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Comparative Analysis of the Pain Provocation Test and the HABER Test to Diagnose Nonspecific Low-Back Pain Associated with the Sacroiliac Joint

Authors' Contribution:

Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Background: This study aimed to investigate the correlation between the pain provocation test and the hip abduction-external rotation (HABER) test for diagnosing low-back pain (LBP)-related sacroiliac joint (SIJ) syndrome, and to determine the efficacy of the HABER test as a potential diagnostic tool for SIJ syndrome.

Material/Methods: One hundred patients with LBP participated. The first and second examiner examined the patients using the pain provocation test and the HABER test, respectively. Positive and negative findings were analyzed to determine the correlation and reliability.

Results: The HABER test showed similar pain reproduction in groups that were positive or negative for SIJ syndrome ($P < 0.05$). Based on the analysis of the receiver-operating characteristic curve, the cutoff values from the HABER test were found to be 29° and 32° of external rotation in the left and right hip joints, respectively.

Conclusions: The HABER test can reproduce similar level of pain in patients with chronic LBP associated with SIJ syndrome, and it can be used as a diagnostic tool in patients presenting with chronic LBP.

Keywords: **Clinical Trial • Low Back Pain • Sacroiliac Joint**

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Background

Low-back pain (LBP) is one of the most common musculoskeletal disorders in modern society. Ehrlich [1] reported that more than 70% to 80% people experience LBP in their lives, and other studies reported that LBP was associated with sacroiliac joint (SIJ) syndrome in 10% to 38% of patients [2-4]. SIJ syndrome causes pain in various areas of the body including the buttocks, groin, and back [5]. Most cases of LBP resolve rapidly, but 10% of patients report progression to chronic LBP [6]. One of the major causes of LBP is SIJ syndrome. However, because of the difficulty in the diagnosis of SIJ, the treatments for LBP vary and have a range of results [7].

There are 3 clinical methods used to identify SIJ syndrome. The first is the motion palpation test. In this method, the examiner places their hands on the SIJ landmark to determine if both sides of the patient's SIJ move symmetrically. The second test is the location symmetry palpation test. This method is used to determine the symmetry of the SIJ landmark in the patient. The third is the pain provocation test. In this method, pressure is applied to the SIJ structure with the intent of causing pain. The motion palpation test shows moderate interexaminer reliability (prevalence-adjusted and bias-adjusted kappa [PABAK= 0.52]), while the pain provocation test shows high interexaminer reliability (PABAK=0.92) [8].

The pain provocation test was used as the standard in the current study because of its high interexaminer reliability in comparison with the other test methods (ie, location symmetry palpation test and motion palpation test). When evaluating LBP with SIJ syndrome, it is difficult to determine if a positive result of a pain provocation test is LBP associated with SIJ; an accurate diagnosis requires the use of more than one of the aforementioned tests. Additionally, the pain provocation test is composed of the following 5 components: the Gaenslen test, compression test, distraction test, thigh thrust test, and sacral thrust test [9,10]. When 3 or more of the 5 pain provocation test components are positive, the overall test result is positive (validity [sensitivity=85%, specificity=76%] [11], inter-rater reliability [$k=0.51-0.75$] in SIJ syndrome) [10].

The pain provocation test can diagnose the presence or absence of SIJ syndrome in patients with nonspecific LBP, but it does not indicate changes in its biomechanics [12,13]. Researchers have found that the motion palpation test can provide biomechanical information related to SIJ syndrome and can discriminate among its various causes [4,8,14]. This test has revealed that the most commonly reported cause of SIJ syndrome-related nonspecific LBP is abnormal movement of the innominate bone (ilium+pubis+ischium) [15-17]. Due to the complex anatomical structure of the SIJ, accurate and reliable physical examination methods for evaluating the movement pattern of

the innominate bone are currently lacking [5,18-20]. A more efficient and clinical test method is needed to address the diagnostic deficiencies of the motion palpation test and pain provocation test when each is administered alone.

