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Comparison of Lumbopelvic-Hip Rotation Asymmetry and Pelvic Asymmetry between Individuals with and without Nonspecific Low Back Pain

Qianhui Sun[1]*, Heng-Ju Lee[1], Cheng-Feng Lin[2], Rakhmad Rosadi[3]

[1]Department of Physical Education and Sport Sciences, National Taiwan Normal University, Taipei City
[2]Department of Physical Therapy, National Cheng Kung University, Tainan
[3]Department of Physiotherapy, Faculty of Health Science, University of Muhammadiyah Malang, Malang, Indonesia
Email: *81030016A@ntnu.edu.tw

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Abstract

Background: low back pain affects many individuals, with 80% classified as non-specific low back pain (NSLBP) due to mechanical rather than structural issues. The link between pelvic alignment and lumbopelvic-hip rotation movement for NSLBP is controversial. **Methods:** twenty males with NSLBP and 20 healthy males participated. Data collected included static pelvic asymmetry and active lumbopelvic-hip rotation with motion capture system for kinematic analysis. **Results**: Unpaired T test was used to compare the difference of kinematic parameters between two groups. NSLBP group showed significantly larger angles between the ASIS-PSIS line and the z-axis ($p < 0.001$). Asymptomatic individuals have greater medial hip joint range of motion on the dominant side compared to the nondominant side during hip medial rotation (NSLBP = 2.37° ± 8.70°; Control = −5.75° ± 4.57°; $p = 0.002$). There is no significant correlation between pelvic asymmetry and lumbopelvic-hip rotation. **Conclusion**: Evaluations focusing on bone structure alone may be inadequate. A more comprehensive approach including functional assessments like muscle strength and range of motion could be beneficial. Integrating lumbopelvic-hip movement patterns and pelvic symmetry into clinical assessments should be considered, as they may be influenced by physical activity.

Keywords

Low Back Pain, Biomechanics, Pelvic Alignment

1. Introduction

Low back pain is one of the most prevalent health issues in modern society, imposing a significant burden on individuals and nations alike. Approximately 85% of low back pain cases are classified as nonspecific low back pain (NSLBP) based on clinical data [1]. To improve treatment outcomes, NSLBP patients should be categorized into specific subgroups and matched with appropriate treatments [2]. Traditionally, functional assessments, such as the McKenzie system and Movement System Impairment (MSI) classification, have been used to differentiate various forms of NSLBP. Most research has focused on the impact of abnormal movement patterns or alignment in the lumbar spine area on low back pain [3]-[8]. Exploring the relationship between the hip joint and NSLBP is also crucial, especially with the growing interest in regional interdependence (RI) [9]. External forces transmitted through the hip joint and lumbopelvic region can influence biomechanical loading, leading to changes in soft tissue or bone adaptation in the lumbar spine [3] [10]. This understanding has contributed to the evolving mechanisms of low back pain.

A systematic review [11] found that NSLBP sufferers often exhibit reduced and asymmetrical hip rotation ROM, which correlates with asymmetrical force transmission to the lumbopelvic region. Studies found that men with NSLBP tend to exhibit greater and earlier lumbopelvic rotation during hip rotation tasks compared to women [12] [13]. Further research involving athletes in rotation-related sports revealed that those with LBP also showed increased and earlier lumbopelvic rotation during hip rotation [14]. These findings suggest that men may be more sensitive to hip rotation tasks, indicating a need for further research to determine if these movement patterns are prevalent among non-athletes with NSLBP. There is limited research on the mechanisms or contributing factors underlying the kinematic differences between patients with nonspecific low back pain (NSLBP) and those without low back pain. Some evidence suggests that hip joint limitations may be associated with pelvic asymmetry [15]. Furthermore, studies indicate that pelvic asymmetry is more common in individuals with chronic NSLBP and may be linked to movement asymmetry in this group compared to healthy individuals [3] [16].

Therefore, the purpose of our study is to compare lumbopelvic-hip rotation and pelvic asymmetry between male non-athletes with and without nonspecific low back pain. We hypothesize that subjects with NSLBP will exhibit greater pelvic asymmetry, increased lumbopelvic-hip rotation asymmetry, and distinct associations among these factors compared to the control group.

