Clinical and radiological assessment of lumbopelvic region to find out hamstring versus iliopsoas contracture or both in spastic cerebral palsy

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Introduction
In cerebral palsy, hamstring contracture is the most prevalent issue. Knee flexion contractures follow if treatment is not received. A typical issue with diplegic cerebral palsy is hamstring tightness, which can lead to a crouching gait.

Aim
To evaluate the hamstring contracture through clinical and radiological assessment of lumbopelvic region.

Patients and methods
This descriptive cross-sectional study design included 30 patients with true hamstring tightness. Every patient underwent the following procedures: a history was obtained; a local clinical examination; an observational gait assessment; an evaluation of gross motor functions; and a radiological assessment that included obtaining plain radiographs of the pelvis and lumbar spine.

Results
Two thirds of the cases had growth motor function (GMF) III, and the other third had GMF II, and that the most common gait was crutch gait (36.7%), followed by jump gait (33.3%), then equines gait (16.7%) and only four (13.3%) cases had normal gait. The vast majority of the cases had pelvic tilt (anterior in 60% of the cases and posterior in 13.3% of them) while only eight (26.7%) cases were normal with no tilt. And most of the cases (60%) had decreased sacro-femoral angle, and another four (13.3%) cases had decreased sacro-femoral angle. Only eight (26.7%) cases of the cases were normal. Two thirds of the cases had abnormal lumbo-pelvic alignment (hyperlordotic in 16 cases; 53.3% and kyphotic in four cases; 13.3%). More than half of the cases had positive shift (53.3%), more than half of the cases had positive Thomas test, and all of the included cases had positive popliteal angle.

Conclusion
The majority of patients seem to be tight, and surgeons need to exercise caution to avoid overextending the hamstrings in order to prevent an increased anterior pelvic tilt.

Keywords:
Hamstring, iliopsoas, pelvic tilt, spastic, cerebral palsy

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Introduction

The main symptoms of cerebral palsy (CP) are abnormalities in posture and movement. According to its definition, it refers to a collection of motor impairment syndromes that are nonprogressive but frequently change because of early-stage brain lesions or abnormalities [1].

It has long been believed that, from a neurological perspective, CP is a static condition. When secondary and related illnesses develop in CP patients, they may worsen over time and result in unintended consequences [2,3].

The most prevalent kind of CP, accounting for 75% of occurrences, is spastic, whereas dyskinetic (15%) and ataxic instances make up fewer than 5% of cases [1].

Spasticity is the velocity-dependent increase in a muscle's resistance during passive or stretched movement. Due to focal muscle hyperactivity, people with spastic CP have stiffness in their affected limbs, which limits or causes uncomfortable movements [4].

In CP, hamstring stiffness is the most prevalent issue. Knee flexion contractures occur if treatment is not received [5].

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The main cause of crouching gait is tight hamstrings, which are frequently paired with a malformation of the hip flexors. Nonetheless, surgically extending the Achilles tendon may result in the development of a crouching gait. Numerous investigations have revealed that the hamstrings and iliopsoas muscles are often normal length in people with CP who have a crouching gait. In certain cases of crouch gait, the hamstrings appear shorter than they actually are because of a proximal shift in their origin caused by an excessive anterior pelvic tilt and increased hip flexion, which may be the result of an adopted trunk lean forward or contracture of the hip flexors [6].

Furthermore, because hamstring lengthening may exacerbate crouch gait by increasing anterior pelvic tilt and decreasing hip joint extension, some have questioned the necessity of this exercise. According to Hoffinger and colleagues, the majority of patients with crouch gait had hamstring lengths during stance phase that were longer than their resting lengths, and the hamstrings played a major role in hip extensor function during this phase. Thus, they recommended that in order to minimize an increased anterior pelvic tilt, surgeons should exercise caution while overextending their hamstrings and think about lengthening the iliopsoas [7].

Aim

To evaluate the hamstring contracture through clinical and radiological assessment of lumbopelvic region.

Patients and methods

Thirty individuals with spastic diplegic CP participated in this descriptive cross-sectional study design. Everybody experienced stiff hamstrings on both sides. Their average age is 8.644, with a range of 5.5–12.5 years. Of the patients, 17 (57%) were female, and 13 (43%) were male patients.

