

# EFFECTS OF HIP FLEXION CONTRACTURE ON SAGITTAL SPINOPELVIC PARAMETERS

## INFLUÊNCIA DA CONTRATURA EM FLEXÃO DO QUADRIL SOBRE OS PARÂMETROS ESPINOPÉLVICOS

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### ABSTRACT

**Objective:** To assess the influence of hip flexion contracture on lumbar lordosis and spinopelvic parameters and the changes in these parameters after total hip arthroplasty (THA). **Methods:** Twenty adult patients with hip osteoarthritis were divided into two groups (ten patients with hip flexion contracture and ten without contracture). Patients were assessed preoperatively and six months after THA using the radiographic parameters sagittal vertical axis (SVA), lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). **Results:** No statistical difference was found between pre- and postoperative LL values in the groups. After THA, both groups had increased PT and the group without hip flexion contracture had reduced SS. **Conclusion:** Patients with hip osteoarthritis and hip flexion contracture tend to have an increased LL in the orthostatic position compared to patients without contracture, but with no statistical significance. After THA, PT increased in both groups and SS decreased in patients without hip contracture. Studies should further investigate the role of hip flexion contracture on pelvic mobility and spinopelvic parameters to better understand these relations. **Level of Evidence III, Case-Control Study.**

**Keywords:** Postural Balance. Spine. Hip. Pelvis.

### RESUMO

**Objetivo:** Avaliar a influência da contratura em flexão da articulação do quadril sobre a lordose lombar, parâmetros espinopélvicos e as alterações desses parâmetros após a artroplastia total do quadril (ATQ). **Métodos:** Vinte pacientes adultos com artrose do quadril e indicação de ATQ foram divididos em dois grupos, sendo 10 pacientes com contratura em flexão da articulação do quadril e 10 sem contratura. Os pacientes foram avaliados no pré-operatório e seis meses após a realização da ATQ, através dos seguintes parâmetros radiográficos: eixo vertical sagital (SVA), lordose lombar (LL), incidência pélvica (PI), inclinação do sacro (SS) e versão da pelve (PT). **Resultados:** Não foi observado diferença estatística entre os valores da LL pré e pós-operatória nos grupos avaliados. Após a realização da ATQ, houve um aumento da PT nos dois grupos, e redução da SS somente no grupo de pacientes sem contratura em flexão do quadril. **Conclusão:** Os pacientes com artrose do quadril e contratura em flexão da articulação do quadril apresentam tendência para uma LL aumentada na posição ortostática comparado aos pacientes sem contratura, porém sem significância estatística. Após a realização da ATQ foi observado aumento da PT em ambos os grupos e redução da SS nos pacientes sem contratura em flexão da articulação do quadril. O papel da contratura em flexão do quadril na mobilidade da pelve e nos parâmetros espinopélvicos deve ser estudado com maior profundidade para melhor compreensão destas relações. **Nível de Evidência III, Estudo de Caso-Control.**

**Descritores:** Equilíbrio Postural. Coluna Vertebral. Quadril. Pelve.

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### INTRODUCTION

The static and dynamic interaction of the spine, pelvis, and lower limbs is responsible for the sagittal balance of the body and an upright posture. These segments suffer mutual alterations and the concept that hip muscle contractures affect the lumbar spine and the sagittal balance of the spine has been universally accepted despite lacking scientific evidence.<sup>1-3</sup>

The interaction between the spine, pelvis, and lower limbs was widely disseminated after Legaye et al.<sup>4</sup> objectively described the angles representing the spinal parameters, the mathematical relationship between the spinal parameters (pelvic incidence = pelvic tilt + sacral slope), and the association of lumbar lordosis with these parameters.<sup>4</sup> The sagittal balance of the spine and its correlation with spinopelvic parameters guide modern spinal

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The study was conducted at the Outpatient Clinic of Orthopedics-Spine of the Hospital das Clínicas de Ribeirão Preto of the Universidade de São Paulo. Correspondence: Rômulo Pedroza Pinheiro. Avenida Bandeirantes, 3900, Ribeirão Preto, SP, Brazil, 14049900. [romulopinheiro@usp.br](mailto:romulopinheiro@usp.br)

