the HVTT consisted of 3 variables: age >35 years, VAS-Best score >3, and a negative prone knee bend test. The mean age of patients in the success group was 30.27 ± 5.65 years, whereas the mean age of the subjects in the nonsuccess group was 34.36 ± 5.24 years. Our results indicate that women who are older than 35 years are less likely to respond to the HVTT intervention. Half of the

Table 7. *Clinical prediction rule for nonresponse to mobilization*

No. of Predictor Variables Present	Sensitivity	Specificity	Positive LR	Probability of Nonsuccess, %
3	0.23 (0.07-0.52)	0.99 (0.91-1)	26.13 (1.43-478.71)	87
2+	0.43 (0.19-0.7)	0.96 (0.86-0.99)	11.79 (2.66-52.24)	75
1+	0.5 (0.24-0.76)	0.84 (0.71-0.92)	3.06 (1.38-6.76)	43

Final model included these 3 variables: (1) age >35 years; (2) VAS-Best >3; (3) negative prone knee bend test.
LR = likelihood ratio.

nonresponders in this study were older than 35 years. Although the older women in this sample had only a slightly higher average number of children than did the younger women, older women tended to have had more children than did younger women, and the repeated strain on the structures of the pelvis could explain persisting pain. It could just be that they have laxity or stiffness that does not respond to the HVTT. In this study, the younger women reported slightly more pain "at worst" than did the older group of women, whereas pain "at best" was slightly less in the younger group.

The +LR, the primary statistic of interest in this study, indicates the increase in the probability of success given a positive test result. The +LR expresses the change in odds favoring the outcome when the patient meets the prediction rule criteria [49]. In this study, the intervention was labeled a success for 80% of the subjects after one HVTT treatment intervention. This success rate is higher than the success rate of the general LBP population found by Flynn and colleagues [50]. When a criteria of 4 out of 4 variables present at baseline (+LR = 3.48) was used, the probability of success increased to 93%; thus, these patients should be considered suitable candidates for HVTT. Flynn and colleagues found a probability of success of 95% when 4 of 5 variables were present at baseline.

For a woman with more than 50% improvement of the ODQ after one intervention session, the intervention was categorized as a success; the interventions for all others were categorized as failures. Previous investigators who used the HVTT intervention found that a 50% improvement in the ODQ could distinguish between subjects who responded to the HVTT and subjects who merely benefited from spontaneous improvement of back and pelvic pain over time [16,17,41]. Subjects who were matched to the HVTT experienced mean improvements in ODQ scores from 57% to 83%. Subjects who were not matched to interventions experienced mean improvements between 20% and 38%. This was during a 1- to 4-week period. Therefore a 50% improvement during a 2- to 4-day period is predicted to be sufficient to distinguish between a positive response to the intervention rather than simply a spontaneous reduction in back and pelvic pain [14].

In the initial recruitment procedure of this study, we relied on obstetricians to refer patients to physical therapy. However, alternate methods of recruitment, including public advertising, were needed because of the small number of referrals, suggesting a potential lack of awareness of physicians regarding a role for physical therapy in assessing and managing postpartum back and pelvic pain. It also suggests that women who could benefit may not be accessing treatment. Subjects who asked to participate in the study were still required to get a referral from their obstetrics and gynecology physician. Whether the women in this study would have recovered without the study intervention for initial relief is not known. However, our findings confirm that the HVTT is an effective intervention for low back and/or pelvic pain for postpartum women. New mothers may benefit and not have to experience unnecessary pain or consider medication that could be harmful to the mother and child during the breast-feeding period as a result of the HVTT.

This study is the first step in the development and testing of a CPR for distinguishing postpartum women who may or may not benefit from a HVTT. The next step will be to validate the rule by means of a randomized clinical trial [15]. The control group would receive a competing intervention protocol, such as a pelvic girdle stabilization program [9], which can be used to determine whether the subjects who met the criteria of the CPR may have benefited from a variety of other interventions or simply had spontaneous recovery of back and pelvic pain.

The results of prediction of treatment failure in this study may be helpful for clinicians. The pretest probability of success (80%) in this population is sufficient to reassure clinicians that the immediate decision to mobilize the patient is therapeutically beneficial, provided that 2 of 3 criteria are met in the CPR for treatment failure (posttest probability of nonresponse increases from 20% to 75%), indicating to the clinician that an alternative approach is needed. Further research is necessary to address an alternative intervention for patients who are less likely to improve with the mobilization technique.

Limitations

This preliminary study was designed to develop a HVTT CPR for women with postpartum LBP. As with all preliminary CPR studies, a follow-up study is needed to confirm and validate the CPR. Another limitation is the short duration of follow-up in this study. A future validation study should include a longer follow-up period with documented recurrence rates.

