Baseline Hamstring Excursion in Indian Pediatric Population: A Pilot Study

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Abstract

Background: Hamstring muscles are primarily affected by many neuromuscular or musculoskeletal conditions, due to which the patient has to suffer various limitations. One must be aware of the hamstring excursion in normal healthy children to recognize the pathological conditions. To the best of our knowledge, no such data is available from the Indian pediatric population to date, so it was considered worthwhile to conduct this study.

Materials and methods: This study was conducted to analyze the limits of hamstring excursion in 50 normal Indian children (aged between 6 and 18 years) using three routinely used tests in the orthopedic outpatient clinic. The tests included are the straight leg raising test (SLRT), popliteal angle unilateral (PAU) and popliteal angle bilateral (PAB), and toe touch test (TTT). The results were based on differences in gender, age group, and sides (left and right).

Results: The mean value of the SLRT was 60.16° and 57.02° in children <12 years (group I) and ≥12 years (group II), respectively. The PAU values were 42.66° for group I and 46.44° for group II, while the TTT results were −0.69 and −5 cm, respectively. Minimal variation was seen between both sides in all three tests. When comparing the data based on gender, the mean value of SLRT was 62.64° and 56.21° for girls and boys, respectively. The PAU values are 43.26° and 45.39°, while the TTT had a mean of 2.64 and −6.45 cm for girls and boys, respectively.

Conclusion: There is more hamstring excursion in younger children than in older ones, and the hamstring excursion values reduce with age. It is also observed that hamstring excursion is more in girls than boys.

Keywords: Cerebral palsy, Children, Excursion, Hamstring, Hamstring shift test, Popliteal angle.

Introduction

The hamstring group of muscles is biarticular, spanning both the hip and knee joints and playing a significant role in daily activities like walking, running, squatting, etc. The four muscles (biceps femoris, semitendinosus, semimembranosus, and adductor magnus) act individually to carry out specific functions. The full range of extensibility and contractility of a muscle is called “functional excursion” or its “amplitude.” The excursion depends on various factors related to either the neurological or musculoskeletal system or both. Hamstring excursion is a subject of interest as various musculoskeletal and neuromuscular disorders tend to affect the same, resulting in morbidity. These limitations have many implications affecting ambulation and activities of daily living.

Hamstrings provide dynamic stability to the knee joint before and after heel strike in a normal gait cycle. They also limit hip flexion and terminate the swing phase. The hamstring involvement in neuromuscular disorders has secondary effects on the entire locomotor system due to the complex role of maintaining a normal gait and posture. When hamstring muscles have reduced excursion compared to physiological limits, they are labeled “tight.” There is also an associated feeling of tightness in the back of the thigh. The tightness is the potential cause of dysfunctional or restricted movements of the hip and knee. It has been documented in all age groups. The altered excursion of hamstrings leads to an array of limitations comprising gait anomalies and restriction of day-to-day activities. Management of the above-said disorders needs assessment of hamstring excursion based on which intervention is planned.

A lot of knowledge has been generated by observational and three-dimensional gait analysis regarding the kinetics and kinematics of individual components of the locomotor system. However, the science of musculoskeletal dynamics evolves with new information gathered every day. It is essential to know the physiological range of excursion in healthy individuals to study the role of hamstring excursion in pathological conditions. So far, the available data from the literature is from the Caucasian population. It is important to collect data from the Indian population because of the difference in lifestyles of the two populations.
Baseline Hamstring Excursion among Indian Children

Moreover, similar studies to assess hamstring flexibility have been performed on neonates and infants in the past.\textsuperscript{13-17} To the best of our knowledge, no similar research has been done on older children of the Indian population. Hence, it is considered worthwhile to study the normal hamstring excursion in the Indian pediatric population of various age groups. The data will give baseline characteristics that can be compared with the available literature.

