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Original Article

Examination of the innominate movements in individuals with and without a positive march test

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Abstract. [Purpose] The March Test (MT), evaluating hypomobility of the sacroiliac joint (SIJ), is often used in clinical practice to evaluate low back pain but has limited reported validity and reliability. Capturing the innominate movement at SIJ associated with the results of MT has not been examined. The purpose of this study was to determine if there was a significant difference in the motion of the innominate between a positive and a negative MT. [Participants and Methods] Sixteen healthy volunteers were assigned into two groups: positive or negative results of the MT. All participants were asked to perform three different tasks: standing on both limbs, static standing on one-limb and flexing the hip to 90 and 100 degrees, and active flexing the hip past 90 degrees. In a 3D motion analysis system, virtual vectors created by landmarks over the ilium defined innominate movement of the ilium related to the sacrum, which were compared between the groups. [Results] There was significantly limited innominate movement in the March Test positive group compared to the March Test negative group. [Conclusion] This study showed hypomobility at SIJ in the March test positive groups. Further investigation is needed for clinical applications.

Key words: March test, Sacroiliac joint, Innominate

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INTRODUCTION

Low back pain (LBP), a very common condition that affects many individuals, is estimated as a lifetime prevalence at approximately 75–84%[1)]. Unfortunately standardized care for patients with low back pain is still controversial because of multi-factorial causes and lack of consensus diagnosis[2)]. Although there are many potential causes for low back pain, one potential cause is dysfunction associated with the sacroiliac joint. The rate of sacroiliac joint (SIJ) dysfunction associated with non-specific LBP is found to be approximately 15%[3)]. This prevalence increases up to 63% after failed back surgeries[4)].

Despite the high prevalence of SIJ dysfunction, quantification of SIJ movement is a challenge. Motion as small as 1–2 degrees at the SIJ is currently accepted in the literature[5)]. Abnormal movement of the SIJ is a commonly reported cause for low back pain[6, 7)]. Though radiologic evaluation is helpful in ruling out other etiologies of low back pain, it has poor sensitivity and specificity for sacroiliac joint dysfunction, necessitating a thorough history and physical exam for clinical diagnosis[7)].

Standardizing a physical examination of sacroiliac joint dysfunction has been difficult. Several SIJ provocation special tests such as the POSH, sacral thrust, FABER tests demonstrate excellent agreement (kappa coefficient k=0.78–0.90)[8)].Yet, varied concerns for SIJ special tests (both provocation and pain provoking) have been discussed as having lower reliability, specificity and sensitivity due to challenging palpation in this region[7)]. In general, any SIJ special tests that require a reproduction of symptoms (i.e. pain) seem to demonstrate higher reliability and clinical validity while any SIJ screening simply assessing movements of the lumbar and pelvic regions demonstrate lower reliability[8, 9)]. This discrepancy in reliability and validity may be due to difficulty in locating landmarks used in testing or could be due to operator difficulty in assessing this change of movement presented under soft-tissue.

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The March Test, also referred to as Gillet Test or Stork Test, is one of the most commonly used motion related palpation test[7, 10]. This test assesses the movement of the posterior superior iliac spine (PSIS) and the ischial tuberosity during active hip flexion in order to examine anterior/posterior innominate movement of the ilium[10]. Unlike provocative tests, this motion palpation test assesses the motion of the innominate as it relates to the sacrum and examines arthrokinematic or biomechanical impairments (hypomobility) in the SIJ. A March test is positive when the examiner palpates minimal movement in the PSIS which indicates hypomobility of the SIJ or a lack of motion with normal innominate rotation that occurs with greater than 90 degrees of hip flexion[10]. Despite its use in common clinical practice, the March Test, has also faced challenges regarding low reliability and questionable validity[11]. One study found that experienced physical therapists were able to reliably detect altered patterns of intra-pelvic motion during the March test[12].