CONCLUSION

In our sample, the intervention was successful in 80% of subjects after one HVTT without an attempt at prediction in postpartum women with either LBP and/or pelvic pain. The HVTT is a low-risk procedure, takes the therapist little time to perform, and appears to be efficacious. The pretest probability of success (80%) with the HVTT unless 2 of 3 criteria are met in the CPR for treatment failure suggests treatment effectiveness. Referral to a physical therapist who can perform the HVTT in women with postpartum LBP and/or PGP is advised.

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APPENDIX 1

Test	Procedure	Criteria for Being Positive
Anterior superior iliac spine (ASIS) symmetry in standing (3,4)	With the subject standing with feet approximately 12 inches apart, the ASIS is palpated and judged for symmetry	If one ASIS is judged to be higher than the other (1 inch at least), the test is positive
Iliac crest symmetry while standing (3)	With the subject standing, the right and left iliac crests are palpated	If one iliac crest is judged to be higher than the other, the test is positive
Standing flexion test (2)	The subject is standing, and the heights of the PSIS are assessed; the patient is then asked to flex forward as far as possible with the examiner continuing to palpate the PSIS	If a superior movement of one of the posterior superior iliac spine (PSIS; 1 inch at least) is sensed, the test is considered to be positive
Gillet test (Stork test) (7)	With the subject standing with feet approximately 12 inches apart, the examiner places one thumb under the PSIS on the side being tested (flexed) and the other thumb over the S2 spinous process; the subject is then instructed to stand on the leg opposite the side being tested and flex the other hip and knee, bringing the leg toward the chest	A positive test in indicated when the PSIS fails to move posterior and inferior with respect to S2 spinous process
Palpation of the PSIS in sitting (2)	With the subject sitting on a level surface, the PSIS are palpated	The presence of a lower PSIS (1 inch at least) indicates a positive test
Seated flexion test (2,3)	With the subject sitting, the relative heights of the PSIS are judged. The subject is asked to bend forward as far as possible while the tester continues to palpate the PSIS	A change in the relative relationship of the PSIS in the fully flexed position (1 inch at least) indicates a positive test
Supine long sitting test (2)	While the subject is in the supine position, a visual estimation of leg length is made by palpating the inferior aspects of the medial malleoli;the subject is asked to come to a long-sitting position	Any change in the relative position of the medial malleoli indicates a positive test
Prone knee bend test (1,3)	While the subject is in the prone position, the relative leg lengths are assessed by examining at the soles of the heels (shoes on) with the knees fully extended; the examiner passively flexes the subjects knees to 90° and the relative leg lengths are assessed again	A change in the relative lengths between the 2 positions (1 inch at least) indicates a positive test
Active straight leg raise (8)	Patient is supine with the legs straight and the feet 20 cm (8 inches) apart; the subject is given the instructions to "Raise your leg above the table 8 inches without bending your knee"	Noting if the subject has difficulty lifting one leg as opposed to the other will be recorded
Sacroiliac joint stiffness test (6)	While the subject is supine with knees and hips flexed, the sacral sulcus just medial to the PSIS is palpated with long and ring fingers while index finger palpates lumbosacral junction; long and ring fingers monitor translation between innominate and sacrum whereas index finger notes any movement between pelvic girdle and L5 vertebra; anteroposterior translation is tested by applying a posterior pressure to innominate through iliac crest and ASIS, and stiffness values are compared between left and right sides; vertical translation is tested by applying superior/inferior pressure to the innominate through distal end of femur, and stiffness is compared between left and right sides	Any apparent discrepancy between either of the 2 motions will be considered as a positive test
Long dorsal SI ligament pain test (9)	With the subject prone or side lying, the long dorsal SI ligament is palpated	Test is positive if pain is produced with palpation
Pain provocation test (thigh thrust test/posterior shear test) (7)	Subject is supine; one leg is flexed to 90° at the hip and knee; with hands on the raised knee, pressure is exerted down the femur into the pelvis	Test is positive if the subject experiences pain in the pubic symphysis and/or the SIJ
Compression/distraction test (5,7)	While the subject is supine, pressure is applied to ASIS in a posterior and lateral direction to compress the joint; next, pressure is applied in an anterior and medial direction on the ASIS to distract the joint	A positive test is indicated when pain is reproduced in the SIJ region with either maneuver
Faber/Patrick test (5)	Faber: subject is supine; one leg is flexed, abducted, and externally rotated so that the heel rests on the opposite knee; over pressure is applied to the medial aspect of the knee while the pelvis is stabilized Patrick: Range of motion is tested by comparing both sides and noting a difference in the range of motion	Faber: Buttock pain and sacroiliac joint pain Patrick: Difference in the range of motion, groin pain with over pressure

PSIS = posterior superior iliac spine; SI = sacroiliac; SIJ = sacroiliac joint.

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