Out of the 16 (54%) cases with apparent hamstring tightness, 14 (46%) cases had actual hamstring tightness.

In order to get health insurance, cases were chosen at random from Sohag General Hospital, the pediatric orthopedic outpatient clinic of the Helwan Orthopedic Department, and the 6 October Hospital.

Ethical approval: The Helwan University Faculty of Medicine's Ethical Committee granted approval for the study procedure. Prior to data collection and following an explanation of the study's aims, informed consent was directly acquired from each parent participant included in the research.

Inclusion criteria

Diagnoses for CP were formerly made using imaging, clinical examination (delayed milestone, aberrant primitive reflexes), or history. Patients who met the specified requirements were added to the study:

(1) There were both male and female CP sufferers present.
(2) Patients with pure spastic CP (diplegic) or quadriplegic, affecting all four limbs, are the most affected.
(3) Patients who were ambulating [general motor cognitive status (GMFCS) levels I–III] were selected to ensure appropriate assessment when standing and walking.
(4) Symmetric hamstring stiffness on both sides with a popliteal angle measurement of at least 50°.

Exclusion criteria

Individuals who met any of the below criteria were not allowed to participate in the study:

(1) Those with hemiplegic CP.
(2) Patients who had procedures performed to repair abnormalities of the lower limbs.
(3) Those with dyskinetic and mixed types of CP.
(4) History of selective dorsal rhizotomy or soft tissue or bone surgery for gait correction.
(5) Asymmetry in the spine or pelvis in the frontal plain.

Neuromuscular and metabolic disorders apart from CP and Patients who had procedures performed to repair abnormalities of the lower limbs were not included.

Methodology

Every patient underwent the following procedures: a history was obtained; a local clinical examination; an observational gait assessment; an evaluation of GMFCS; and a radiological assessment that included obtaining plain radiographs of the pelvis and lumbar spine.

History taking

The patients' names, ages, and sexes were recorded. Next, a developmental achievement-focused developmental history was obtained, with an emphasis on sitting, crawling, standing, and walking.

The number of limbs afflicted (quadriplegic or diplegic), the frequency of baclofen use, and the frequency of physiotherapy sessions (twice a week) were assessed and recorded.

Observation gait analysis

For each example, observational gait analysis was tracked in the sagittal plane. Every case was observed while walking, either independently or with assistance, and the patient's gait was categorized into four types: apparent equinus (flexed knee and apparent tip toeing), crouch (flexed hip, flexed knee, and dorsiflexed ankle), jumping (flexed hip, flexed knee, and plantar flexed ankle).

Gross motor function classification system [8]

In order to assess motor performance, the GMFCS were used. The nonambulating patients (GMFCS IV, V) were omitted due to challenges in obtaining standing radiographs and assessing gait, while the ambulating patients (GMFCS I, II, III) were included.

Patient was categorized as GMFCS I if the kid can walk both inside and outdoors, climb stairs without assistance, and use gross motor abilities including running and leaping but with limited speed, balance, and coordination. The kid was categorized as having GMFCS II status if they were unable to walk in crowds or small places, walk both indoors and outdoors, and climb stairs while holding onto a railing. The kids were categorized as GMFCS III if they could use an assistive mobility equipment to walk on level surfaces both inside and outdoors, climb stairs while clinging to a rail, push a wheelchair by hand, or be carried over long distances or on uneven ground.

Local examination of back and lower limbs

Back assessment [9]

The child was placed in an erect position while the back was assessed to see if the lower back was normal (indicating normal pelvic position) or hyperlordotic (implying overstretched hamstrings and anterior pelvic tilt). Flat/kyphotic is linked to hamstring tightness and posterior pelvic tilt.

Popliteal angle measurement [10]

In a clinical setting, popliteal angle measurement was used to assess hamstring spasticity. The patient was placed on an examination table in a supine posture with the contralateral hip fully extended and the hip flexed to 90°. After that, the ipsilateral flexed knee was extended. The popliteal angle is the angle that forms between the vertical and the position at which the tibia may be stretched. When a youngster is 4 years old or older, their popliteal angles typically range from 0° to 49°, with a mean value of 26°. Popliteal angle values vary by sex and age, with boys having tighter popliteals than girls and both become tighter as people age, particularly during the teenage growth spurt. At any given age, values higher than 50° are regarded as abnormal.