Quantification of SIJ movements is a challenging task for all clinical researchers. Many conventional biomechanical models define the pelvis as a rigid segment without counting SIJ motion[13, 14]. In order to establish clinical validity for the March Test, a study to investigate if a biomechanical model can quantify movement of the ilium related to the sacrum is needed. Bussey and her colleagues could successfully define SIJ movement during hip abduction and external rotation with higher reliability and clinical validation by digitizing motion using a Polhemus Liberty™ electromagnetic tracking device[15]. The authors stated successful quantifying of innominate angle calculation (ICC >0.97) and low standard error of measurement (<2.02mm). Another study also established a method of quantifying the SIJ movements with higher reliability (ICC=0.91–0.94) by using a 3D kinematic analysis[16]. These studies indicated the possibility of quantifying SIJ movements using motion analysis to investigate clinical meaning of the March Test. Therefore, the objective of this experiment is to examine innominate movement measured by using a 3D motion capture system in those with a positive or negative March test.

PARTICIPANTS AND METHODS

This project was approved by the Institutional Review Board in Human Research Protection Office at University of New Mexico Health Science Center (No. 17-164). Volunteer participants for the study were recruited from the Metropolitan Albuquerque area via flyers. Eligibility was screened by a designated research assistant based on inclusion criteria. Inclusion criteria for the study were applied to individuals who were 1) between the age of 18 and 70, 2) capable of hip flexion beyond 95 degrees, capable of standing on one leg for at least 30 seconds with reasonable accommodation, 3) able to understand English at least to the 9th grade level, and 4) having reliable transportation to and from the testing site. Exclusion criteria were applied to the individuals who demonstrated 1) inability to perform the physical tasks required for the March Test including standing on 1 leg for 30 seconds with reasonable accommodation, 2) neurologic symptoms or deficits (recent stroke, unilateral weakness, tremor, positive Trendelenburg sign, recent changes in bowel and bladder), 3) inability to consent due to deficits with memory, cognition, or mental capacity, 4) diagnosed leg length discrepancies, and 5) bilateral involvement of SIJ as determined by a physical therapist during screening. After the screening, a total of sixteen volunteers participated in this study after obtaining their approved informed consents. All testing procedures were performed at a single site; the Gait and Motion Analysis Laboratory in Division of Physical Therapy at University of New Mexico.

The participants began by filling out a questionnaire for demographic information (age, gender, body height and body weight, and bodily pains). Although all participants were healthy volunteers, common complaints of pain and dysfunction could be found in this population. To capture all complaints of pain and dysfunction, all participants completed three clinical outcome scales; visual analog scale (VAS), Lower Extremity Functional Scale (LEFS) and the Modified Oswestry Low Back Disability Questionnaire (m-OSW)[18]. These clinical outcome measures were used because of the established validity and reliability (VAS; ICC=0.90, LEFS; ICC=0.89–0.99, m-OSW; ICC=0.90)[17–20]. Because of previous evidence related to inter-rater reliability, the lumbopelvic screening and identifying of the marker positions for ASIS and PSIS were performed by the primary tester[14–16]. The primary tester was a board certified clinical specialist in orthopedic physical therapy with over 37 years of clinical experience in this field who did not have experience in using a motion capture system and was blinded to the algorithm to calculate SIJ movement. The primary tester performed a lumbopelvic screen to eliminate those with structural dysfunctions (alignment of the bony pelvis, long sit test, pubic symphysis assessment of alignment and hip dysfunction/range of motion). Once cleared for obvious structural issues, the March test for upper and lower poles in both SIJs was assessed (Fig. 1). The results of the March test was blinded to the secondary tester, a clinical biomechanist.

To quantify the innominate movements, the markers' locations in the lab coordinate system were captured using a motion analysis system (Vicon Motion System Ltd, Oxford, UK). The given tasks during data acquisition were: 1) static standing 2) one limb standing with the contralateral hip flexed at both 90 degree and 100 degree by resting the foot on an adjustable stool, and 3) active one legged standing with the participant flexing the hip from 0 to greater than 90 degrees, much like the March Test. The first two tasks are static tasks while the last one was a dynamic trial capturing motion of the pelvis during hip flexion. Hip flexion positions were passively created by resting a foot on an adjustable box. One investigator measured the hip flexion positions for each of the participants. The participant was asked to relax and stand still for 3 seconds for both the 90 degree and 100 degree positions. Lastly, the participant was asked to actively flex the hip with an instruction 'just like you did during the March Test'. Five trials were captured for each task (i.e. standing, hip flexion at 90 degree and 100 degree, and the March Test) while the therapist oversaw if the marker maintained its location over the anatomical landmark. The averaged data from the 5 trials were used for analysis.

