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Original Research

Investigation of the relationship between femoral anteversion, pelvic inclination and spasticity in children with spastic diplegic cerebral palsy

Femoral anteversion and spasticity in cerebral palsy

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Abstract

Aim: This research was planned to analyze the relationship between femoral anteversion, pelvic inclination and spasticity in children with spastic diplegic cerebral palsy.

Methods: The study included 33 participants with spastic diplegic cerebral palsy, aged 5–18 years (mean age 13.7 years; [SD 3.1 years] 15 girls, 18 boys), with Gross Motor Function Classification Score 1 and 2. Femoral anteversion was evaluated with the Craig test. Pelvic inclination angle was measured using a specially designed caliper-like device and a mobile application (rotating sphere clinometer) with a phone placed on the device. Spasticity was evaluated using the Modified Ashworth Scale. The average spasticity values in the lower extremity hip flexor, adductor, internal rotator, knee flexor, plantar flexor and evertor muscles were calculated.

Results: A moderate positive correlation was observed between the femoral anteversion angle and pelvic inclination angle (right: $r = 0.373$, $P < .05$; left: $r = 0.412$, $P < .05$) and between femoral anteversion angle and the mean value of lower extremity total spasticity (right: $r = 0.361$, $P < .05$; left: $r = 0.368$, $P < .05$). There was no significant relationship between the pelvic inclination angle and the mean value of lower extremity total spasticity (right: $r = 0.208$, $P > .05$; left: $r = 0.302$, $P > .05$).

Conclusion: It was observed that an increase in lower extremity spasticity value may cause an increased femoral anteversion angle, while an increase in femoral anteversion may cause an increase in pelvic inclination angle.

Keywords

cp (cerebral palsy), spasticity, femoral, biomechanical

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Introduction

Cerebral Palsy (CP) is a chronic but non-progressive clinical picture that develops due to damage to the developing fetal or infant brain and causes various abnormalities in children.[1] Diplegic CP, which constitutes 32% of all CP and is the most common in premature infants, is characterized by spasticity in the pelvis and lower extremities and milder spasticity and incoordination in the upper extremities.[2]

Children with cerebralopalsy (CP) have a normal skeletal structure at birth.[3] However, deformities may occur as a result of abnormal biomechanical loads due to spasticity. One of the important deformities seen in the hip joints ofochildren with CP is the increased Femoral Anteversion (FA) angle. The FA range is 30°-40° at birth and decreases to 15° by the age of 16. Due to the delay in walking, inability to stand upright, and continued hip flexion in children with CP, the iliofemoral ligament does not have a reducing effect on FA and an increased anteversion angle continues.[4] However, the etiology of increased FA in children with spastic CP is unclear. According to several previous studies , FA in children with CP may be functionally impacted by fetal positioning and hip adductor stiffness, but the results are conflicting.[5] In a study, it was shown that the moment created by the iliopsoas, rectus femoris, adductor brevis, medial hamstring muscles at certain degrees of hip flexion is the reason why flexion and internal rotation contracture are often seen together in spastic children. It was explained that internal rotationicontracture in the hip also limits the physiological decrease in FA.[6] Some studies have shown that increased FA is a cause of lower extremity deformities such as gait abnormalities, pelvic rotation, and anterior pelvic tilt, especially it is believed that the most important cause of bone deformities are abnormal muscle and joint strengths caused by the extra load on the bones.[7] In a study, it has been discovered that the pressure exerted on the hip of a spastic child created in the computerized mathematical model are six times greater than the pressure exerted on the hipiof a typical developing child.[8] Pelvic tilt is one of the biggest problems in children with spastic diplegia, as it transmits vertical forces to the pelvic spine and lower limbs as part of the kinetic chain. Increased pelvic anterior tilt is a common problem in children with CP and has been frequently described.[9]

In light of this background, we consider that in the evaluation of the child with CP, a holistic approach to the child and a detailed biomechanical evaluation should be carried out, and thus, great gains can be achieved with small corrections in rehabilitation, therefore posture should be emphasized. Assuming that an increased FA angle has biomechanical effects on posture in children having spasticidiplegic CP, we think that especially increased FA and spasticity would cause anterior pelvic tilt in the pelvis. We assume that there would be biomechanical changes in the upper and lower extremities to compensate for this situation, but, to the best of our knowledge, there are none yet on this topic, according to a review of the literature. Therefore, this research was planned to examine the relationshipİbetween FA, pelvic inclination and spasticity in childrenİwith spastic diplegic CP.

Materials and Methods

We conducted a multicenter, non-invasive and cross-sectional. The research was carried out with individuals attending SpeciallEducation and RehabilitationlCenters in Elazig and Malatya city centres. Study data were gathered from April to June of 2018. The research was examined and authorized by the EthicsiCommittee of local ClinicaliResearch (Approval number: 2018/5-5; Approval Date: 27.02.2018), and this study was carried out in accordance with the principles of the Declaration of Helsinki. The parents of the participants were informed about the study procedure before the study entry and an informed consent form was signed by both of sides indicating that they would willingly participate.