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and hip surgery – particularly total hip arthroplasty (THA) – and several studies have reported its influence on the results of surgical treatment.<sup>5,6</sup>

Patients with previous lumbar spinal fusion have presented greater late dislocation of the prosthesis (6%) than other patients (1.6%), motivating the study of spinopelvic mobility and its relationship with spinopelvic parameters.<sup>6-8</sup> This is likely because those subjected to lumbar spinal fusion cannot retrovert the pelvis in the sitting position, thus reducing acetabular anteversion and leading to dislocation.<sup>7,8</sup> Several studies have shown how spinopelvic mobility is essential for the transition from orthostatic to sitting position since it promotes pelvic retroversion and acetabular anteversion to accommodate the head of the femur, influencing the dislocation of THA components.<sup>6,8-10</sup>

Hip arthrosis causes pain and limits joint movements, possibly resulting in hip flexion contracture, which is classically assessed by the Thomas test.<sup>7,9</sup> Hip contracture can then increase lumbar lordosis and affect spinopelvic parameters by reducing sacral slope, increasing pelvic tilt, and reducing thoracic phosis.<sup>6,9</sup>

This study's object of interest was hip flexion contracture in patients with arthrosis and subjected to THA. The literature has reported on the interaction between hip joint and spine and the changes in spinopelvic parameters,<sup>7,9,11</sup> but the behavior of lumbar lordosis in patients subjected to THA is still unclear.

This study aimed to assess and compare lumbar lordosis and spinopelvic parameters in patients with unilateral hip osteoarthritis (with and without flexion contracture of the affected joint) and before and after THA.

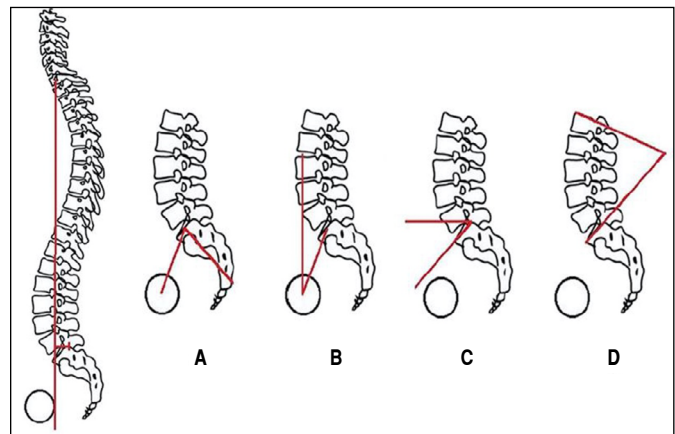
## MATERIALS AND METHODS

This study was approved by the Research Ethics Committee of the Hospital das Clínicas of Faculdade de Medicina de Ribeirão Preto under no. 4.531.372. The study was retrospective and observational. Twenty patients who met the inclusion criteria were randomly allocated, being ten patients with hip flexion contracture (positive Thomas test) before surgery and ten patients without hip flexion contracture (negative Thomas test) also before surgery. The study's inclusion criteria were adult patients (over 18 years old) of both sexes with hip arthrosis subjected to primary total arthroplasty and with no spinal deformities, no previous spinal or hip surgery, and no hip flexion contracture (negative Thomas test) after surgery. All patients included in the study signed an informed consent form.