**Materials and Methods**

We conducted a pilot observational study in 50 healthy children aged 6–18 years of a tri-city population, Chandigarh, Northwest India. Our objective was to analyze the baseline hamstring excursion in the Indian pediatric population by evaluating the baseline value of the SLRT, PAU and PAB, and TTT. The included children will be divided into two groups, from 6 to <12 years and between 12 and 18 years.

- **Group I**: Age from ≥6 to <12 years.
- **Group II**: Age from ≥12 to <18 years.

**Exclusion Criteria**

Any major musculoskeletal injury to the lower limbs that limits the range of motion (ROM), any lumbar spine pathology, any surgical procedure of the lower limb during the past, disturbances of the vestibulocochlear system, children engaged in activities in which extremes of flexibility are important, such as ballet and gymnastics, children with connective tissue disorders (e.g., Marfan syndrome, Ehlers–Danlos syndrome, etc.), neurovascular pathology of the lower limbs, the child having any history of congenital, musculoskeletal, neurologic, or developmental abnormality were excluded.

**Procedure**

We have adopted the Indian Council of Medical Research Ethics Guidelines for biomedical research involving children to obtain consent and assent as applicable. The primary demographic details were captured. The subject’s height in barefoot and weight were measured in centimeters and kilograms respectively, before the procedure using a standardized medical scale. Also, the ligament laxity was measured using the Beighton score\textsuperscript{18} before the procedure, and kids with scores of 4 or more were excluded from the study. Subjects were asked questions about their daily activities, and if they could squat for 20 seconds, they were included. Data collected was filled in a proforma by the investigator.

Three methods used to measure the value of hamstring excursion are:

- **The SLRT**: The limb to be examined was raised passively. A 360° goniometer was used to measure the angle subtended between the raised leg and the horizontal. The point where the knee started to flex or when the subject felt restriction in the posterior aspect of the thigh was considered to be the endpoint of the SLRT.

- **The PAU and PAB, or modified popliteal angle (PA) tests**: The PAU is defined as the angle between the long axis of the tibia and femur when the hip is flexed to 90° and knee extension is attempted.\textsuperscript{1,19–24} In the PAU test, the limb to be examined was flexed at the hip to 90°, and the contralateral limb was kept in full extension (Fig. 1), unlike the PAB test in which the subject’s contralateral leg had been flexed at the hip to such a position where the anterior superior iliac spine and posterior superior iliac spine were aligned vertically\textsuperscript{25} (Fig. 2). The examiner extended the test leg at the knee passively until a considerable resistance to the motion is felt. The hamstring shift was found by calculating the difference between the values of PAU and PAB (while performing, the contralateral thigh and the pelvis had been stabilized in a neutral position in both SLRT and the PAU tests).

- **The TTT**: The subject was asked to sit on the examination table with knees extended and ankle dorsiflexed to neutral and was then instructed to touch the toes actively by bending while maintaining legs in extension. Measurement was such that the distance between the great toe and the tip of the middle finger of the hand was recorded in centimeters; a negative value when the subject could not reach the toes and a positive for any distance reached past them.

**Data Collection and Analysis**

For each subject, the measurements were performed by a physiotherapy intern and an experienced physiotherapist. The measurements were taken by keeping the eye level the same as that of the level of the goniometer to avoid parallax error. Proper stabilization was done, and precautions were maintained while taking measurements. Clear and understandable instructions were

Fig. 1: Position of the contralateral limb while measuring PAU

Fig. 2: Position of the contralateral limb while measuring PAB
given to the subject. The same goniometer was used for all subjects to avoid instrumental errors. Also, the body part required for the measurements was adequately exposed and free. This was done to improve accuracy and avoid trick movements.

After the completion of the collection of data, the raw data was subjected to analysis and comparison. Interobserver agreement was checked using Bland–Altman plots. The values were subjected to statistical analysis to calculate the mean, standard deviation, and range for each group. Tables and graphs have been created for clear and easy interpretation.

