



Relationship between Spinopelvic Parameters and Hip Function in Patients with Femoroacetabular Impingement at Diagnosis: A Cross-Sectional Study

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Purpose: The aim of this study was to determine correlation between the spinopelvic parameters in sitting and standing positions (sacral slope [SS], lumbar lordosis [LL], spinopelvic tilt [SPT], pelvic incidence [PI], and pelvic femoral angle [PFA]), with hip function assessed using the modified Harris hip scores (mHHs) in patients with symptomatic femoroacetabular impingement (FAI) at diagnosis.

Materials and Methods: A retrospective study of 52 patients diagnosed with symptomatic FAI was conducted. Evaluation of the spinopelvic complex in terms of SS, LL, SPT, PI and PFA was performed using lateral radiographs of the pelvis and lumbosacral spine in standing and sitting positions. Assessment of hip function at diagnosis was performed using the mHHs. Calculation of spinopelvic mobility was based on the difference (Δ) between measurements performed in standing and sitting position.

Results: The median time of pain evolution was 11 months (interquartile range [IQR], 5-24 months) with a median mHHs of 66.0 points (IQR, 46.0-73.0) at diagnosis. The mean change of LL, SS, SPT, and PFA was $20.9 \pm 11.2^\circ$, $14.2 \pm 8.6^\circ$, $15.5 \pm 9.0^\circ$, and $70.7 \pm 9.5^\circ$, respectively. No statistically significant correlation was observed between spinopelvic parameters and the mHHs ($P > 0.05$).

Conclusion: Radiological parameters of the spinopelvic complex did not show correlation with hip function at the time of diagnosis in patients with symptomatic FAI. Conduct of further studies will be required in the effort to understand the effect of the spinopelvic complex and its compensatory mechanics, primarily between the hip and spine, in patients with FAI before and after hip arthroscopy.

Key Words: Femoroacetabular impingement, Spinopelvic mobility, Lumbar lordosis, Hip function

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INTRODUCTION

Knowledge regarding pathologies of the hip has evolved with passage of time from an isolated approach to one involving the interaction with the pelvis and the spine, known as the spinopelvic complex. Appropriate interaction between these structures determines the correct sagittal balance of each person, which can be evaluated in different anatomical positions using radiological parameters, such as sacral slope (SS), lumbar lordosis (LL), spinopelvic tilt (SPT), pelvic incidence (PI), and pelvic femoral angle (PFA)¹⁻³.

In the last decade, femoroacetabular impingement (FAI), which is attributed to abnormal contact between the acetabulum and the femoral head-neck junction, has been identified as a primary cause of hip pain and functional limitation⁴. Abnormalities in spinopelvic parameters, with reduced SPT and PI, and increased SS, as well as a lower lumbar range of movement have been reported in patients with FAI compared to those without FAI⁵⁻⁷. These findings suggest that a change in any of the structures of the spinopelvic complex can lead to modification of the optimal balance between the femur and the acetabulum, resulting in development of intra-articular pathology.

In contrast, authors including Fader et al.⁵ and Yin et al.⁸ evaluated the effect of spinopelvic parameters on the occurrence of hip pain. Fader et al.⁵ reported no significant differences in LL, PI, and SS values between patients with asymptomatic FAI and those with symptomatic FAI. However, they reported that the group with symptomatic FAI showed lower lumbar mobility compared to the control group without FAI. In addition, Yin et al.⁸ reported lower PI and SS in patients with symptomatic FAI, which is reflected in a reduced capacity for pelvic adaptation during movement from a sitting to a standing position. However, they did not evaluate the relationship between SPT and LL with hip pain.

In summary, despite the reported findings described above, evidence regarding the relationship between spinopelvic parameters and FAI symptomatology is still inconclusive. Only studies on its relationship with the occurrence of hip pain, not with perceived hip function, have been reported. Therefore, in the effort to obtain more favorable results from conservative and surgical treatment, attaining a more in depth understanding of the dynamic effect of the spinopelvic complex on the severity of FAI symptomatology could be helpful in the development of physical rehabilitation protocols.