The hip abduction-external rotation (HABER) test combines the abduction and external rotation of the hip joint in the prone position, making it possible to control the load of the SIJ through gradual hip joint movement [21]. In previous studies, the HABER test successfully identified the exact movement pattern of the innominate bone using electromagnetic palpation digitization technique on the pelvic landmarks in the HABER test positions [21-24]. Adhia et al [23] showed that the innominate movement pattern measured through the HABER test demonstrated a high level of interrater reliability (intra-class correlation coefficient=0.97). In a recent study, the HABER test revealed a relationship of LBP with SIJ syndrome and the kinematics (movement pattern and rotation trends) of the innominate bone [25]. As reported, the HABER test appears to have the advantage of distinguishing between the kinematic characteristics of the SIJ and LBP. Additionally, the HABER test does not reproduce the specific angle of the hip joint in patients with nonspecific LBP associated with SIJ syndrome.

The purpose of the current study was to examine the correlation between the HABER test and the pain provocation test in identifying patients with nonspecific LBP associated with SIJ syndrome. The diagnostic accuracy of the HABER test in relation to the pain provocation test was examined. The reference values and diagnostic accuracy of the HABER test were assessed using SIJ syndrome-positive predictions based on the pain provocation test results.

Material and Methods

Subjects

This study included 100 adult patients (56 men and 44 women) who visited a local metropolitan university hospital in the Republic of Korea for the treatment of nonspecific chronic LBP. With regard to the study sample size, the median effect size was 0.15, the significance level was 0.05, and the power was 0.9. The appropriate sample size was determined to be a minimum of 88. To account for the potential dropout rate during the research process, 100 people were recruited in total. The mean age, height, weight, body mass index, and visual analog scale (VAS) score of participants were 35.5 years, 164.6 cm, 64.3 kg, 23.4 kg/m², and 4.6, respectively (**Table 1**). The inclusion criteria were as follows: (1) LBP for more than 3 months, (2) current LBP rated as 4 or higher on a VAS for pain, and (3) no lower extremity pain during the straight leg raise test. The exclusion criteria were as follows: (1) fracture of the

Table 1. General characteristics of the participants.

| Variable | Nonspecific chronic low-back pain patients |
|------------------------|--|
| Sex, Male/Female | 56/44 |
| Age, years | 35.5 (11.70)* |
| Height, cm | 164.6 (10.94) |
| Weight, kg | 64.3 (14.80) |
| BMI, kg/m ² | 23.4 (3.52) |
| VAS, score | 4.6 (0.81) |

BMI – body mass index; VAS – visual analog scale.
* Mean (standard deviation).

vertebral joint, (2) spinal joint surgery, and (3) hip joint surgery or fracture. Explanations about the procedure and stability were provided to all patients before the experiment, and written informed consent was obtained from all participants. This study was approved by the Bioethics Committee of Konyang University (approval number: 2019-195-02) in the Republic of Korea, and it is registered with the World Health Organization International Clinical Trials Registry Platform (KCT0005663).

Procedure

First, the pain provocation test was performed to distinguish SIJ syndrome. If 3 or more of the 5 component tests were positive, the case was judged as SIJ-positive. A second examiner performed the HABER test and diagnosed positive and negative SIJ syndrome on the left and right sides (Figure 1).

Pain Provocation Test

The pain provocation test result was classified as positive if it reproduced pain similar to the patient's pain during the test. Test results were classified as SIJ-positive if 3 or more tests were positive and SIJ-negative if fewer than 3 tests were positive. The experiment was conducted in a random order to avoid examiner's bias.