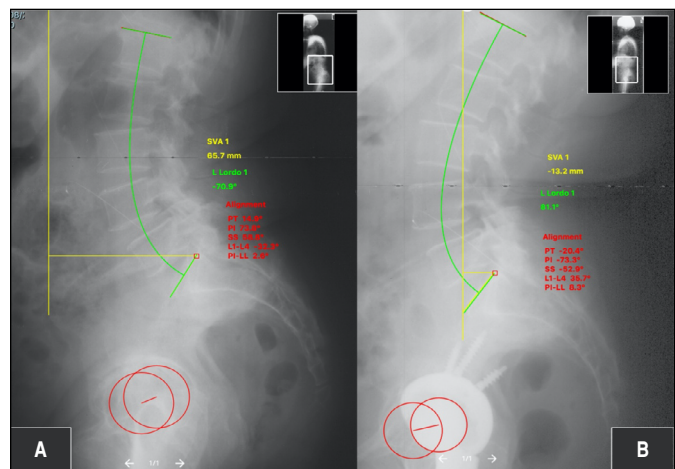
Hip joint contracture was assessed by the Thomas test preoperatively and six months after THA surgery. Patients with and without hip flexion contracture before surgery were divided into two groups to compare the parameters selected.

Radiographic assessment was performed using panoramic radiographs of the spine obtained in anteroposterior and lateral projections preoperatively and six months after THA surgery. Radiographs were conducted with the patient in the standardized position: standing position with hips and knees extended, upper limbs flexed at 30°, and elbows slightly flexed to place the upper limb on the support.

The radiographic parameters selected for the study were sagittal vertical axis (SVA), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) (Figures 1 and 2). Clinical and radiographic parameters were assessed independently by two study participants. The images were analyzed individually and the radiographic parameters selected were measured using the SURGIMAP software (Nemaris Inc., NY)



**Figure 1.** Drawing illustrating the radiological parameters assessed: the image on the left represents the sagittal vertical axis; image A represents pelvic incidence (PI); image B represents pelvic tilt (PT); image C represents the sacral slope (SS); and image D represents lumbar lordosis (LL).



**Figure 2.** Pre- (a) and postoperative (b) lateral radiographs illustrating the radiological parameters assessed.

Descriptive statistical analysis was performed for quantitative variables (mean, standard deviation). Pearson's correlation coefficient was used to assess the reliability degree of the measurements of the two evaluators. The radiographic parameters were compared using Student's *t*-test and the significance level of 5% ( $p < 0.05$ ) was established.

## RESULTS

Table 1 shows the demographic data of patients and results of the assessed parameters. Thirteen patients (65%) were male and seven (35%) were female. The age of the patients ranged from 42 to 71 years ( $59.35 \pm 8.56$  years). In the group of patients without hip contracture, age ranged from 42 to 69 years (mean  $57.7 \pm 9.11$  years); in the group with hip flexion contracture, age ranged from 49 to 71 years (mean  $61 \pm 8.11$  years).

Hip flexion contracture assessed using the Thomas test ranged from 10 to 30° (mean  $18 \pm 7.88^\circ$ ) in the preoperative assessment and the Thomas test was negative in all patients in the 6-month postoperative assessment (Table 1).

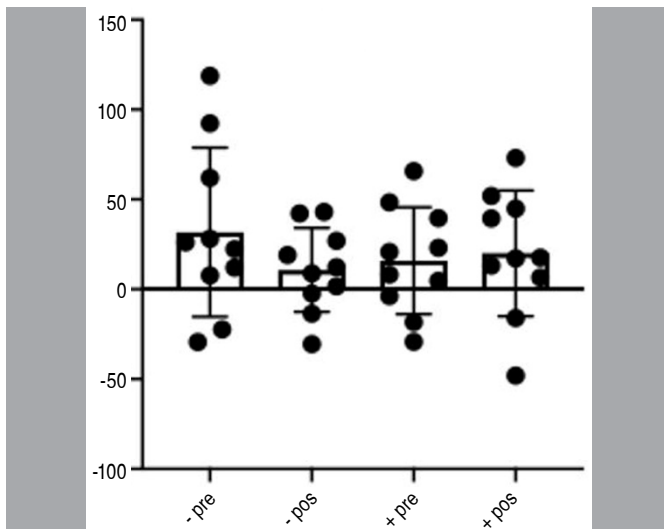
A high degree of correlation ( $> 0.9$ ) (Pearson's Coefficient) was found between the radiographic parameter measurements of the two evaluators using the SURGIMAP software (Surgimap – New York, USA).