Therefore, the aim of this study was to determine corre-

lation between the spinopelvic parameters in sitting and standing positions (SS, LL, SPT, PI, and PFA), with hip function assessed using the modified Harris hip scores (mHHs) in patients with symptomatic FAI at diagnosis. According to our hypothesis, there is an association of better lumbar mobility and pelvic adaptability with a higher level of perceived function in patients with symptomatic FAI.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee of Clínica Imbanaco Grupo QuirónSalud (approval code: CEI-595) and conducted under the agreements of the Declaration of Helsinki (2013). A retrospective review of a consecutive cohort of patients who consulted for hip pain and were diagnosed with FAI at Clínica Imbanaco Grupo QuirónSalud by the lead author (B.A.B) from 2020 to 2021 was conducted. Patients with lateral radiographs of the pelvis and lumbosacral spine in standing and sitting positions were considered eligible for inclusion in this study. Patients with osteoarthritis (Tönnis grade 2-3), previous fractures of the femur or pelvis, hip dysplasia, or a history of lumbar pathologies were excluded.

Confirmation of the diagnosis of FAI was based on findings from physical examination (FADDIR: flexion, adduction, and internal rotation) and imaging including hip radiograph (anteroposterior pelvis, 45° and 90° Dunn projection, and false profile) and 3-Tesla magnetic resonance imaging. Spine radiographs taken in a standing and seated position became an indication in all cases in January 2020 due to the increasing interest in the spinopelvic complex in pathologies of the hip. In addition, assessment of hip function was performed using mHHs prior to deciding on a specific treatment; mHHs is regarded as a valid and reliable scale for quantifying hip function in patients with FAI^{9,10}. The mHHs values range from 0 (worst) to 100 (best).

Both standing and seated radiographs were extracted from the institutional medical records system. All radiological measurements were performed using the tools included in the Weasis visualization program (ver. 3.5.3; Weasis Team)¹¹. According to the institutional protocol, the standing radiographs were taken with a focus on perpendicularity of both femoral heads and when taken in the seated position both femurs were aligned in parallel in order to obtain an apparent hip flexion of 90°.

Evaluation of the spine was performed through the LL and measurement was based on the angle between the zone of greatest lumbar inflection (superior endplate of L1) and the

superior endplate of S1. PI, which corresponds to the sum of SS and SPT, was used in assessment of pelvic morphology; use of these two parameters enables evaluation of the pelvic alignment in relation to the sacrum and femoral heads, respectively. Measurement of SPT was based on the angle formed between the line from the midpoint of the sacral plateau to the femoral head and a vertical reference line drawn from the same point, and SS was measured as the angle between the horizontal line and the superior plate of S1. Assessment of the hip was performed through the PFA, which was measured as the angle between a line defined by the anterior cortex of the most protruding femur toward the mid zone and the superior S1, using the center of the femoral head as a reference point (Fig. 1).

Assessment of the mobility of the spine, pelvis, and hip was performed using the parameters of the spinopelvic complex and was defined as the difference between measurements taken in standing and sitting positions ($\Delta X_{(standing/sitting)} = X_{standing} - X_{sitting}$).

A ΔLL less than 20° was regarded as a stiff lumbar spine¹²⁾. Sagittal alignment was classified as flatback if the difference between standing PI and LL (PI-LL) was $>10^\circ$ and hyperlordotic if PI-LL $<-10^\circ$ ^{1,12)}. ΔSPT less than 10° was defined as stiff mobility of the spinopelvic complex and $\Delta SPT >30^\circ$ was defined as hypermobile^{1,12)}. All measurements were performed simultaneously and independently by two evaluators. Calculation of standing PFA and sitting

LL could not be performed in all cases. Most lateral radiographs taken in standing position did not include visualization of the anterior cortex of the femur and lateral radiographs taken in a seated position did not include the superior endplate of L1, so that data measurement could not be performed.

Stata 17.0 (StataCorp, College Station, TX, USA) was used in performance of all statistical analyses. Testing of the assumption of normality was performed using the Shapiro–Wilk test. Normally distributed variables were indicated with mean \pm standard deviation and otherwise, with median (interquartile range [IQR]). Assessment of interobserver agreement was performed using Lin's concordance correlation coefficient (CCC). Values of CCC >0.75 were regarded as an indicator of good reliability¹³⁾.