The pain provocation tests were conducted as follows. First, in the distraction test, the subject lay in the supine position with the experimenter's hand placed on both sides of the anterior superior iliac spine in turn. Then, checks were performed to find whether the pain occurred by applying pressure in the posterior and lateral directions. The second test, the thrust test, was performed with the subject in the prone position. The experimenter's hand was on the sacrum, and pressure was applied from the back to the front. In the third test, the compression test, the subject was in the side-lying position. The experimenter's hand was on the iliac crest, and pressure was applied. In

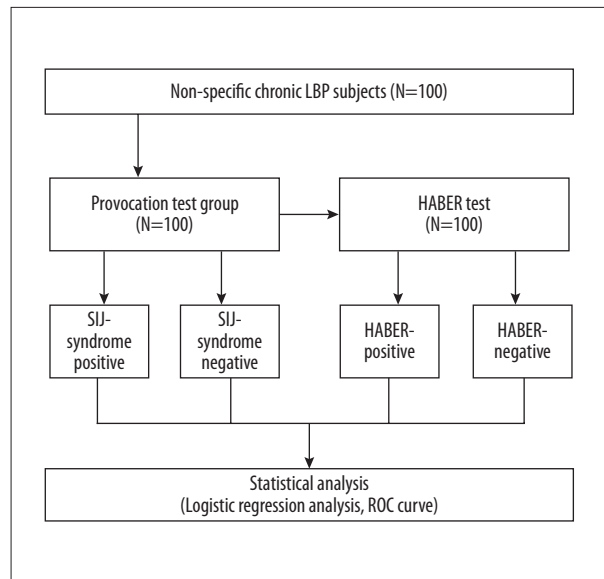


Figure 1. Study flow chart HABER. LBP, low-back pain; HABER, hip abduction and external rotation; SIJ – sacroiliac joint; ROC – receiver-operating characteristic.

the fourth test, the thigh thrust test, the subject was looking up at the ceiling while lying down with the hip and knee joints bent at 90° and in a slightly adducted position. The experimenter checked whether the pain was caused by applying a shearing stress to the back of the thigh, by vertically pressing the femur. In the fifth test, the Gaenslen test, the subject looked up at the ceiling and dropped one hip off the table while the other leg was bent at the knee and hip, as much as possible. After that, the experimenter checked whether the pain caused was due to the overpressure on both hip joints.

Hip Abduction and External Rotation Test

A second examiner administered the HABER test after the patient rested for 10 min following the pain provocation test. The results of the pain provocation tests were unknown to the second examiner. The HABER test was performed using the hip joint rotating frame used by Bussey et al [26]. The angle of the hip joint was measured on the left and right sides of the motion combined with abduction and external rotation. The HABER test was conducted as follows. The subject lay in the prone position, and the knee joint was bent 90° and then immobilized. The subject moved the hip joint in an external rotation, and when the pain typically felt by the subject was reproduced or when the VAS for the pain increased by 1 point or more, the result was recorded as positive and the angle at which the pain was reproduced was measured.

To measure the external rotation angle of the hip joint, a mobile phone was fixed with a band under the tibial tuberosity. The Goniometer Pro application (5fuf5, Bloomfield, NJ, USA)

Table 2. Results of the binary logistic mixed model regression analyses for the interactions of the HABER test side and the clinical group.

| | R ² | B | Standard error | Sig Exp(B) | 95% CI Exp(B) | |
|------------|----------------|------|----------------|------------|---------------|--------|
| | | | | | Lower | Upper |
| HABER Test | 14.4 | 1.54 | 0.002 | 4.668 | 1.785 | 12.202 |

CI – confidence interval; HABER – hip abduction and external rotation.