A full-circle manual universal goniometer was used to measure popliteal angles and assess both knees. The side with the biggest angle was honored if there was an asymmetry between the two limbs.

Contralateral popliteal angle (modified popliteal angle) [10]

In order to assess the bilateral popliteal angle and level the pelvis, the contralateral hip must be flexed until the lumbar lordosis vanishes and the back becomes flat.

The youngster was assessed while in the supine position, with the ipsilateral hip flexed to 90° and the contralateral hip flexed to completely eliminate the impact of an anterior pelvic tilt. Next, the ipsilateral knee was extended, and a full-circle manual universal goniometer was used to measure the angle between the vertical plane and the maintained position.

A hamstring shift is defined as a considerably decreased popliteal angle after the pelvic position has been adjusted. The genuine hamstring contracture is measured by the popliteal angle with a neutral pelvis; the functional hamstring contracture is determined by the popliteal angle with lordosis eliminated. The degree of hamstring shift is shown by the differential between the two. Excessive anterior pelvic tilt is often indicated by a hamstring shift of more than 20°.

Thomas test [11]

To quantify hip flexion contracture, one might utilize the Thomas test. It suggests that either the hip extensor (hamstring) is relatively weak or that iliopsoas contracture is present. On the examination table, the patient was placed in a supine posture. To secure the pelvis against movement and flatten the lumbar spine's lordosis, the opposing hip was completely flexed. Typically, this examination is conducted with the inspected limb lying flat on a table. A positive Thomas test results from any degree of hip flexion during lumbar lordosis correction.

Since a contracture causes the hip to rise up in flexion off the table, the angle between the table and the concerned hip was then measured.

Radiological assessment

The pelvis is examined radiographically in both lateral and anteroposterior lumbar spine radiographs. The patient was standing when the lateral radiographs were obtained in order to determine the sacro-femoral angle (SFA) and the angle of lumbar lordosis. When taking the lateral radiographs, the patient was standing and bearing weight. The lumbar lordosis angle and the SFA were measured using a radiograph that was focused on the lumbar vertebra to the proximal third of the femur.

Angle of lumbar lordosis

The angle formed by the superior endplates of L1 and S1 is known as the lumbar lordosis angle. The mean lumbar lordosis angle ranges from 51° to ±10°. Two lines were drawn: one along L1's superior endplate and the other along S1's superior endplate. The lumbar lordosis angle (L1S1) is the angle formed by the two lines.

The pelvis is followed by the lumbar spine's attitude in the sagittal plane. It may be inferred that in the event of a posterior pelvic tilt, the lumbar spine will retract and the lumbar lordosis angle will drop; conversely, in the event of an anterior pelvic tilt, the lumbar spine will advance and the lumbar lordosis angle would rise.

Sacro-femoral angle

A standing lateral radiograph was obtained, showing the lumbar spine and the proximal femoral shaft. Two lines were drawn: one along the femoral shaft and the other along the superior surface of the sacrum (S1). The SFA was the point where these lines intersected; this angle should typically be between 45° and 65°.

The SFA decreases when a hip flexion contracture is present. Hip flexion contracture may be objectively measured using the SFA.

The statistical analysis examined the correlations between the SFA and hamstring shift, lumbar lordosis and hamstring shift, and the SFA and the angle lumbar lordosis. Additionally, the impact of muscle imbalance on these angles was assessed.

Statistical analysis

For the purpose of analyzing statistical data, IBM-SPSS, version 24 (Armonk, NY: IBM Corp.), which was released in May 2016, was utilized.

Information presented as mean, number, percentage, and SD. For quantitative data, the descriptive values were mean and SD; for qualitative data, the descriptive values were number and percentage.

The means of the two groups were compared using the Student *t* test. The percentages of the qualitative data were compared using Pearson χ^2. Three explanations are available for the degree of significance (*P* value): no significance *P* value more than 0.05, significance *P* value less than 0.05, and strong significance *P* value less than 0.001.