Children aged 5-18 (13.7 ± 3.1) years, diagnosed with spastic diplegic CP, with GrossiMotor FunctioniClassification Score (GMFCS) 1 and 2, who had not undergone botox in the last 6 months, had not undergone any orthopedic surgery, and whose families gave informed consent were included in this study. Children who did not meet the inclusion criteria , children who did not want to participate voluntarily, and children of families who did not want their children to be included in the research were not included in the research. Individuals in institutions were chosen using a straightforward random selection procedure. All participants were registered..

Initially, 41 children with spastic diplegic CP were identified, and 5 children who did not meet the inclusion criteria were excluded. Afterwards, 3 more children who could not complete the evaluation parameters were excluded. Totally, 33 kids were included in our research (Figure1).

Assuming that the FA angle increased in 75% of the children with spastic diplegic CP with α = .05 and 1-β (power) = .80 in the power analysis performed before the study, it was calculated that at least 33 subjects should be included in the study.[10] The sample size was determined using the freely downloadable statistical program OpenEpi, version 3.

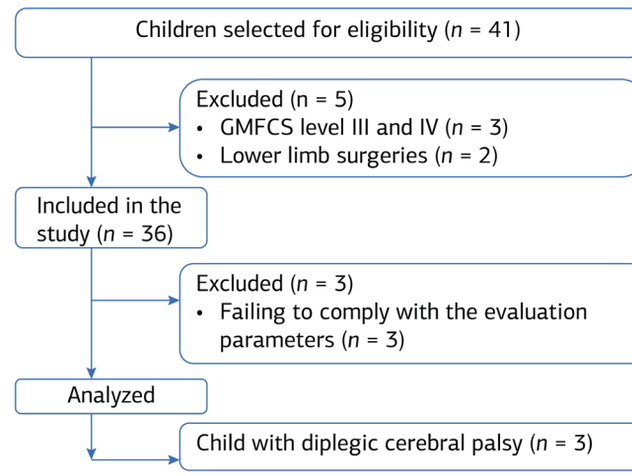

Figure 1. *Flow Chart*

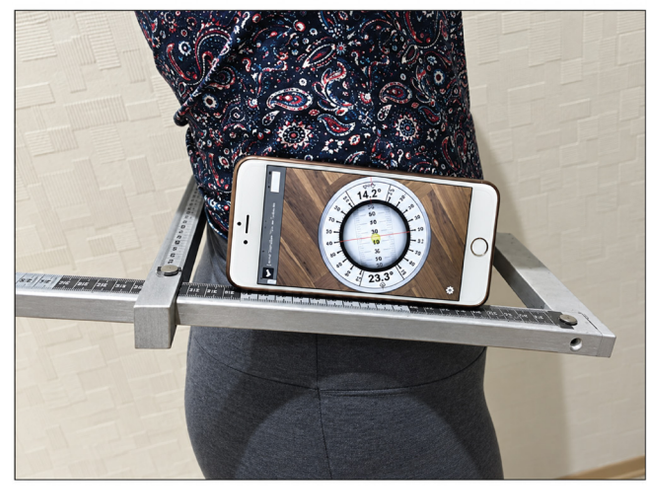

Figure 2. *Measurement of Pelvic Inclination*

Test Procedure

Evaluation of the FA angle was done with the Craig test.[11] The patient was placed in the prone position, and the Craig test was carried out on the side of the hip that will not be tested. The hips were extendedand the knee on the side to be tested was in 90° flexion. The tester palpated the trochanter major with her left hand and internally rotated the hip with her right hand. The angleobetween the vertical plane and the tibia was calculaed by using a goniometer at the point where the trochanteric protrusion was most prominent.[12]

Pelvic inclination angle was measured with the help of a device designed like a caliper and a public mobile application (Rotating Sphere Clinometer) that performs inclinometric measurements while the patient was standing. The short end of the caliper was kept to the anterior superior of the spina iliaca and the long end was held to the posterior superior of the spina iliaca, and a phone was placed on the device and the measurement was made in terms of angles with the mobile application (Rotating Sphere Clinometer) (Figure 2). In the studies, it was emphasized that the smartphone inclinometer is valid and reliable, in perfect agreement with the goniometer-based goldistandard for ROMimeasurement.[13]

Spasticity was evaluated with the Modified Ashworth Scale, which is one of the methods that is easily used in practice. The Modified Ashworth Scale does not require equipment; It is easily and widely used in clinic. Scoring is done between 0-4.[14] In our study, a total value for the lower extremity was calculated by taking the average of spasticity values in hip flexor, adductor, internal rotator, knee flexor, plantar flexor and evertor muscles in the evaluation of spasticity.