**Table 1.** Demographic data of patients and assessed parameters.

Patient	Contracture	Preoperative					Postoperative				
	Degrees	SVA	PI	PT	SS	LL	SVA	PI	PT	SS	LL
1	0	12	58	3.4	54.7	69.9	12.3	56.4	8.4	48	68.1
2	0	118.8	79.6	31.9	47.8	52.4	42.1	83.9	37.1	46.8	55.7
3	0	-29.4	40.9	1.1	39.8	60.1	-13.6	44.2	4.6	39.6	61
4	0	-22.4	48.6	4.2	44.4	64	8.9	52.8	6.3	46.6	60.3
5	0	92.3	58	13.9	44.1	50.2	43.1	61.3	18	43.3	49
6	0	26.1	34.3	-8.4	42.7	47.2	-2.3	35.9	3.7	32.2	41.6
7	0	62	42.6	4	38.6	51	1.6	45.7	14.1	31.6	52
8	0	7.7	40.1	-4.9	45	63.8	-30.6	40.4	-2.3	42.7	70.9
9	0	22.3	41.3	16.9	24.4	43.4	19.1	48.6	26.9	21.7	41.5
10	0	28.1	54.9	11.3	43.6	63.2	26.9	56.4	14.9	41.5	62.8
11	20	4.7	46.9	-7.2	54.2	69.9	39.5	48.2	13	35.2	62.9
12	30	23.1	50.1	8.5	41.6	68.9	73.1	62.3	15.1	47.2	65.7
13	10	8.1	50.2	17.4	32.9	49.3	6.6	54.8	27.9	26.8	47.7
14	10	-3.8	63.4	7.1	56.3	72.3	-16	65.1	16.8	48.4	72
15	20	-29.3	24.2	-12.7	37	52.5	-48	21.9	-14.1	36	58.3
16	30	39.6	40	-1.1	41.1	52.1	17.6	45.7	1.8	43.9	53.5
17	20	20.7	52.5	1.3	51.1	77.3	44.9	54.5	7.4	47.1	70.7
18	20	48.4	33.5	14.5	19	18.5	51.9	33.3	16.2	17.1	19.7
19	10	-18.3	68.1	14.5	53.7	81.1	17.2	63.2	13.2	50	76.6
20	10	65.7	73.8	14.9	58.8	70.9	13.2	73.3	20.4	52.9	81.1

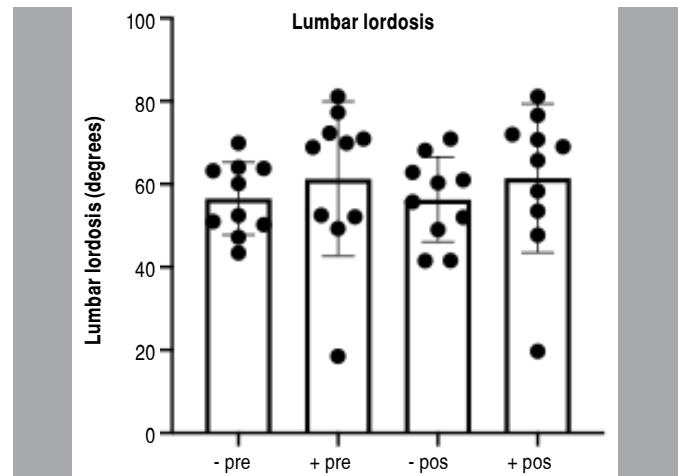
SVA: sagittal vertical axis; PI: pelvic incidence; PT: pelvic tilt; SS: sacral slope; LL: lumbar lordosis

The sagittal vertical axis corresponds to the distance from the vertical plumb line that passes through the center of C7 to the rear edge of S1. This parameter is age-dependent and values under or equal to 5 mm are considered normal.<sup>12</sup> In the preoperative period, the SVA ranged from -29.4 to 118.8 mm (mean  $31.75 \pm 47.06$  mm) in the group without hip flexion contracture and from -29.3 to 65.7 mm (mean  $15.89 \pm 29.73$  mm) in the group with hip flexion contracture. Postoperatively, the SVA ranged from -30.6 to 43.1 mm (mean  $10.75 \pm 23.38$ ) in the group without hip flexion contracture and from -48 to 73.1 mm (mean  $20 \pm 34.95$  mm) in the group with hip flexion contracture. No statistical difference was found between the pre- and postoperative SVA values in the groups assessed (Table 1 and Figure 3).