The angle between the cross-products of the two vectors from the ASIS and PSIS can be used to define innominate movements in the sagittal plane (i.e. innominate angles). Innominate angles of the ilium were defined by processing the vector between anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). The 3-dimensional coordination for each bony prominence was calculated as the cross-products to define the angle based on the previously reported algorithm (Fig. 2)[21]. The anterior/posterior tilt of ilium created by both right and left ASIS-PSIS vectors indicated the angle of innominate movements in the sagittal plane.

Repeated Measures Analysis of variance (ANOVA) test was used to test whether there was any significant interaction between groups over positions of the hip in innominate angle. Tukey HSD ("honestly significant difference") test was used for post-hoc analyses to determine which specific group means were different. An independent t-test was used to analyze differences in innominate movement in the sagittal plane during the March tests between groups. Alpha level of significance was set as 0.05.

RESULTS

Ten out of sixteen participants were diagnosed as having a positive March Test (March+). There were no significant differences in participant demographics (Table 1). Clinical outcomes show no significant difference for the VAS, LEFS or m-OSW, however participants in the March + group demonstrated greater score on the m-OSW, exceeding the minimal clinical important difference (MCID) defined as a change of 4.2 or greater as outlined by Mehta[20].

For the group with a negative result of the March Test (March−), inter-limb differences were tested using paired t-tests. Because all results between inter-limb differences in the March- were not significant ($p>0.05$), the average of each tested variable between limbs was used for analysis (Table 2). There was a significant interaction between groups over three hip positional tasks (static 90 degrees and 100 degrees and dynamic motion reproducing the March Test) for the innominate movements in the sagittal plane ($F_{(2, 36)}=12.539$, $p<0.001$). The post-hoc test revealed a significant greater innominate angle at static standing in the March+ group compared to the March- group (Δ=3.47°, p=0.015). This angle difference became significantly less in the March+ group compared to the March-group at 90 degree of the contralateral hip flexion (Δ=7.00°, p=0.004) and at also at 100 degree of the contralateral hip flexion (Δ=6.39°, p=0.018). Additionally, independent t-test revealed that there were significant differences in innominate movement in the sagittal plane during the March Test (Δ=7.73°, p=0.005).

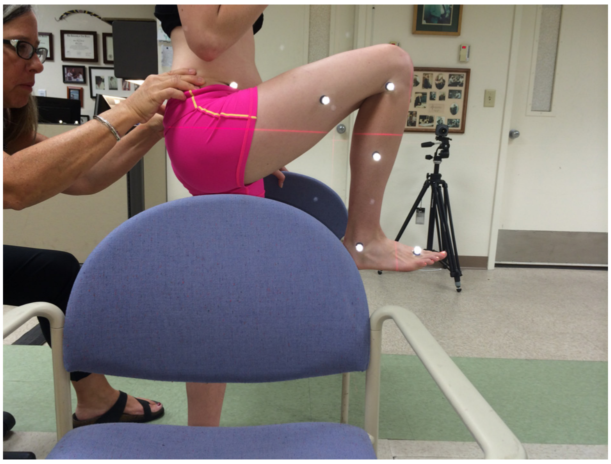

Fig. 1. Demonstration of the March Test portion of the study.

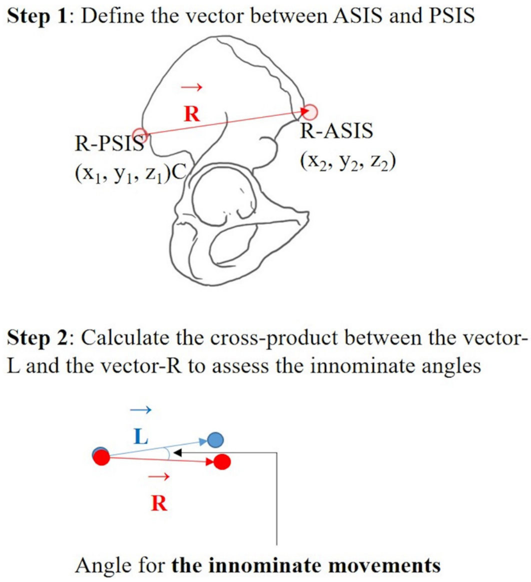

Fig. 2. Basic Diagram for the algorithm in this study. Each marker location indicates the 3-demensional coordinate system (x, y, z) in the laboratory space.
R-: Right side; L-: Left side, ASIS: Anterior superior iliac spine; PSIS: Posterior superior iliac spine.