Results

Table 1 shows that the mean age of the study population was 8.6 years, with a range from 5.5 to 12.5 years, and more than half of the cases were females (56.7%) while only 13 (43.3%) cases were males.

Table 2 shows that two thirds of the cases had GMF III, and the other third had GMF II, and that the most common gait was crutch gait (36.7%), followed by jump gait (33.3%), then equinus gait (16.7%) and only four (13.3%) cases had normal gait.

The vast majority of the cases had tilt (anterior in 60% of the cases and posterior in 13.3% of them) while only eight (26.7%) cases were normal with no tilt. And most of the cases (60%) had decreased SFA, and another four (13.3%) cases had decreased SFA. Only eight (26.7%) cases of the cases were normal (Figs 1 and 2).

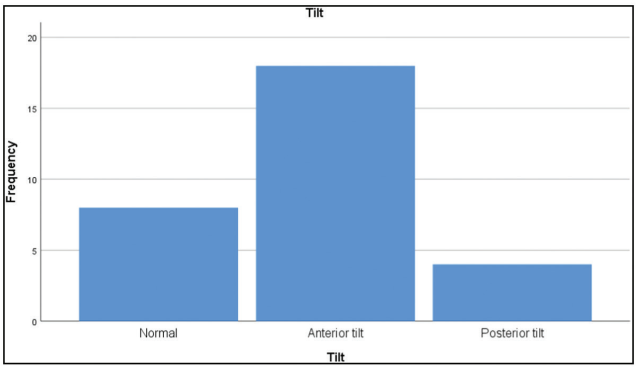
Table 1 Demographic characteristics of the study patients

Age	
Mean	8.633
Median	8.500
SD	2.0622
Minimum	5.5
Maximum	12.5
Sex	
Male	13
Female	17
Total	30

Table 2 Gross motor function and gait

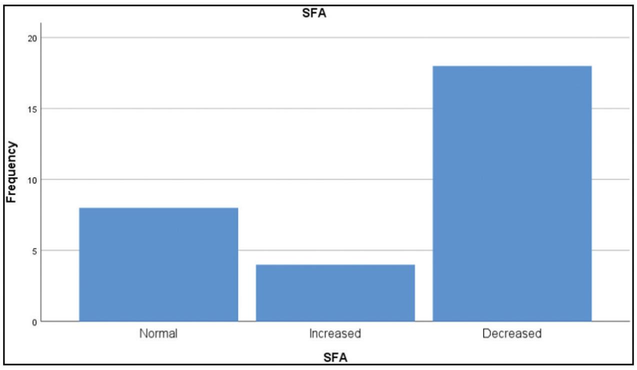
	n (%)
Gross motor function	
II	10 (33.3)
III	20 (66.7)
Total	30 (100.0)
Gait	
Normal	4 (13.3)
Jump	10 (33.3)
Crouch	11 (36.7)
Equinus	5 (16.7)
Total	30 (100.0)

Figure 1



Tilt. This figure shows that the vast majority of the cases had tilt (anterior in 60% of the cases and posterior in 13.3% of them) while only eight (26.7%) cases were normal with no tilt.

Figure 2



Sacro-femoral angle (SFA). This figure shows that most of the cases (60%) had decreased SFA, and another four (13.3%) cases had decreased SFA. Only eight (26.7%) cases of the cases were normal.

In Table 3, two thirds of the cases had abnormal lumbo-pelvic alignment (hyper lordotic in 16 cases; 53.3% and kyphotic in four cases; 13.3%).

Table 4 shows that more than half of the cases had positive shift (53.3%), more than half of the cases had positive Thomas, and all of the included cases had positive popliteal angle.

Discussion

Ataxic is fewer than 5% of instances, dyskinetic is 15%, and spastic CP is the most frequent, accounting for 75% of all cases [1].

Spasticity is the velocity-dependent increase in a muscle's resistance during passive or stretched movement. Because of focal muscle hyperactivity, people with spastic CP have stiffness in their afflicted limbs, which limits or causes uncomfortable motions [2,3].