Ethical Approval

This study was approved by the Clinical Research Ethics Committee of Inonu University (Date: 27.02.2018, Decision No: 2018/5-5)

Statistical Analysis

Quantitative data obtained from the research were analyzed utilizing the IBM SPSS Statistics 18 package program. The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Shapiro-Wilk Test). Descriptive statistics (mean, standard deviation, frequency) were applied for the characterization of the patients. The relationship between FA, pelvic inclination and mean value of lower extremity total spasticity was evaluated with the Pearson correlation test. Correlation values ($r \geq 1.0$ excellent correlation, 0.71–0.99 strong correlation, 0.30–0.70 moderate correlation, 0.01–0.29 weak correlation, 0.00 no linear correlation (neutral correlation)). *P* values below .05 were considered statistically significant.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

Results

The study included 33 participants with spastic diplegic CP. The demographic characteristics of the individuals are summarized in Table1. The mean age of the children was 13.70 ± 3.16; mean height was 147.5 ± 21.09 cm; mean body weight was 45.73 ± 14.73 kg; body mass index was 20.80 ± 4.82. The mean FA, pelvic tilt, and lower extremity total spasticity values of the individuals are given in Table 2.

Table 1. Demographic Characteristics of Children with Diplegic Cerebral Palsy

Demographic values	Total (*n* = 33) Mean ± SD
Age, y	13.7 ± 3.1
Height, cm	147.5 ± 21.09
Weight, kg	45.73 ± 14.3
BMI, kg/m^2	20.80 ± 4.82

BMI, Body mass index; SD, Standard deviation.

Table 2. Femoral Anteversion, Pelvic Inclination and Spasticity Values of Individuals

		Mean ± SD	Min	Max
Craig's Test	Right	32.55 ± 9.04	20	62
	Left	32.58 ± 8.25	19	58
Pelvic inclination angle	Right	20.03 ± 4.7	10	28
	Left	20.45 ± 5.3	12	30
Lower extremity spasticity	Right	1.42 ± 0.46	0.89	3.00
	Left	1.38 ± 0.45	0.78	3.00

SD, Standard deviation; Min, minimum; Max, maximum.

Table 3. The Relationship Between Femoral Anteversion, Pelvic Inclination and Spasticity

			Femoral anteversion angle		Pelvic inclination angle		Lower extremity spasticity	
			Right	Left	Right	Left	Right	Left
Femoral Anteversion Angle	Right	*r*	1	0.950	0.373	0.342	0.361	0.357
		P		.000	.032	.051	.039	.041
	Left	*r*	0.950	1	0.351	0.412	0.322	0.368
		P	.000		.045	.017	.068	.035
Pelvic Inclination Angle	Right	*r*	0.373	0.351	1	0.930	0.208	0.326
		P	.032	.045		.000	.244	.065
	Left	*r*	0.342	0.412	0.930	1	0.124	0.302
		P	.051	.017	.000		.493	.087
Lower Extremity Spasticity	Right	*r*	0.361	0.322	0.208	0.124	1	0.897
		P	.039	.068	.244	.493		.000
	Left	*r*	0.357	0.368	0.326	0.302	0.897	1
		P	.041	.035	.065	.087	.000	

**, P < .05 value; r, pearson correlation test.*

According to the correlation analysis conducted to examine the relation between FA, pelvic inclination and spasticity in children with spastic diplegic CP, a moderate positive correlation was found between femoral anteversion angle and pelvic inclination angle (right: r = 0.373, P = .032; left: r = 0.412, P = .017). There was also a moderate positive correlation between femoral anteversion and the mean value of lower extremity total spasticity (right: r = 0.361, P = .039; left: r = 0.368, P = .035). There was no statistically significant relationship between the pelvic inclination angle and the mean value of lower extremity total spasticity (right: r = 0.208, P = .244; left: r = 0.302, P = .087) (Table 3).

Discussion

The study findings demonstrated that a moderate positive correlation was found between femoral anteversion angle and pelvic inclination angle, and between femoraloanteversion angle and loweroextremity total spasticity mean value. However, it was found that there was no direct significant relationship between the pelvic inclination angle and the mean value of lower extremity total spasticity.