**Results**

After taking written consent and assent, 50 healthy children of age group between 6 and 18 years were recruited in the study (Fig. 3). They were divided into two groups based on their age, namely group I (≥6 till <12 years) and group II (≥12 till <18 years). A total of 24 children (48%) were in group I, and 26 (52%) were in group II. Based on their gender, 36% were girls, while 64% were boys.

We measured the angle of the passive SLRT, PAU, and PAB, and the distance of the tip of the great toe from the middle finger in a long sitting position. All these tests were performed bilaterally. The results are shown in Tables 1 to 3.

**Straight Leg Raising Test**

According to our observation, the normative value of SLRT in children varies in groups I and II, both with age and gender. However, there is a statistically insignificant variation on both sides, that is, left and right. The average value of SLRT in group I was 60.16°, while in group II was 57.02°. Among group I, while comparing both sides, the mean SLRT was 60.10° and 60.21° for the left and right sides, respectively. While comparing both sides, group II showed that the mean SLRT value was 56.63° and 57.40° for the left and right sides, respectively. There was a marked change in the average SLRT when comparing the girls with the boys. The girls had an average SLRT value of 62.64°, and the boys had 56.21°.

**Popliteal Angle and Hamstring Shift**

The average value of PAU and PAB in group I was 42.66° and 30°, respectively. The PAU values were 42.66° for group I and 46.44° for group II, respectively. The PAU values were 43.26° and 45.39° for girls and boys, respectively. The hamstring shift was calculated by subtracting the value of the PAB from that of the PAU. The average value of hamstring shift in group I was 12.66° which is slightly less than the value of hamstring shift in group II, which was 13.13°. When the results were compared based on gender, girls had a higher value of hamstring shift which was 13.26°, as compared to boys, who had a value of 12.70°, implying girls have a greater anterior pelvic tilt. On comparing the left and the right sides, the average value of this test was 12.29° and 13.02°, respectively in group I, whereas 12.4° and 13.85° in group II.

**Toe Touch Test**

The normative value of this test in group I was −0.69 cm and −5.47 cm in group II. Also, it varies with gender, this being 2.64 cm in girls and −6.45 cm in boys. When compared for both sides, there was not much difference in these test values, that is, left and right in age group II. However, in group I, the average value was −0.73 cm for the left side and 0.65 cm for the right side.

The interobserver variability was assessed by Bland–Altman plots, in which the mean of the two values was plotted against
the difference between the two values. Graphical interpretation concluded that our observations lied within the 95% confidence interval. They showed that both observers were in agreement with each other for each test performed.

**Discussion**

The hamstring muscle complex has an important role and governs the kinetics and kinematics of the entire lower limb during gait and other activities. At the hip joint, the hamstrings are active along with the gluteus maximus during the initial contact subphase of the stance phase. The action of these muscles (hip extensors) restraints flexor moment. In the next subphase, that is, loading response, there is a reduction in the action of the hamstrings, whereas an increase in the action by the gluteus maximus. There is no muscular activity by the hamstrings in the mid-stance, terminal contact, and early swing subphases of the gait cycle. They start contracting in the mid-swing subphase, and the peak contraction is in the early terminal swing. At the knee joint, hamstrings act as posterior stabilizers of the knee during the initial contact subphase. In the subsequent subphases of the stance phase, their control gradually diminishes. They again become active in the early swing phase and have their maximum role in the late mid-swing and terminal swing subphases.

The hamstring is commonly involved in neuromuscular disorders like cerebral palsy. Alteration of the normal functioning of hamstring muscles brings various physiological and pathological abnormalities affecting the normal gait cycle and day-to-day activities. In mid-swing, increased knee flexion is a voluntary action to avoid a toe dragging from the plantar flexed foot. In some neuromuscular disorders, such as diplegic cerebral palsy, tibial progression is restricted, thus resulting in persistent knee flexion in terminal swing with inadequate knee posturing for stance.