2. Method

2.1. Participants

Two groups of participants were recruited for this study: one group of 20 male patients with non-specific low back pain (NSLBP group) and a control group of

20 male healthy participants without low back pain in the past year. Both groups were matched for age and BMI. The inclusion criteria for the NSLBP group were males aged 20 to 40 years, with low back pain lasting at least 3 months, localized between the 12th rib and the inferior gluteal folds without radiating pain, an NPRS (Numerical Pain Rating Scale) score above 3, and a BMI under 30. Exclusion criteria included neurological syndromes, red flags for lumbar spine conditions (e.g., fracture, infection, radiculopathy, tumor, axial spondylarthritis), and regular participation in rotation-related sports (e.g., badminton, golf, baseball) for more than 120 minutes per week. Participants with NSLBP were recruited from the National Cheng Kung University Hospital.

2.2. Protocol

Participants meeting the inclusion and exclusion criteria were recruited for this study. All participants provided written informed consent, approved by the National Cheng Kung University Hospital Human Research Ethics Committee. Testing comprised two parts: self-report questionnaires and asymmetry tests.

Three self-report questionnaires were used: a basic information form (including demographic data, LBP history, and sports behavior), the Oswestry Disability Index (ODI) [17], and the Fear-Avoidance Belief Questionnaire (FABQ) [18]. Participants with low back pain completed all three questionnaires, while those without pain only completed the basic information form. An eight-camera motion analysis system (Eagle camera Cortex system, Motion Analysis Corporation, USA) capturing 3D marker trajectories at 60 frames per second was used for the asymmetry test. Eight retro-reflective markers were placed on key bony landmarks shown in **Figure 1**: the anterior and posterior superior iliac spines (ASIS &

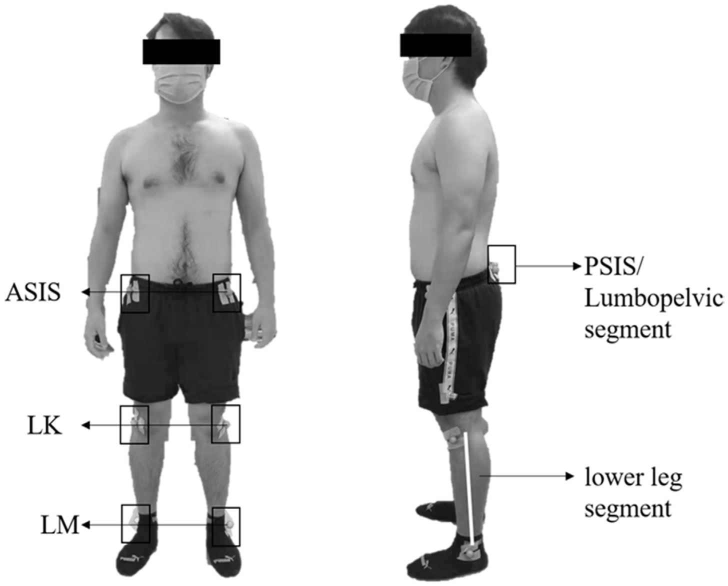

Figure 1. Marker set. 8 Markers were placed on the anterior superior iliac spine (ASIS), posterior superior iliac spine (PSIS), lateral knee, and lateral malleolus on both the right and left sides.

PSIS), lateral knee joint line (LK), and distal lateral malleolus (LM), bilaterally. The pelvic segment was defined by the vector between the PSIS markers, and the lower leg by the vector between the LM and LK markers. ASIS markers were used to assess pelvic symmetry during the static test and removed for hip rotation in the prone position.

After completing self-report measurements and marker placement, subjects were instructed to maintain a natural standing posture with feet shoulder-width apart for 5 seconds, ensuring minimal sway or movement. During this time, participants were asked to keep their eyes forward, with shoulders relaxed and arms hanging naturally. Participants performed active hip lateral rotation (HLR) and hip medial rotation (HMR) tests following a 5-minute warm-up. Before testing, subjects were secured on the treatment bed in a prone position using a bandage along the line of the 12th thoracic spine, as shown in **Figure 2**. The order of the tasks was randomized, and subjects were required to complete each test within 10 seconds in their own transverse plane. Symptom changes during the tests were recorded, with possible responses being 1) remained the same, 2) increased, or 3) decreased. Kinematic data were collected three times for each side, unless severe pain was reported, in which case only one trial was conducted.