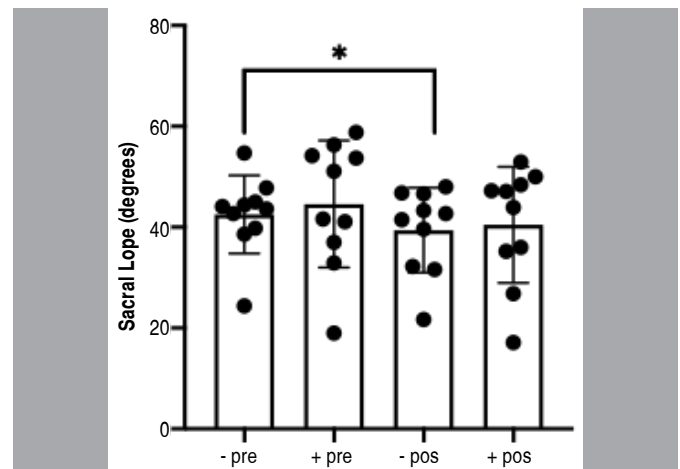
**Figure 3.** Values of the sagittal vertical axis (in millimeters) in the group of patients with (+) and without (-) hip flexion contracture pre- and postoperatively. No statistical difference was observed between the groups ( $p > 0.05$  – Student's *t*-test).

Preoperatively, lumbar lordosis ranged from 43.4 to 69.9° (mean  $56.52 \pm 8.76^\circ$ ) in the group of patients without hip flexion contracture and from 18.50 to 81.1° (mean  $61.28 \pm 18.65^\circ$ ) in the group with hip flexion contracture. Postoperatively, LL ranged from 41.5 to 70.9° (mean  $56.29 \pm 10.22^\circ$ ) in the group without hip flexion contracture and from 19.70 to 81.10° (mean  $61.43 \pm 17.93^\circ$ ) in the group with hip flexion contracture. No statistical difference was found between the pre- and postoperative LL values in the groups assessed (Table 1 and Figure 4).



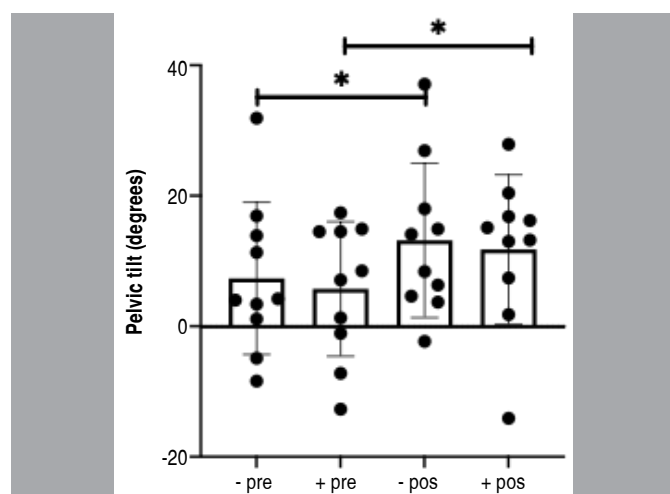
**Figure 4.** Lumbar lordosis values (in degrees) pre- and postoperatively in the group of patients with (+) and without (-) hip flexion contracture. No statistical difference was observed between the groups ( $p > 0.05$  – Student's *t*-test).