Since there are various consequences of the limitation of hamstring flexibility, there arises a need to document the baseline limits by objective measurements of hamstring muscle length, both in patients and healthy people.

Youdas et al.\textsuperscript{10} from the United States of America analyzed the influence of age and gender on hamstring muscle length in the healthy adult population. They found that hamstring muscle length was not influenced by age (20–79 years), but female adults had greater flexibility than their male counterparts. The passive SLRT values have minimal variation compared to the left and right sides. We also notice a slight reduction in soft tissue stretch capacity with age which could be attributed to reduced physical activity and skeletal maturity. However, SLRT is not only influenced by hamstring muscle flexibility but also by other factors, including pathologies of the spine, sacroiliac joint, etc.

The popliteal angle is a very common and useful measure of assessing hamstring tightness in patients, especially with movement disorders like cerebral palsy. It is routinely tested in an orthopedic outpatient clinic. It is measured unilaterally as well as bilaterally, and the difference between the two values gives the value of the hamstring shift. The PAB is measured to negate the effect of lordosis on hamstring excursion. The hamstring shift is a measure for finding out anterior pelvic tilt.

To the best of our knowledge, no study has been done previously in India that finds the trend of hamstring excursion with age, gender, or sides. Although only PAU has been considered in the previous studies, these studies were performed on Caucasians. Most of them were performed on the younger population of infants and neonates.\textsuperscript{13–17} The results are similar to the one of SLRT, where girls show more flexibility than boys, and minimal changes are seen in between both sides. We have found that the value of popliteal angle and hamstring shift is age-dependent. It increases with age, implying that with increasing age, there is a limited excursion of hamstrings. But our findings show a higher mean value of PAU as compared to the other studies.

**Table 4:** Comparison of results of our study with the previous two studies

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<th><strong>Our study</strong></th>
<th><strong>Kuo et al.\textsuperscript{1}</strong></th>
<th><strong>Katz et al.\textsuperscript{2}</strong></th>
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<tbody>
<tr>
<td>SLRT</td>
<td>Group I 60.16°</td>
<td>60° at 6 years and then constant</td>
<td></td>
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<tr>
<td></td>
<td>Group II 57.02°</td>
<td>till skeletal maturity</td>
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<tr>
<td>PAU</td>
<td>Group I 42.66°</td>
<td>35°</td>
<td>≥5 years till 10 years: ~26°</td>
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<td></td>
<td>Group II 46.44°</td>
<td>Upper range/lower range: 0–55°</td>
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<td>PAB</td>
<td>Group I 30°</td>
<td></td>
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<td></td>
<td>Group II 33.32°</td>
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<td>Hamstring shift</td>
<td>Group I 12.66°</td>
<td></td>
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<td>Group II 13.13°</td>
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<td>TTT</td>
<td>Group I −0.69 cm</td>
<td>&lt;15 cm hamstring tightness</td>
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<td>Group II −5 cm</td>
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compared to the study of Kuo et al. To justify this, we need a study with a higher sample size. These findings support the results of the study conducted by Katz et al., who measured the popliteal angle of 482 normal children, ages ranging up to 10 years. According to it, the value of the popliteal angle in normal children should be <50° as it does not interfere with normal gait patterns. However, a value of >40–45° in patients with spastic cerebral palsy should sound alarmed for intervention. TTT is an active screening test and incorporates some amount of spinal motion as well. Hence, it is not a pure test for measuring hamstring excursion. It is also affected by the child’s size as the length of the legs is longer in older children increasing the toe-touch distance.

The limitations of our study were the small sample size and the presence of more boys than girls.

**Conclusion**

The hamstring excursion decreases as the child grows older. The girls tend to have more hamstring excursion than boys, and only a minimal variation is present between both sides. The average baseline hamstring excursion value of Indian children can be applied in future studies involving pathological states like cerebral palsy.

**References**