The experimenter first explained the HLR and HMR tasks, including the location of the hip joint and the rotation technique. Both HLR and HMR were performed in a prone position with the arms resting horizontally on the treatment bed. The starting position for both tasks involved positioning the lower leg at 90˚ of knee flexion, with neutral hip abduction, adduction, and rotation, as shown in **Figure 3**. For HLR, participants were instructed to laterally rotate the hip to bring the foot toward the midline as far as possible (**Figure 4**), then return to the start position. For HMR, they were instructed to medially rotate the hip, moving the lower leg away from the midline (**Figure 5**), and then return to the start position. Each movement was performed at a self-selected speed within a 10-second period, with both left and right sides tested in a randomized order. Participants were allowed to practice the tasks until they could perform them correctly.

2.3. Data Analysis

All kinematics were processed by the custom-made algorithm using MATLAB

Figure 2. Prone position.

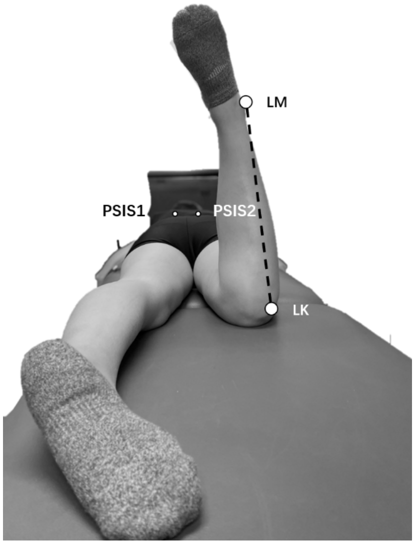

Figure 3. Neutral position.

Figure 4. HLR (hip lateral rotation).

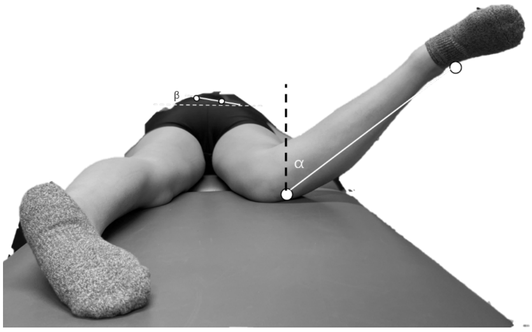

Figure 5. HMR (hip medial rotation).

computer programming language version R2018a (Mathworks Inc., Natick, MA, USA). All data were filtered by Butterworth filter with a fourth-order, dual-pass, and a cutoff frequency of 2.5 Hz.

Pelvic asymmetry parameters quantify the extent of pelvic asymmetry and were calculated using methods developed from previous studies [19] [20]. These calculations include the pelvic asymmetry ratio (PAR), pelvic asymmetry index in the sagittal plane (PAIS), and pelvic asymmetry index in the frontal plane (PAIF). Details of these formulas are provided in **Table 1**. During the static test, coordinates of the ASIS and PSIS on both dominant and nondominant sides were recorded. The relationship between global and local coordinates is illustrated in **Figure 6**. For PAIF, the right PSIS and ASIS were used as the origin, with angles between vectors of the left and right PSIS or ASIS and the x-axis being negative in the clockwise direction.

Table 1. Calculation way of pelvic asymmetry.

Calculation way of pelvic asymmetry	Description
• PAR = |right ASsh − left ASsh|/horizontal distance ASIS − ASIS + |right PSsh-left PSsh|/horizontal distance PSIS-PSIS a) ASsh, anterior superior iliac spine height b) PSsh, posterior superior iliac spine height	Advantages: This formular correct the shortcoming of dimensions of the pelvis by divided by horizontal distances ASIS-PSIS, and would not be influenced by the difference between the anatomical sides and dominant sides. Disadvantages: The result of formula cannot provide judgement about which kind of asymmetry of the pelvis has shown.
• PAIS = ∠S_D − ∠S_ND a) ∠S_D, angle between ASIS-PSIS line in the dominant side and z-axis b) ∠S_ND, angle between ASIS-PSIS line in the nondominant side and z-axis	PAIS = 0, perfect symmetry of the pelvis; PAIS > 0, larger posterior rotation/extension of the innominate in the *dominant side;* PAIS < 0, larger posterior rotation/extension of the innominate in the *nondominant side.*
• PAIF = (∠FA + ∠FP)/2 a) ∠FA, angle between R-L ASIS line and x-axis b) ∠FP, angle between R-L PSIS line and x-axis	PAIF = 0, perfect symmetry of the pelvis: lines R-L ASIS and R-L PSIS are parallel to the x-axis or the angles between them and x are identical but opposite; PAIF > 0, higher left innominate; PAIF < 0, higher right innominate.