Table 3. Measures of the cutoff criterion of the HABER test for identifying SIJ-positive LBP individuals.

| PPT group | HABER side | Cutoff value | Sen* | Spec* | AUC* | PLR* | NLR* | SE | P |
|-----------|------------|--------------|------|-------|-------|------|------|-------|--------------------|
| L-SIJ | Left | >32 | 0.79 | 0.91 | 0.828 | 8.25 | 0.29 | 0.062 | 0.001 [#] |
| R-SIJ | Right | >29 | 0.68 | 0.92 | 0.804 | 0.24 | 0.34 | 0.063 | 0.001 [#] |

AUC – area under curve; HABER – hip abduction and external rotation; LBP – low-back pain; NLR – negative likelihood ratio; PLR – positive likelihood ratio; PPT – pain provocation test; SE – standard error; SIJ – sacroiliac joint; Sen – sensitivity; Spec – specificity. * 95% confidence interval; [#] significant difference between groups.

Table 4. Overall measures of the HABER test for identifying SIJ syndrome-positive LBP individuals.

| Test | Sen* | Spec* | PPV* | NPV* | PLR* | NLR* | OR* |
|----------|------|-------|------|------|------|------|------|
| SIJ test | 0.8 | 0.53 | 0.48 | 0.83 | 1.73 | 0.37 | 4.67 |

HABER – hip abduction and external rotation; LBP – low-back pain; NLR – negative likelihood ratio; NPV – negative predictive value; PLR – positive likelihood ratio; PPT – pain provocation test; PPV – positive predictive value; OR – odds ratio; SIJ – sacroiliac joint; Sen – sensitivity; Spec – specificity. * 95% confidence interval.

was then used to measure the angle at which the pain appeared. Three HABER tests were performed on each subject, and the results were averaged.

Statistical Analysis

The data were analyzed with SPSS Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). The necessary sample size was calculated using the G. Power 3.1.9.2 program (Franz Faul, Christian-Albrechts-Universität Kiel, Kiel, Germany). The correlation between the pain provocation test and the HABER test was analyzed using binary logistic mixed model regression analysis. To determine the overall diagnostic accuracy of the HABER test; sensitivity, specificity, positive predictive value (PPV), odds ratio (OR), positive likelihood ratio (PLR), and negative likelihood ratio (NLR) were calculated using a 2×2 table (95% confidence interval [CI]). MedCalc Version 16.8.4 (MedCalc Software, Mariakerke, Belgium) was used to examine the cutoff value and diagnostic accuracy of the HABER test. The receiver-operating characteristic (ROC) curve was analyzed to determine the 95% CI and the area under the curve (AUC). The AUC was classified as follows: 0.5 < AUC ≤ 0.7 is less accurate; 0.7 < AUC ≤ 0.9 is moderately accurate; 0.9 < AUC < 1 is very accurate; and AUC=1 is a complete test.

Results

Binary logistic mixed model regression analysis of the HABER test and pain provocation test demonstrated a correlation between the results generated by the 2 tests (**Table 2**). Binary logistic regression analysis showed a significant correlation with pain reproduction between the pain provocation test group and the HABER test group ($P < 0.002$). The Nagelkerke R^2 value showed that approximately 14% of the dependent variables were explained by the logistic regression model.

The sensitivity, specificity, predictive value, OR, PLR, and NLR of the HABER test compared with those of the provocation test are shown in **Table 3**. The HABER test showed 80% sensitivity and 53% specificity for diagnosing LBP associated with SIJ syndrome. The PPV was 0.48 and the negative predictive value (NPV) was 0.83. The PLR was 1.73 and the NLR was 0.37. The OR was 4.67.

Based on the HABER test value, the calculated cutoff value accurately predicted a positive result in the pain provocation test (**Table 4, Figure 2**). A cutoff value of 32° was shown in the ROC analysis in the left (L)-SIJ with 73% sensitivity, 91% specificity, 0.828 AUC, 8.53 PLR, and 0.29 NLR ($P < 0.001$). ROC analysis of the right (R)-SIJ revealed a cutoff value of 29° with