Analysis of the correlation between hip function (mHHs) and spinopelvic parameters was performed using Spearman's correlation coefficient. All analyses were performed using a complete case approach, which implies that calculation of each correlation coefficient was performed using the observations without missing values for the variables of interest. A P -value <0.05 was considered statistically significant.

RESULTS

Lateral radiographs of the pelvis and lumbosacral spine taken in standing and sitting positions for 58 patients diag-

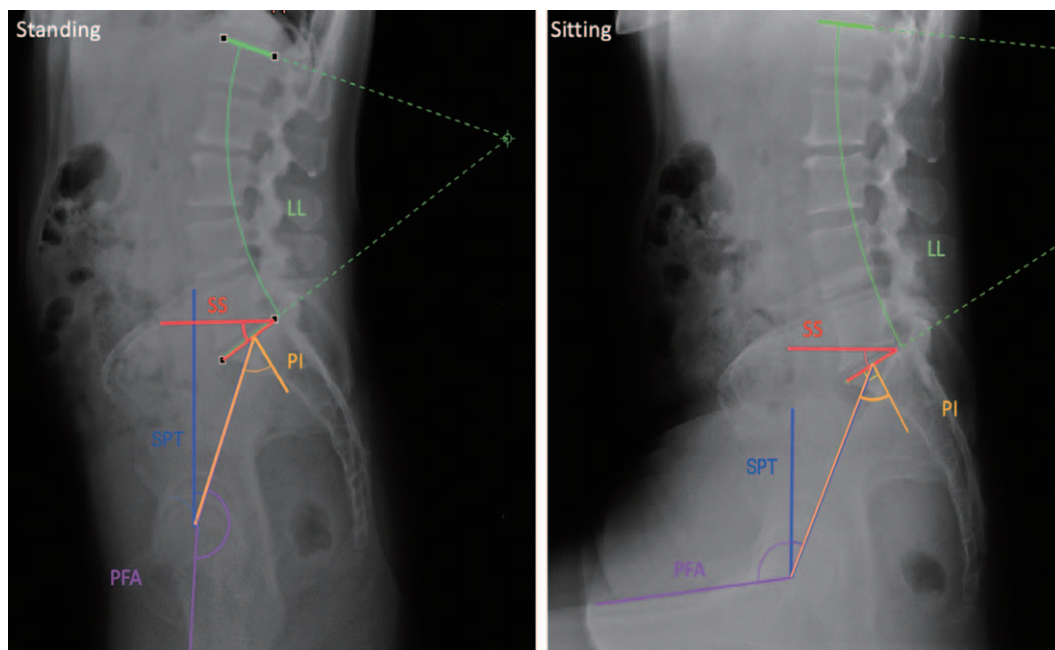


Fig. 1. Radiographic measurements of the spinopelvic complex in sitting and standing positions. SS: sacral slope, LL: lumbar lordosis, SPT: spinopelvic tilt, PI: pelvic incidence, PFA: pelvic femoral angle.

nosed with FAI between 2020 and 2021 were available for analysis. Five patients with a history of lumbar pathology and one patient who had previously undergone hip surgery were excluded from the study. Therefore, 52 patients with FAI with a mean age of 44.3 ± 13.9 years were included; 59.6% (31 patients) of the patients were female and the right hip was affected in half of these patients. The median time of pain evolution was 11 months (IQR, 5-24 months) with a median mHHs of 66.0 points (IQR, 46.0-73.0) at diagnosis (Table 1).

As shown in Table 2, the mean change in dynamics of the spinopelvic complex based on LL, SS, SPT, and PFA was $20.9 \pm 11.2^\circ$, $14.2 \pm 8.6^\circ$, $15.5 \pm 9.0^\circ$, and $70.7 \pm 9.5^\circ$, respectively. The interobserver reliability for all measures

ranged from 0.863 to 0.934 (Appendix 1). Stiff lumbar mobility was detected in 48.1% (13/27) of patients with ΔLL ($^\circ$) measurements. Results from measurement of the spinopelvic complex using SPT showed stiffness in 28.0% (14/50) of FAI patients during movement from a standing to a sitting position (Fig. 2A). Abnormal sagittal spinopelvic balance was observed in 49.0% of the patients, predominantly the hyperlordotic type; only one patient had a flatback deformity (Fig. 2B).