In CP, hamstring stiffness is the most prevalent issue. Knee flexion contractures follow if treatment is not received. A typical issue with diplegic CPs is hamstring stiffness, which can lead to a crouching gait. In addition, surgical hamstring release may exacerbate crouching by elevating anterior pelvic tilt, particularly in patients with hip flexor rigidity [12].

The primary cause of crouching is tightened hamstrings, which are frequently paired with a malformation of the hip flexors. Crouch gait, however, might appear as a result of surgically extending the Achilles tendon or from triceps surae weakness. Numerous investigations have revealed that the hamstrings and iliopsoas muscles are often normal length in people with CP who have a crouching gait. In certain cases of crouch gait, the hamstrings appear shorter than they actually are because of an excessive anterior pelvic tilt that

Table 3 Radiological lumbopelvic parameters

	n (%)
Radiology	
Normal	10 (33.3)
Hyperlordotic	16 (53.3)
Kyphotic	4 (13.3)
Total	30 (100.0)

Table 4 Hamstring shift, Thomas test, and popliteal angle

	n (%)
Hamstring shift	
Negative	14 (46.7)
Positive	16 (53.3)
Total	30 (100.0)
Thomas test	
Negative	12 (40.0)
Positive	18 (60.0)
Total	30 (100.0)
Popliteal angle	
Negative	0
Positive	30 (100.0)
Total	30 (100.0)

causes their origin to shift proximally. This increased hip flexion can be caused by either an adopted trunk leans forward or a contracture of the hip flexors [6].

Furthermore, because hamstring lengthening may exacerbate crouch gait by increasing anterior pelvic tilt and decreasing hip joint extension, some have questioned the necessity of this exercise. According to Hoffinger *et al.* [13], the majority of patients with crouch gait had hamstring lengths during stance phase that were longer than their resting lengths, and the hamstrings played a major role in hip extensor function during this phase. Thus, they recommended that in order to minimize an increased anterior pelvic tilt, surgeons should exercise caution while overextending their hamstrings and think about lengthening the iliopsoas. However, for those with neurological impairments, spasticity is not always a bad thing. It could serve as a brace to support the person's weight as they walk or transfer. Therefore, in order to create a clear aim for managing spasticity, a thorough examination and motion analysis are necessary. This process should begin as soon as possible to avoid irreversible alterations in the musculoskeletal system that might further distort the biomechanics of movement.

True or apparent hamstring tightness are the two types of hamstring muscle tension seen in CP patients. Numerous writers have demonstrated that the majority of hamstring tightness situations are noticeable when the hamstring is of normal length [6].

Because of the anterior migration of its origin and the anterior pelvic tilt, the hamstring appears short. The majority of CP patients have an anterior pelvic tilt, which results from abnormalities in the balance of the muscles in the lumbar, pelvic, and hip areas [14].

Both ambulatory and non-ambulatory patients with CP frequently have increased anterior pelvic tilt. The pelvic tilt is influenced by both suprapelvic and infrapelvic variables. Tight hip flexors are the most frequent infrapelvic cause of elevated anterior pelvic tilt [15].

A further reason for infrapelvic pain is weakening in the hamstrings and hip extensors. One of the suprapelvic causes of CP is severe weakening of the abdominal muscles, which is less prevalent in children with CP than in many other neurologic illnesses. Another influence is the erector spinae's tightness [16].

The goal of this work is to evaluate the hamstring contracture through clinical and radiological assessment of lumbopelvic region. According to our research, hamstring tightness was evident in the majority of instances of knee flexion deformity (popliteal angle >50°). In actuality, this was verified radiologically by reduced SFA in 60% of instances and hyperlordotic lumbar spines in 52% of cases, as well as clinically by positive Thomas tests in 68% of cases.