Table 1. Demographic information (N=16)

Characteristics	March− (N=6)	March+ (N=10)
Age (years)	27.0 ± 4.70	38.4 ± 19.3
VAS (% of total length)	0.58 ± 0.54	0.30 ± 0.50
LEFS (%)	96.3 ± 3.79	92.5 ± 6.0
m-OSW (%)	3.67 ± 4.27	13.1 ± 28.7
Height (m)	1.69 ± 0.05	1.70 ± 0.10
Weight (kg)	75.9 ± 8.04	66.6 ± 16.7
BMI (m/kg^2)	26.5 ± 2.45	23.3 ± 3.0
R-hip e-AROM (º)	14.5 ± 7.45	16.0 ± 3.50
R-hip f-AROM (º)	122 ± 6.83	116 ± 7.64
L-hip e-AROM (º)	16.2 ± 3.77	16.5 ± 5.30
L-hip f-AROM (º)	127 ± 7.23	128 ± 8.90

BMI: Body Mass Index; LEFS: Lower Extremity Functional Scale; L-Hip f-AROM: Left HIP flexion; Active range of Motion; M-OSW: Modified Oswestry Low Back Disability Questionnaire; March+: Match Test positive group; March−: March Test negative group; R-Hip e-AROM: Right HIP extension Active range of Motion; VAS: Visual Analog Scale.

Table 2. Innominate movement in the sagittal plane

	Standing position—Hip positional tasks—			Dynamic motion
	Standing	Hip flexion at 90°	Hip flexion at 100°	March test
March+	4.96 ± 2.94°*	8.06 ± 4.29°**##	8.25 ± 4.39°**##	9.03 ± 4.65°**
March−	1.47 ± 0.96°	15.06 ± 3.02°	14.69 ± 4.59°	16.76 ± 4.31°

*$p<0.05$ for a comparison between March+ and March–.
**$p<0.01$ for a comparison between March+ and March–.
##$p<0.01$ for a comparison between standing and single limb stance.
°: degree; March+: Group with positive results of the March Test; March−: Group with negative results of the March Test.

DISCUSSION

Our methods could successfully differentiate the innominate movement of the ilium in the sagittal plane as those who had a March Test positive compared to those who were negative. Those who had March Test positive demonstrated hypomobility of the ilium compared to those with negative results. The magnitude of movement of the ilium were approximately twice greater in the March Test negative group compared to those with positive results of the March Test.

Some reviewers may be surprised by the large magnitude of anterior/posterior tilt of the innominate within the results. This can be explained by the different method of measurement as compared to previous studies. By creating virtual vectors between ASIS and PSIS, our measurement of the angle increased accuracy through linear displacement away from the anatomical joint center of the SIJ as similar to the previous report[22)]. A clinically important take away from this study is that greater innominate movement differences are only captured when the volunteer elevated to at least 90 degrees of hip flexion as seen in the previous work by Cooperstein and his colleagues[23)]. This indicates that clinicians must instruct their patients to flex their hip to at least 90 degrees in order to observe asymmetrical innominate movements during the March test.

There are several potential limitations in this study. Our participants with relatively lower body mass index (BMI) contribute to our significant findings by minimizing the soft-tissue artifact errors[24)]. We were pleased to be able to show significant difference in the innominate movement between the groups. Body composition may also be a limitation for correct palpation and identification of placement of the ASIS and PSIS markers. One study indicated that BMI had no effect on accuracy of palpation with an experienced manual therapist[25)].

Despite these limitations, our results could provide insight for quantifying movements of the innominate and potentially validate the March test as a clinical tool for SIJ dysfunction. This is the first attempt to quantify innominate movements in the 3D coordinate space related to the other side of ilium within a limitation of a passive external marker motion capture system. Further investigations are certainly needed to address reliability issues regarding the March test screening. Methods could include the use of fluoroscopy and/or ultrasound to verify that the markers are perfectly aligned with the bony landmarks or possibly the creation of a tracking devise that captures real time motion of the innominate in space.

The reliability and validity of the March Test is clinically controversial, yet innominate movements defined by virtual vectors between ASIS-PSIS showed significantly different movement patterns of the innominate in relatively healthy individuals with negative and positive results of the March Test.

Conflict of interest

All authors declare that there is no potential conflict of interest.

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