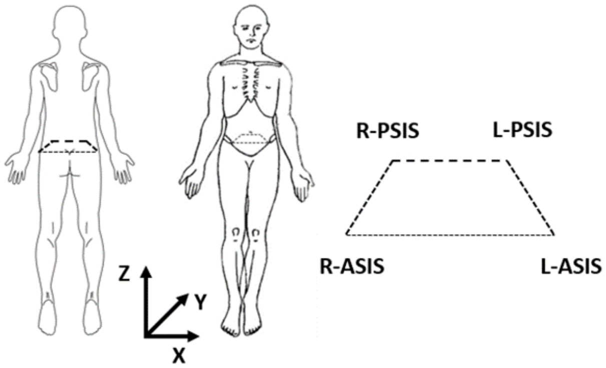

Figure 6. Global and local coordination.

Movement asymmetry parameters included the absolute and relative differences in hip and lumbopelvic rotation angles between the nondominant and dominant sides during HLR and HMR. The absolute angular difference during HLR is calculated as the maximal hip lateral rotation angle on the nondominant side minus that on the dominant side. Relative angular differences during HLR are expressed as the Movement Asymmetry Ratio (MAR), calculated by dividing the absolute angular difference by the sum of the maximal hip lateral and medial rotation angles. The start and end time points for both hip and lumbopelvic rotation were determined using the same criteria based on the angular displacement (AD) and angular velocity (AV) of the lower leg. Angular displacements between the start and end positions of the lower leg (α) and lumbopelvic segments (β) were calculated solely in the transverse plane, as shown in **Figure 4** and **Figure 5**. Angular velocities were derived by dividing these angular displacements by the corresponding rotation duration. Hip rotation was defined by the start of lower extremity movement when both AD ≥ 0.5˚ and AV ≥ 5% of AV(MAX) were met simultaneously, and the end when AD reached 99% of AD(MAX). Lumbopelvic rotation was determined similarly: the start was marked when AD of the pelvic segment ≥ 0.5˚ and AV ≥ 15% of AV(MAX), and the end when AD reached 99% of AD(MAX) for the pelvic segment.

2.4. Statistics

Independent-samples t-tests and Chi-Squared tests were used to compare the basic information between the NSLBP and control groups. Independent-samples t-tests also compared asymmetry variables between the groups. Outliers were assessed using boxplots and retained in the analysis as they did not significantly affect the results, confirmed by comparing analyses with and without the outliers. Time scores were normally distributed, as verified by the Shapiro-Wilk test. The relationship between pelvic asymmetry parameters and movement asymmetry parameters was assessed using the bivariate Pearson correlation coefficient, with an alpha level of.05. Statistical analyses were conducted using SPSS 17.0.

3. Results

We have recruited 40 subjects in our study, 20 in NSLBP group, 20 in control group. All basic data was summarized in **Table 2**, including the means, standard deviations (SDs) of the demographic parameters and low back pain (LBP) information, such as the age, weight, height, BMI, subjective pain intensity and scores of the questionnaires, and descriptive statistic data, like the number of subjects with different types of dominant leg (right or left), different locations of LBP (two sides, left side or right side), different LBP duration (3 - 18 months, 18 - 36 months or >36 months), different LBP frequencies (0 - 5 times, 6 - 10 times, >10 times) within prior 6 months and symptom arousal or uncomfortable feeling during any active dynamic tasks.

3.1. Pelvic Asymmetry

Only the difference of single innominate postures in dominant and nondominant side between two groups were presented significantly ($p < 0.001$) in **Table 3**.

Table 2. Descriptive profiles of the two groups.