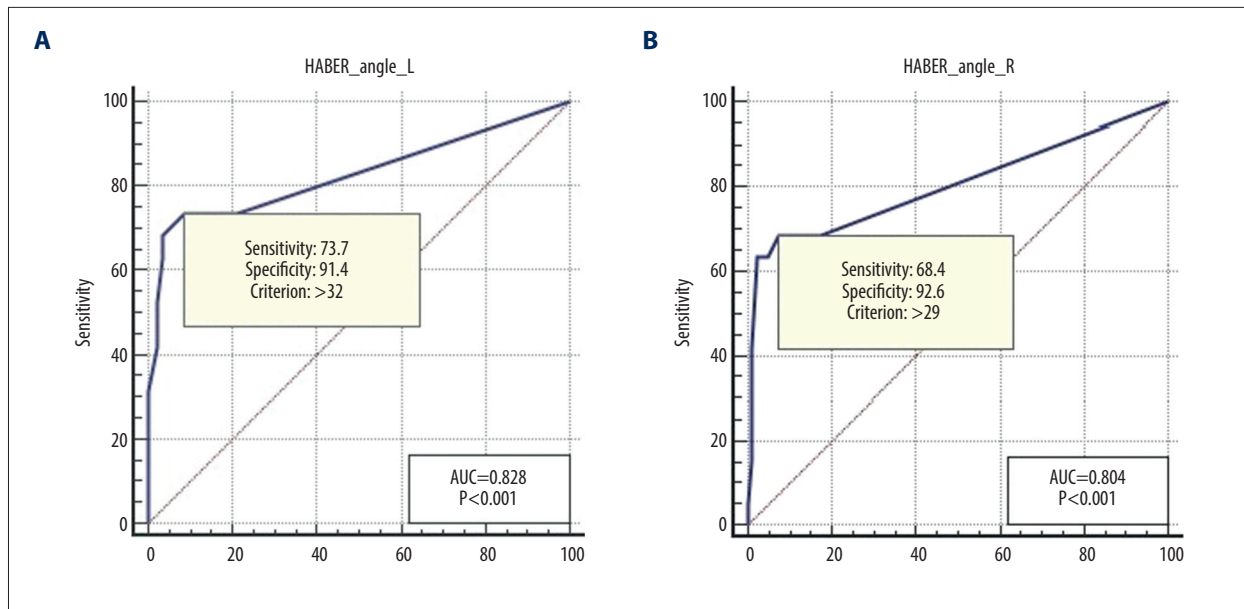


Figure 2. Receiver-operating characteristic (ROC) curve of the HABER test. (A) Left hip joint. (B) Right hip joint. HABER – hip abduction and external rotation; AUC – area under the curve.

68% sensitivity, 92% specificity, 0.804 AUC, 9.24 PLR, and 0.34 NLR ($P<0.001$).

Discussion

This study yielded multiple significant findings. First, the pain provocation test is both time consuming and complicated for diagnosing SIJ syndrome because it involves the results of 5 tests. Second, as the pain provocation test causes pain and is performed repeatedly, the sensitivity of the test may be reduced by increasing the patient's sensitivity to pain. As such, the HABER test may be superior for diagnosing SIJ syndrome in clinical practice because it is simpler and can be safely repeated. In addition, movement of the innominate bone, which is highly correlated with back pain, can be evaluated.

We assessed, in detail, the correlation between the pain provocation test and the HABER test, and tested the reliability of the HABER test in diagnosing LBP associated with SIJ syndrome. Correlation was shown to exist between the 2 tests ($R^2=0.14$, $P<0.002$). The reliability of the HABER test as a stand-alone test to diagnose LBP associated with SIJ syndrome by measuring the cutoff value was also strengthened by this study. As a result of the study, the pain provocation test and HABER test were correlated with the diagnosis of LBP-related SIJ syndrome. The HABER test, a single test, can identify whether SIJ is associated with LBP.