The sacral slope is represented by the angle formed between the horizontal plane and the line of the upper surface of the first sacral vertebra (Figure 1). Preoperatively, LL ranged from 24.40 to 54.70° (mean  $42.51 \pm 7.75^\circ$ ) in the group of patients without hip flexion contracture and from 19 to 58.80° (mean  $39.40 \pm 8.41^\circ$ ) in the group with hip flexion contracture. Postoperatively, LL ranged from 21.70 to 48° (mean  $39.40 \pm 8.41^\circ$ ) in the group without hip flexion contracture and from 17.10 to 52.90° (mean  $40.46 \pm 11.50^\circ$ ) in the group with hip flexion contracture. Statistical difference was observed between pre- and postoperative SS in the group of patients without hip flexion contracture ( $p < 0.05$  – Student's *t*-test). No statistical difference was observed between the other comparisons of SS among the groups studied (Table 1 and Figure 5).



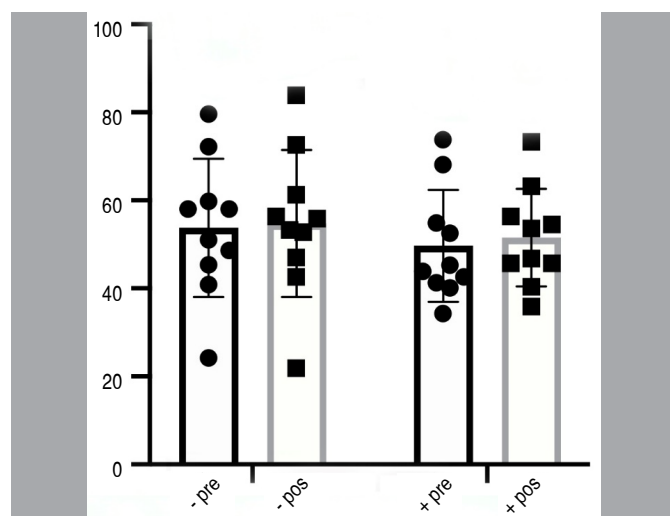
**Figure 5.** Sacral slope values (in degrees) pre- and postoperatively in the group of patients with (+) and without (-) hip flexion contracture. The asterisk (\*) indicates statistical difference ( $p < 0.05$  – Student's *t*-test).

The pelvic tilt is represented by the angle between the vertical line and a line that unites the center of the femoral heads with the center of the sacral vertebrae. Preoperatively, LL ranged from  $-8.40$  to  $31.90^\circ$  (mean  $7.34 \pm 11.67^\circ$ ) in the group without hip flexion contracture and from  $-12.70$  to  $17.40^\circ$  (mean  $3.10 \pm 10.31^\circ$ ) in the group with hip flexion contracture. Postoperatively, PT ranged from  $-2.30$  to  $37.10^\circ$  ( $13.70 \pm 11.84^\circ$ ) in the group without hip flexion contracture and from  $-14.10$  to  $27.90^\circ$  (mean  $11.77 \pm 11.46^\circ$ ) in the group with hip flexion contracture. Statistical difference was observed (Table 1 and Figure 6) between the pre- and postoperative values of PT in the group of patients without hip flexion contracture ( $p = 0.0006$  – Student's *t*-test) and in the group with contracture ( $p = 0.0156$  – Student's *t*-test).



**Figure 6.** Pelvic tilt values (in degrees) pre- and postoperatively in the group of patients with (+) and without (-) hip flexion contracture. The asterisk (\*) indicates statistical difference ( $p < 0.05$  – Student's *t*-test).

Pelvic incidence is a morphological parameter defined as the angle between the line perpendicular to the upper edge of the first sacral vertebra at its midpoint and a line that connects this point to the center of the femoral heads. No statistical difference was found between the pre- and postoperative PI values in the groups assessed (Table 1 and Figure 7).



**Figure 7.** Pelvic incidence values (in degrees) pre- and postoperatively in the group of patients with (+) and without (-) hip flexion contracture. No statistical difference was observed between the groups ( $p > 0.05$  – Student's *t*-test).