Results of the correlation analysis between spinopelvic parameters and hip function are shown in Table 3 and Fig. 3. No statistically significant correlation was observed between spinopelvic radiographic parameters and mHHs in standing and sitting positions. In addition, no evidence of a significant relationship was found between symptoms at diagnosis of FAI (mHHs) and mobility of the spinopelvic complex (Δ) ($P > 0.05$). The median of mHHs among patients with stiff, normal, and hypermobile spinopelvic complex was 65.5 points (IQR, 53.7-73.0), 54.0 points (IQR, 32.5-73.0), and 58.5 points (IQR, 46.0-71.0), respectively, and no statistically significant differences were observed between spinopelvic mobility groups (Fig. 4A). Similarly, no significant change in mHHs at diagnosis was observed between FAI patients with stiff lumbar mobility and those with normal lumbar mobility (Stiff, 66.0 points [IQR, 54.0-71.0] vs. Normal, 67.5 points [IQR, 43.7-73.0]) (Fig. 4B).

Table 1. Characteristics of FAI Patients (n=52)

Variable	Value
Age (yr)	44.3±13.9
Sex	
Female	31 (59.6)
Male	21 (40.4)
Laterality	
Right	26 (50.0)
Left	26 (50.0)
FAI	
Pincer	23 (44.2)
Cam	5 (9.6)
Mixed	24 (46.2)
mHHs	66.0 (46.0-73.0)

Values are presented as mean±standard deviation, number (%), or median (interquartile range).

FAI: femoroacetabular impingement, mHHs: modified Harris hip score.

DISCUSSION

Differences in the radiological parameters of the spinopelvic complex have been associated with the presence of morphological findings of FAI; however, no studies using

Table 2. Description of Spinopelvic Parameters in Standing and Sitting Positions

Parameter	Standing	Sitting	Change from a standing to a seated position	P-value
LL, No.	51	27	27	
Mean±SD ($^\circ$)	59.1±10.9	38.4±13.9	20.9±11.2	<0.001
SS, No.	52	52	52	<0.001
Mean±SD ($^\circ$)	38.4±8.7	24.1±11.2	14.2±8.6	
SPT, No.	50	52	50	
Mean±SD ($^\circ$)	11.6±6.6	26.9±10.2	15.5±9.0	<0.001
PI, No.	50	52	50	
Mean±SD ($^\circ$)	50.3±10.1	51.1±11.3	-1.3±5.5	0.093
PFA, No.	14	52	14	
Mean±SD ($^\circ$)	183.5±12.6	113.6±12.8	70.7±9.5	<0.001

No.: number of cases with non-missing values, LL: lumbar lordosis, SS: sacral slope, SPT: spinopelvic tilt, PI: pelvic incidence, PFA: pelvic femoral angle, SD: standard deviation.