Variables	NSLBP (n = 20)	Control (n = 20)	Statistical and P value
Age (yr)	24.15 ± 2.74	25.40 ± 2.72	t = −1.48; p = 0.156
Weight (kg)	70.30 ± 9.25	68.85 ± 8.88	t = 0.506; p = 0.616
Height (m)	1.73 ± 0.05	1.72 ± 0.05	t = 0.761; p = 0.452
BMI (kg/m^2)	23.50 ± 2.77	23.33 ± 2.71	t = 0.190; p = 0.851
Dominant leg (R, right/L, left)	R = 17; L = 3	R = 19; L = 1	χ^2 = 1.111; p = 0.292
Location of LBP(n)	Two sides:12 Left side:4 Right side:4	-	-
Duration of LBP(n)	3 - 18 months: 13 18 - 36 months: 4 >36 months: 3	-	-
Frequency of LBP (n)	0 - 5 t/p6m: 5 6 - 10 t/p6m: 8 >10 t/p6m: 7	-	-
MVAS (0 - 100 mm, prior 6 months)	62.99 ± 12.42	-	-
AVAS (0 - 100 mm, prior 6 months)	39.47 ± 14.41	-	-
ODI (0% - 100%)	12.4 ± 7.69	-	-
FABQ (0 - 96)	32.15 ± 13.58	-	-
Percentage of the symptom arousal (%)	55% (11/20)	-	-

Means ± SDs of age, weight, height, BMI, duration of LBP, MVAS, AVAS, ODI and FABQ for subjects. BMI, Body Mass Index; t/p6m, time/prior 6 months; MVAS, Visual Analogue Scale of Maximal Pain Intensity (a horizontal line, 100 mm in length with longer line indicating higher symptom intensity); AVAS, Visual Analogue Scale of Average Pain Intensity; ODI, Oswestry Disability Index; FABQ, Fear-avoidance Belief Questionnaire.

Table 3. Angles of Single Innominate and pelvic asymmetry.

Variables	NSLBP (n = 20)		Control (n = 20)		
	MEANs	SDs	MEANs	SDs	statistical and P value
S_ND (˚)	83.57	5.28	77.19	5.21	t = 3.852; p < 0.001
S_D (˚)	84.73	5.39	78.32	4.62	t = 4.045; p < 0.001
FA (˚)	0.93	2.90	1.77	2.96	t = −0.908; p = 0.370
FP (˚)	−0.47	2.09	−0.62	1.54	t = 0.261; p = 0.795
PAR	0.07	0.04	0.07	0.04	t = −0.086; p = 0.932
PAIS (˚)	−0.83	2.20	−1.34	1.81	t = 0.053; p = 0.958
PAIF (˚)	0.23	2.17	0.58	1.84	t = −0.543; p = 0.590

S_ND, angle between ASIS-PSIS line in the nondominant side and z-axis; S_D, angle between ASIS-PSIS line in the dominant side and z-axis; FA, angle between R-L ASIS line and x-axis; FP, angle between R-L PSIS line and x-axis, PAR, pelvic asymmetry ratio; PAIS, pelvic asymmetry index in sagittal plane; PAIF, pelvic asymmetry index in frontal plane.

According to our results, we have found that subjects in NSLBP group have much more posterior innominate in nondominant and dominant side than control group. But index of asymmetry were no significant differences.

3.2. Lumbopelvic-Hip Rotation Asymmetry

The differences in maximal hip medial rotation angle (MHMR) between the two legs and the corresponding movement asymmetry ratio (MAR) demonstrated significant variation between the NSLBP and control groups shown in **Table 4**. In the NSLBP group, the nondominant side exhibited a higher MHMR compared to the dominant side, while the control group showed the opposite trend (p = 0.002).

Table 4. Lumbopelvic-hip rotation asymmetry.

		Difference (˚)			MAR (%)		
	Group	Mean	SD	P-value	Mean	SD	P-value
MHLR	NSLBP	−1.01	6.20	0.888	−0.43	5.99	0.835
	control	−0.69	7.27	-	−0.93	8.23	-
MHMR	NSLBP	2.37	8.70	0.002	3.40	12.70	0.009
	control	−5.75	4.57	-	−5.73	4.60	-
MLP-HLR	NSLBP	0.41	1.97	0.437	2.27	14.23	0.939
	control	−0.23	3.02	-	1.88	16.77	-
MLP-HMR	NSLBP	−0.30	2.61	0.355	−1.02	14.93	0.736
	control	0.52	2.86	-	0.74	17.45	-

Difference = value of angle in nondominant side minus value of angle in dominant side; MAR (movement asymmetry ratio) = Difference/value of angle in nondominant side plus value of angle in dominant side; MHLR, maximal hip lateral rotation; MHMR, maximal hip medial rotation; MLP-HLR, maximal lumbopelvic rotation during hip lateral rotation; MLP-HMR, maximal lumbopelvic rotation during hip lateral rotation.