## DISCUSSION

Patients with positive Thomas test (indicating hip flexion contracture) had higher mean lumbar lordosis values pre- and postoperatively than patients with negative Thomas test. However, no statistical difference was observed between the groups, requiring a cautious interpretation of the results. Hip flexion contracture has been considered responsible for increasing lumbar lordosis in ambulatory patients with neurological disease despite the lack of reliable evidence.<sup>1</sup> Patients with arthrosis and hip flexion contracture cannot tilt and physiologically move the pelvis while standing, which could increase lumbar lordosis.<sup>9</sup> Patients with hip arthrosis had increased lumbar lordosis in the orthostatic position<sup>13</sup>, but other authors did not observe this relationship.<sup>9,14,15</sup> Arthrosis patients can adapt the lumbar spine by increasing lumbar lordosis to compensate for the loss of hip extension.<sup>7,9,16</sup> The amplitude of the hip joint extension allows assessing the movements of the hip and understanding the adaptation mechanism of the spinal complex, considering that the lumbar lordosis does not increase in all individuals with hip flexion contracture but depends on one's ability to adapt the lumbar spine.<sup>7,9,16</sup>

Lumbar lordosis was equal in both groups after THA, corroborating another national study.<sup>11</sup> This result was unexpected after hip mobility restoration, being likely caused by degenerative changes in the lumbar spine from increasing age, which reduce mobility<sup>17</sup>. Lumbar spine stiffness has been described for individuals over 65 years old, with increased prevalence after 75 years old.<sup>5,14,18</sup>

Lumbar lordosis values showed no statistical difference after THA; however, PT showed statistical difference in both groups and SS had statistical difference in the group without hip flexion contracture. Total hip arthroplasty restores the movements of the hip joint and the anterior pelvic rotation in the orthostatic position, corresponding to the increased PT and reduced SS observed. The literature has widely reported on the readaptation of the pelvic parameters after THA<sup>11,19,20</sup>, usually showing how limited hip movement hinders posterior pelvic rotation, reducing PT.<sup>5,7,9</sup> However, few studies have assessed the effects of hip flexion contracture on these parameters. Reduced thoracic kyphosis is the additional mechanism of patients with limited lumbar spine and hip arthrosis to compensate for hindered posterior pelvic rotation, and sagittal imbalance of the spine occurs when all compensation mechanisms are insufficient.<sup>9,14,15</sup> Sagittal vertical axis assessment also expresses the interaction between the hip, pelvis, and lumbar spine. Patients with more severe hip arthrosis have shown higher SVA values than patients with lighter degrees of the disease.<sup>9</sup> Sousa et al.<sup>11</sup> also observed that patients with hip arthrosis had higher SVA values than patients without hip joint disease. No statistical difference was observed in our group of patients, but the group studied was small. Patients without hip flexion contracture tended to have higher mean and greater variation of SVA values and greater reduction of these values after THA.

This study has limitations, including sample size, assessment in the orthostatic position only, and the non-inclusion of radiographic parameters related to hip flexion contracture (pelvic-femoral angle, femoral version angle), which have been used for complementary assessment of hip range of motion.<sup>7,10</sup> Despite these limitations, the study addresses an unexplored topic in the study of spinal and hip arthrosis mobility, presenting preliminary results that could motivate further studies on spinopelvic mobility.

The complexity of the interaction between the lumbar spine, the pelvis, and the hip increases with the divergent results in the literature. The available scientific evidence on the influence of spinopelvic mobility on the results of THA, especially regarding stability, reinforces the need to better understand all parameters involved. To date, studies on spinopelvic mobility and its influence



on THA have not focused enough on hip flexion contracture, which should be considered as an additional parameter in this scenario.

## CONCLUSION

Patients with hip arthrosis and hip flexion contracture are more likely to have increased LL in the orthostatic position than patients

without contracture; however, our results showed no statistical significance. After THA, both groups had increased PT and patients without hip flexion contracture had reduced SS. Further studies should focus on the effects of hip flexion contracture on pelvis mobility and spinopelvic parameters to better understand these relationships.

**AUTHORS' CONTRIBUTIONS:** Each author contributed individually and significantly to the development of this article. RPP: data collection and analysis, writing of the article, project review, intellectual concept, and article review; MPD: data collection and analysis, writing of the article, project review, intellectual concept, and article review; FLG: study design, data analysis, and project review.

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