The following three groups of cases will be examined in relation to the role of pelvic obliquity in decision making in patients with hamstring tightness in CP patients:

(1) Cases when the buttocks and lumber spine seem flat, the hamstrings are tight (positive popliteal angle of 50°), and the hamstring shift test (negative modified popliteal angle test) is negative. When the lumber pelvic hip complex is radiologically assessed, the lumber spine is flat, and the posteriorly tilted pelvis in these situations indicates actual hamstring tightness.
(2) Patients with hamstring strain (popliteal angle 50°), negative hamstring shift, positive Thomas test, and normal lumber spine appearance. A normal pelvis and lumber spine are revealed by radiological evaluation of the lumbopelvic hip complex. These instances show tense hamstring and iliopsoas muscles.
(3) Cases with hamstring tightness (positive popliteal angle of 50°) with positive hamstring shift test 20° (positive modified popliteal angle) with positive Thomas test with lumber spine looks hyperlordotic and buttocks prominent.

The hyperlordotic lumber spine and anteriorly tilted pelvis are shown by radiological examination of the lumber pelvic hip complex. These instances seem to indicate hamstring stiffness. The population under investigation had a mean age of 8.6 years, according to the current study. A 56.7% of the cases involved females. GMF III was present in two thirds of the cases, and GMF II in the remaining third.

Crutch gait accounted for 36.7% of all gaits, with jump gait coming in third at 33.3%, equinus gait for 16.7%, and normal gait for just 4.3% of instances. Just 26.7% of the cases were normal with no tilt, but the great majority of cases showed tilt (anterior in 60% and posterior in 13.3% of them). Thirteen percent of the patients and 60% of the cases had reduced SFA. Of the instances, only 26.7% were typical. The lumbopelvic alignment was aberrant in two thirds of the patients. Positive shift was seen in almost half of the instances. Additionally, the majority of patients had good Thomas results. Every case that was included had a good popliteal angle.

The final and most intriguing case involves hamstring muscle tension (popliteal angle >50°), a positive hamstring shift (≥20°), and a positive Thomas test result. Here, the lumbar spine is hyperlordotic and the pelvis is flexed due to the major and dominating action of the iliopsoas, or hip flexor. The hamstring is prolongedly overextended. This seems to be a case of hamstring stiffness. A hamstring shift of more than 20° is typically a sign of an excessive anterior pelvic tilt, which can be caused by weak hip extensor muscles, tight hip flexor muscles, or weak abs [17].

According to Joshi *et al.* [18], of CP patients (33.3%) had anterior pelvic tilt (average pelvic tilt <5°), 44.4% had normal pelvic tilt (average pelvic tilt <10°), and 22.2% had posterior pelvic tilt (average pelvic tilt <10°). This study used SFA to evaluate pelvic tilt more quantitatively. The results showed that only 13.3% of patients had posterior pelvic tilt, while 53.3% of cases had anterior pelvic tilt and 33.3 percent had normal pelvic tilt. The discrepancies between Joshi's work and ours might be attributed to the latter's lack of objectivity and accuracy in our measurement of pelvic tilt, which was achieved by using the SFA to determine the relationship between the pelvis and femur.

A unique technique was created to assess the hip range of motion by use the SFA, which may be acquired by lateral radiographs. It is a straight forward approach that removes the pelvic and lumbar spine's contributing motion during hip flexion, making it more objective, accurate, and somewhat reliable. This suggested approach may be helpful to better comprehend the complex action in hip flexion by illuminating the link between the femur, pelvis, and spine. By preventing data from being tainted by the motions of the pelvis and lumbar spine during hip flexion, the SFA provides a more objective, accurate approach with reasonable reliability and validity for evaluating range of hip flexion [19].

Conclusion

Among those with diplegic CP, anterior pelvic tilt and hamstring tightness are frequent issues. Between GMFCs II and III, walkers account for the majority of situations. Less than 25% of patients have kyphotic lumbar spines, one third have normal lumbar spines, and more than half have clinically hyperlordotic lumbar spines. Through radiographic assessment of the lumbar spine, closer values can be obtained. A positive Thomas test is found in about two thirds of patients, and a positive hamstring test is found in half of cases. Hip flexor contracture is the main cause of positive hamstring shift instances, which manifest as tightness in the hamstrings. As a result, the majority of patients seem to be tight, and surgeons need to exercise caution to avoid overextending the hamstrings in order to prevent an increased anterior pelvic tilt.

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Conflicts of interest

There are no conflicts of interest.

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