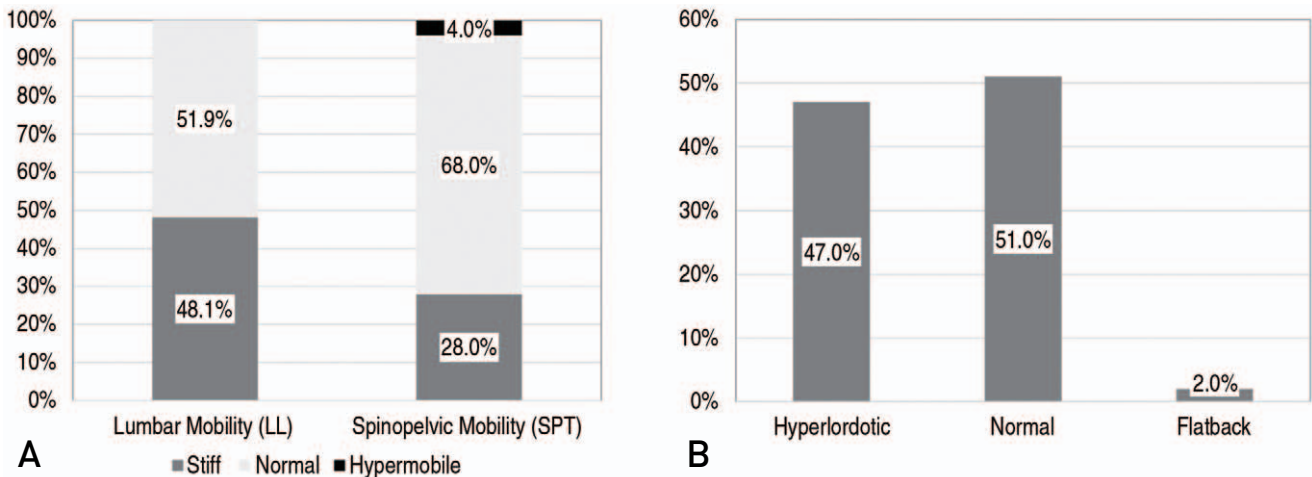


Fig. 2. (A) Distribution of femoroacetabular impingement (FAI) patients according to lumbar and spinopelvic mobility. Measurements of lumbar lordosis (LL) and spinopelvic tilt (SPT) were available in 27 and 50 cases, respectively. **(B)** Distribution of FAI patients according to sagittal alignment.

Table 3. Correlation between Radiological Parameters of the Spinopelvic Complex and Hip Function with Modified Harris Hip Score

Parameters of spinopelvic complex	No. of observations	Spearman coefficient	P-value
LL standing	51	0.100	0.483
SS standing	52	0.169	0.231
SPT standing	50	0.031	0.829
PI standing	50	0.104	0.472
PFA standing	14	0.066	0.822
LL sitting	27	0.028	0.889
SS sitting	52	0.138	0.330
SPT sitting	52	-0.063	0.656
PI sitting	52	0.144	0.307
PFA sitting	52	-0.062	0.661
ΔLL	27	0.049	0.805
ΔSS	52	-0.117	0.409
ΔSPT	50	-0.119	0.409
ΔPFA	14	-0.286	0.321

No.: number of cases with non-missing values, LL: lumbar lordosis, SS: sacral slope, SPT: spinopelvic tilt, PI: pelvic incidence, PFA: pelvic femoral angle.

patient-reported outcomes measures (PROMs) to determine their relationship with hip function have been conducted. The results of this study indicated that LL, SS, SPT, PI, and PFA values did not show correlation with perceived functional disability in patients with FAI. This finding is similar to that reported in patients with advanced osteoarthritis of the hip, for whom similar scores on preoperative PROMs have been reported according to the type of spinopelvic mobility¹⁴.

Although we found no direct relationship between lumbar mobility (Δ LL [°]) and hip function, a greater range of lumbar mobility has been associated with a decrease in

pelvic tilt or anteversion, resulting in a lower functional demand on the hip joint¹⁵. Patients with greater lumbar mobility are also known as “spine users”, who, according to one hypothesis, may be endowed with a protective effect against the risk of hip injury. For example, as suggested by Fader et al.⁵, even patients with radiographic FAI who have optimal lumbar mobility may remain pain-free, with avoidance of excessive hip flexion and, consequently, the onset of pain. In addition, an association of lumbar stiffness with higher complications rates following total hip replacement, such as wear and dislocation of the prosthesis, has been reported^{16,17}.