3.3. The Relationship of Pelvic Asymmetry and Lumbopelvic-Hip Rotation Asymmetry

The correlation coefficients were displayed in **Table 5**. There was no significant correlation between pelvic asymmetry parameters (PAR, PAIS and PAIF) and movement asymmetry parameters in two groups.

4. Discussion

4.1. Pelvic Alignment and Pelvic Asymmetry

Current results in our study suggest that the pelvic alignment during static test in standing position vary between two groups. Specifically, the bigger inclination angles between ASIS-PSIS line and z-axis in both dominant side and nondominant side may reveal the subjects with nonspecific low back pain show much more pelvic posterior tilt than subjects without low back pain. However, there is no other significant differences in terms of pelvic asymmetry parameters like PAR,

Table 5. The relationship of pelvic asymmetry and movement asymmetry.

		PAR (˚)	PSIS (˚)	PAIF (˚)	D_MHLR (˚)	D_MHMR (˚)	D_MLP-HLR (˚)	D_MLP-HMR (˚)
PAR (˚)	NSLBP	-	0.226	0.246	0.222	−0.156	0.097	−0.238
	control	-	−0.564*	0.169	−0.115	0.453	−0.177	−0.469
PAIS (˚)	NSLBP		-	0.531*	0.124	0.169	0.099	−0.254
	control		-	0.18	0.05	−0.269	0.093	0.143
PAIF (˚)	NSLBP			-	−0.038	−0.103	−0.216	0.088
	control			-	0.104	0.217	−0.321	−0.032
D_MHLR (˚)	NSLBP				-	−0.007	0.234	−0.618**
	control				-	−0.625*	−0.027	0.223
D_MHMR (˚)	NSLBP					-	−0.092	0.148
	control					-	−0.05	−0.359
D_MLP-HLR (˚)	NSLBP						-	−0.541*
	control						-	0.009
D_MLP-HMR (˚)	NSLBP							-
	control							-

*: Statistically significant correlation coefficient (P < 0.05); **: Statistically significant correlation coefficient (P < 0.01); D_MHLR, difference in maximal hip later rotation; D_MHMR, difference in maximal hip medial rotation; D_MLP-HLR, difference in maximal lumbopelvic rotation during HLR; D_MLP-HMR, difference in maximal lumbopelvic rotation during HMR.

PAIS or PAIF between two groups. Therefore, our data suggests that absolute pelvic alignment in sagittal plane may be more likely to be related to occurrence of nonspecific low back pain.

On one hand, from the perspective of pelvic asymmetry parameters, our results were supported partly by two previous studies [21] which have yielded the conclusion that there is no significant alternation of pelvic asymmetry parameters in the frontal plane for NSLBP subjects, but small association between asymmetry ratio in sagittal plane and NSLBP. The possible reasons of the controversy may come from the different data collection techniques, data analysis methods and subjects compared with findings from previous study. Yu *et al.* have used the relatively new technique, the global postural system, for assessment and the system was operated by two testers to distinguish right and left sides in the recruited females and males. However, in our study, we have collected data with a motion analysis system with eight infrared cameras, and all statistical analyses were conducted by comparison of dominant and non-dominant side between two groups for only male. Interestingly, the average value of PAR (0.073 ± 0.04) for NSLBP group in our study is quite similar as the result (0.066 ± 0.04) in previous study, but much greater (0.074 ± 0.04) for control group compared with results (0.046 ± 0.03) from ones of Egan *et al.* [3], which could suggest that asymptomatic individuals could also have different types of PAR based on multiple factors like sex, sports behavior and even have adaptation alternation influenced by external mechanical force[22]. Another reason might be the limited number of subjects in our study.

On the other hand, in terms alternation of sagittal lumbopelvic posture for subjects with low back pain, relative existing evidence is conflict. For example, previous studies have shown that low back pain have been associated with lumbar lordosis and sacral inclination. However, some have found subjects with low back pain have increased lumbar lordosis and sacral inclination [21] [23] and others hold the opposite view [24]-[26]. No matter what kind of view they hold, the alignment of pelvic is always not considered as a single item, which is influenced by other multi-segments, like lumbar spine through lumbosacral and sacroiliac joints [27] [28] or the thoracic spine [29]. Furthermore, the alteration of pelvic alignment may change the biomechanics of force transition from distal to proximal joints or from distal to proximal joints and increase the stress to surrounding soft tissues [21].