The high level of sensitivity (80%) of the HABER test shown in this study differs from previous study findings [27]. The test

has also previously been proven to be effective in evaluating the innominate bone in patients with LBP associated with SIJ syndrome [23,26,27]. Most pain-causing tests of the SIJ structures focus on the compression of the structures through multiple tests. The HABER test, however, was hypothesized to effectively reflect the complex anatomical structures of the SIJ and to help diagnose SIJ syndrome with only 1 test. The single-test design of the pain provocation test can also be viewed as a test constraint that could affect the accuracy of the diagnosis, and it requires further examination [4,9,27].

Bussey et al [21] predicted that the movement pattern of the innominate bone could be altered by a small range of hip abduction and external rotation. Moreover, Adhia et al [25] reported that a change occurred in the movement pattern of innominate bone in people with LBP associated with SIJ syndrome. Together, these studies strengthen the likelihood that the HABER test could be an effective single diagnostic tool for SIJ syndrome, and the results led us to explore its accuracy. Additionally, the current study revealed that the probability of the HABER test being positive when the pain provocation test was also positive was about 5 times higher than when the pain provocation test was negative.

The moderate level of specificity (53%) of the HABER test shown in this study is consistent with previous study findings [27]. The moderate specificity of the HABER test may have been influenced by the complex anatomical structure of the SIJ. This could be due to the test delivering a weight load to a joint other than the SIJ [21,26]. The test is intended to transmit the force applied to the hip joint to the SIJ through the abduction and

external rotation of the hip joint. The applied force is, however, not limited to the SIJ and can be distributed to the lumbar spine through the lumbosacral junction [27]. This can influence the outcome of the test. For example, the dispersed force can stimulate inflammation in inflammatory spinal diseases, to cause pain. In this situation, the HABER test could be result positive for LBP that is not associated with SIJ syndrome. The misdiagnosis rate from false positives could explain the moderate rate of specificity. To address this problem, providing stability to the lumbar-sacral junction could be helpful in future study and possibly result in a higher rate of specificity for a modified HABER test.

This study showed that the external rotation of the hip joint during the HABER test in the SIJ syndrome-positive group had AUC values of 29° in the left hip joint and 32° in the right hip joint. Previous studies have suggested that patients diagnosed with SIJ syndrome have limitations of the axial rotation and abduction of the hip joint [21,28]. Adhia et al [27] previously determined that a 30° widening of the hip joint distinguishes LBP associated with SIJ syndrome in the HABER test. Our similar findings further strengthen our conclusion. It is important to note that additional objective variables are also useful when differentiating LBP associated with SIJ syndrome from LBP unrelated to the SIJ.

Based on the results of our study, the advantages of the HABER test are as follows. First, the HABER test can facilitate obtaining information usually gained from the pain provocation test and the motion palpation test in a single test. Second, patient discomfort is minimized and the patient undergoes a simplified

process with the HABER test. Third, the HABER test can be used as an objective evaluation tool to discriminate LBP associated with SIJ syndrome from LBP not associated with SIJ syndrome by utilizing the test's cutoff value.

Our study differs from previous similar studies in multiple ways. First, in terms of research methods, unlike previous studies, we used an automatic smartphone protractor to enhance ease of use and digitalization of data. Second, in previous studies, outer hip joint rotation during the HABER test was classified in increments of 10°, whereas in this study, we used the total angle of the outer hip joint rotation to obtain more accurate results. Nevertheless, there were some limitations to this study, including the following. First, recruiting patients with LBP occurred over a short period. Second, the HABER test cannot be used to determine the amount of force distributed to the lumbar vertebrae through the lumbosacral junction. Third, the standard test for the differentiation of SIJ syndrome is based on the SIJ block. In this study, the pain provocation test was used as the standard. Many studies have shown the power of both the SIJ block and the pain provocation test; however, it is expected that future HABER test studies will require the use of the SIJ block as the standard test.

Conclusions

The HABER test can reproduce a similar level of pain in patients with chronic LBP associated with SIJ syndrome, and it can be used as a diagnostic tool when examining patients presenting with chronic LBP.

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