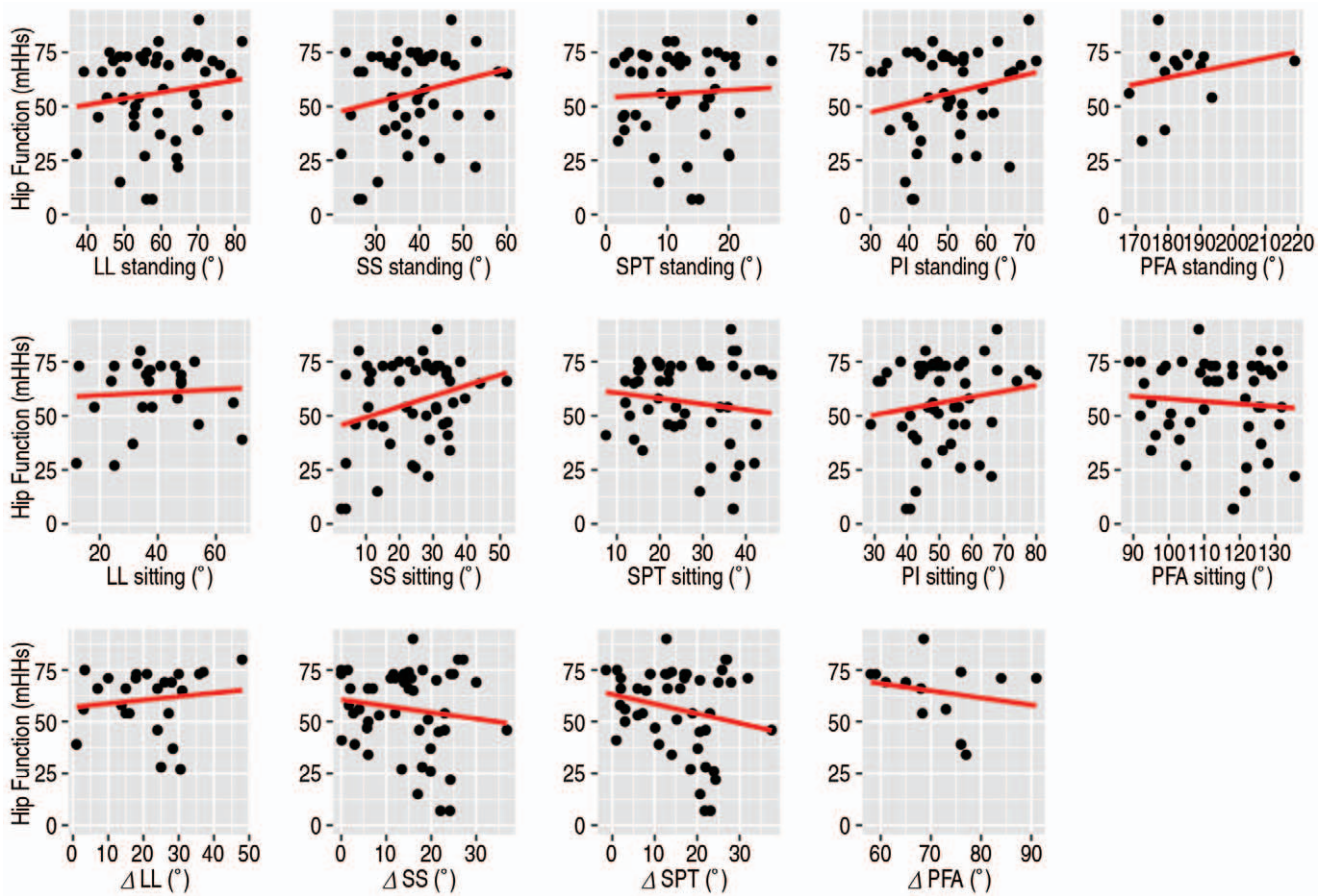


Fig. 3. Correlation plot for the relationship between hip function at diagnosis and spinopelvic parameters. The red line represents the trend line using linear regression analysis. mHHS: modified Harris hip score, LL: lumbar lordosis, SS: sacral slope, SPT: spinopelvic tilt, PI: pelvic incidence, PFA: pelvic femoral angle.