In our study, we evaluated FA with the Craig test, since physical assessment, which is an indirect method in FA evaluation, is important for its practical use in clinical practice and to give an idea about rotational problems before imaging methods. At the same time, it was found that the pelvic inclination angle, which we evaluated using a caliper-like device and mobile application, which has practical use in the clinic, and the increase in FA and a tendency towards anterior pelvic tilt was observed. Studies in the literature support our conclusion. Akalan et al. demontstrated that an increase in FA may cause an increase in pelvic rotation and anterior pelvic tilt.[15] In a study comparing walking characteristics of children with and without neurological problems with increased FA, they showed that even without neurological problems, increased FA caused more complex problems such as anterior pelvic tilt, increased hip and knee flexion, apart from foot introversion.[16]

Most researchers and clinicians attribute that children with CP acquire bone malformations as a result of a muscular imbalance brought on by muscle spasticity. However, there is no consensus about the muscles that cause this illness. According to certain theories, an overactive Psoas drags the lesser trochanter forward, torsion is caused on the proximal femur by the internal rotators contracting, and the greater trochanter loses stimulation as a result of the adductors' spasticity.[3] Hip displacement has been attributed to abnormal forces produced by the hip adductor muscles, followed by the influence of the iliopsoas and hamstrings.[17] These abnormal forces were thought to induce numerous abnormalideformities of the femur and hip, including excessive FA and coxa valga, resulting in hip displacementiand dislocation. It is thought that hip flexor tension, hip rotator imbalance, adductor muscles, tight hamstring and weak abductors are among the elements affectingiFA.[18] However, controversial results have also been reported. In a study, no relationship was found between FA and hypertonicity of hipiadductor and hamstringimuscles.[19] In another research, no significant difference was found between FA grade and ankle plantar flexors, knee flexors, and hip flexors, but a strong correlation was found between FA grade and hip adductors.[In another research, no significant difference was found between FA grade and ankle plantar flexors, knee flexors, and hip flexors, but a strong correlation was found between FA grade and hip adductors. available at: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp] Shefelbine et al. stated that hip flexors and hip adductors had an effect on the FA angle.[3] Arnold et al. showed in their study that adductors do not significantly contribute to excessive internal rotation of the hip.[20] As stated in studies on this subject, the effect of hip flexor and adductor spasticity on FA is still a question mark. Factors affecting FA should be studied further. Different results may be due to validation problems and validation bias in clinical evaluation studies of goniometry to measure FA. In addition, accurate correct results may not have been obtained because the weight-bearing position was not used. In light of this information in the literature, a moderate correlation was found between FA and the mean value of lower extremity total spasticity in the data we obtained in our study. We think that this relationship may be secondary to the prevention of natural derotation of the femur due to spasticity and muscle imbalance, and to the non-stretching of the anterior capsule due to the child's general spasticity.

There are not many studies in the literature on the relationship between pelvic inclination angle and spasticity, but different results have been shown. It has been hypothesized that rectus and psoas spasticity cause increased anterior pelvic tilt.[21] Ja Young Choi et al. in their study on 30 children with spastic CP, showed that higher dynamic spasticity of the hamstring is associated with greater posterior pelvic tilt.[22] In our study, no significant relationship was found between the pelvic inclination angle and the mean value of lower extremity total spasticity. If the severity of spasticity does not cause an increase in the femoral anteversion angle, it is possible to interpret this situation as that there may not be an increase in the pelvic inclination angle. At the same time, it is not always easy to determine the effect of any effect on other subjects, as in the biomechanical effects of spasticity in children with complex neurological problems such as CP. Due to the time-consuming and costly objective evaluation parameters, subjective parameters are used in the clinic, which do not take much time and are low in cost, but with high validity and reliability. However, these parameters are often incomplete in evaluating functional quality in CP. In order to exclude the limitation in terms of this inclination angle, application was used as a relatively objective method in our study. In addition, although the evaluation criteria and parameters used in the studies reveal objective results, no method can clearly reveal muscle spasticity. We assume that this may be the cause of the various study outcomes.

Limitations

Our study has some limitations. First of all, it is influenced by the sample size. More generalizable results will come after scanning with bigger samples. In addition, more research needs to compare test results test results in kids with various types of CP.

Conclusion

It was observed that the increase in the mean value of lower extremity total spasticity may cause an increase in the FA angle, in this case, an increase in the pelvic inclination angle. However, it was not found that the mean value of lower extremity total spasticity may not have a direct effect on the pelvic inclination angle without causing an increase in the femoral anteversion angle. In the evaluation of the child with CP, we think that a holistic approach to the child and detailed biomechanical evaluation can be made, and thus, with small corrections in rehabilitation, great gains can be achieved.

Since our research is the first study to examine the relationship between FA, pelvic inclination and spasticity in children with CP, a new perspective can be gained on this subject, which has not been clarified to a large extent in the literature.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Written informed consent was obtained from the parents or legal guardians of all participants.

Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy reasons but are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Abbreviations

BMI: Body mass index
CP: Cerebral palsy
FA: Femoral anteversion
GMFCS: Gross motor function classification system
Max: Maximum
Min: Minimum
ROM: Range of motion
SD: Standard deviation
SPSS: Statistical package for the social sciences

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