In particular, sagittal spino-pelvic alignment was presented commonly by radiographic parameters shown in **Figure 7**, such as pelvic tilt (PT, the angle between line from center of head of hip to mid-point of sacral upper surface and z-axis), pelvic incidence (PI, the angle between perpendicular line of sacral upper surface and connection line from center of head of hip to mid-point) of sacral upper surface)and sacral slope (SS, the angle between upper surface of sacrum and x-axis) [30]. With the new technical development, other method with high reliability and safety, for example, global postural system [31] or motion analysis system in our study, have gradually replaced the traditional way to measure the pelvic morphology and pelvic orientation. Based on our results, the angles between the line from PSIS-ASIS in dominant side and nondominant side and z-axis is larger for NSLBP subjects, which may suggest that pelvis have posterior tilt trend around frontal axis. This was also proved by previous studies that greater proportion of subjects with chronic low back pain have increased PT, decreased LL and SS [24] [32] [33]. Rajnics *et al.* argued that there could be relationship between larger compressive force contributing to the disk degeneration and decreased SS&LL and increased PT.

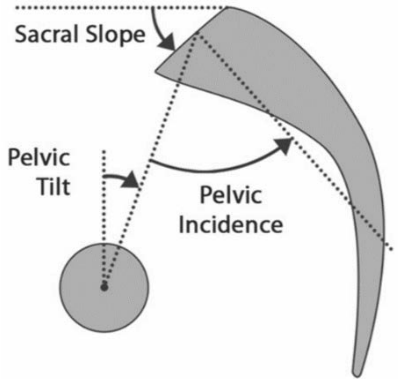

Figure 7. Spino-pelvic alignment in sagittal plane.

4.2. Lumbopelvic-Hip Rotation Asymmetry

According to our results, only the difference in maximal active hip joint angle during medial rotation between the two groups was significant. In the NSLBP group, the value was positive (2.37˚ ± 8.70˚), while in the control group, it was negative (−5.75˚ ± 4.57˚). This suggests that asymptomatic individuals exhibit greater medial hip joint ROM on the dominant side during hip medial rotation than on the nondominant side, with a larger deviation between the two sides.

In reviewing previous studies, Van Dillen *et al.* demonstrated that different subgroups of NSLBP exhibited varying degrees of symmetry in lumbopelvic rotation during active hip lateral rotation. Specifically, according to the Movement System Impairment (MSI) classification for low back pain developed by Sahrmann *et al.*, the Rot subgroup showed less asymmetry in lumbopelvic rotation compared to the RotExt subgroup [34]. This underscores the importance of subdividing nonspecific low back pain into distinct subgroups to provide tailored therapeutic strategies.

4.3. The Relationship of Pelvic Asymmetry and Movement Asymmetry

The orientation of the acetabulum and the shape of the pelvis can influence hip range of motion. For instance, excessive posterior pelvic tilt can alter acetabular orientation, which in turn may affect hip range of motion and biomechanical performance [35]. Additionally, greater hip ROM can be influenced by larger femoral heads [36] and the morphology of the anterior inferior iliac spine (AIIS) [37]. Although the angles between the ASIS-PSIS line and the z-axis on the nondominant and dominant sides were significantly associated with differences in maximal hip angles between passive and active patterns during hip medial rotation, these associations were small. This suggests that pelvic asymmetry may have a limited role in the occurrence of NSLBP.

These significant findings suggest that focusing solely on bone structural alignment during clinical evaluations may be insufficient. A more comprehensive assessment that includes movement tests and evaluations of soft tissue properties, such as muscle strength, flexibility, and joint angles, should be considered to gain a more complete understanding of the factors contributing to nonspecific low back pain.

5. Conclusion

Male participants with NSLBP who do not engage in rotation-related sports do not exhibit clear pelvic asymmetry or differences in lumbopelvic segment rotation but do show differences in active maximal hip medial rotation angle compared to asymptomatic participants. There is no significant correlation between pelvic asymmetry and lumbopelvic-hip rotation. These nonsignificant results suggest that adding lumbar-pelvis-hip movement pattern and pelvic symmetry measurements to routine clinical assessments for NSLBP should be carefully considered, as these factors may depend on physical behaviors, such as the type of sports or regular activities. Not all NSLBP subjects will necessarily display pathological differences in pelvic asymmetry or lumbopelvic-hip movement patterns.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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