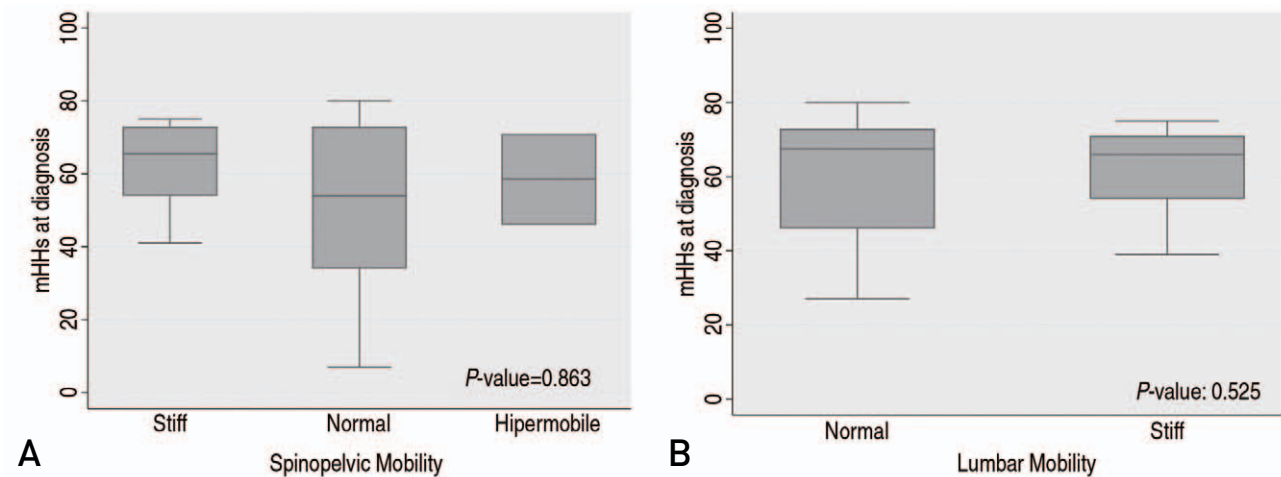


Fig. 4. (A) Boxplot showing the values of modified Harris hip score (mHHS) according to the classification of spinopelvic mobility. (B) Boxplot showing the values of mHHS according to lumbar mobility.

In this study, abnormal mobility of the spinopelvic complex was detected in one third of FAI patients at diagnosis,

with a stiffness pattern predominating in most cases. No specific pattern of spinopelvic mobility has been described

in patients with advanced osteoarthritis of the hip, with an equal percentage of stiff or hypermobile patterns (~20%)¹⁾. However, compared to patients without osteoarthritis of the hip, the percentage of patients with a hypermobile pattern is higher, which has been interpreted as a compensatory mechanism for more posterior tilting of the pelvis to match the reduced range of hip flexion.

Several studies evaluating the influence of the spinopelvic complex on the clinical outcomes after total hip replacement have been reported¹⁶⁾. However, thorough study of functional outcomes after hip arthroscopy and their relationship to parameters of the spinopelvic complex in cases of FAI has not been conducted. Jimenez et al.¹⁸⁾, in a study of 51 patients who underwent hip arthroscopy at one-year follow-up, reported that lumbopelvic mobility is not a predictor of worse functional outcomes based on the dynamics of SS during position changes ($\Delta SS < 10^\circ$). However, SPT and LL may be better indicators of pelvic and lumbar motion, respectively, thus this finding should be interpreted with caution¹⁾. In addition, through conduct of a case-control study, Beck et al.¹⁹⁾ reported lower PROMs scores at two-year follow-up in FAI patients with a history of lumbar pathology compared to FAI patients without spinal pathology, indicating that lumbar mobility could be considered a poor prognostic factor in FAI patients treated with hip arthroscopy¹⁹⁻²¹⁾.

This study has several limitations. First, measurement of parameters of interest could not be performed due to the retrospective nature of this study and the quality of the radiological images in all patients, which decreased the sample size and the statistical power. Nonetheless, these findings denote a starting point in the effort to attain a more in depth understanding of the role of the spinopelvic complex in FAI. Second, computation of a prior sample size was not performed in this study. However, the number of patients included is sufficient for detection of a strong correlation of at least 0.70 with a power of 80% and a one-sided level test of 5%. Third, no stratified analyses according to the type of FAI were performed because the sample size was not large enough.

CONCLUSION

Radiological parameters of the spinopelvic complex in patients with symptomatic FAI did not show correlation with hip function at diagnosis. However, conduct of further studies will be required in the effort to understand the effect of the spinopelvic complex and its compensatory mechan-

ics, primarily between the hip and spine, in patients with FAI before and after hip arthroscopy.

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CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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Appendix 1. Interobserver Agreement of Radiological Measurements of the Spinopelvic Complex

Parameters of the spinopelvic complex	Interobserver agreement CCC (95% CI)
SS	0.904 (0.834-0.974)
LL	0.863 (0.767-0.958)
SPT	0.931 (0.879-0.982)
PI	0.934 (0.886-0.983)
PFA	0.873 (0.784-0.962)

CCC: concordance correlation coefficient, CI: confidence interval, SS: sacral slope, LL: lumbar lordosis, SPT: spinopelvic tilt, PI: pelvic incidence, PFA: pelvic femoral angle.