

## Effect of Pelvic Control Exercises on Balance in Children with Cerebral Palsy: A Randomized Controlled Trial

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### Abstract:

**Objective:** The study's goal was to find out how children with cerebral palsy's (CP) balance was affected by exercises for pelvic control.

**Material and Methods:** Forty-two children that participated in this single-blind trial were divided into two groups at random. Group A (n=21) received conventional intervention and pelvic control exercises, while Group B (n=21) received only conventional intervention. For a period of eight weeks, the intervention was carried out; three days a week. The time up and go scale was used for assessment before and after treatment. The paired-t test was used to analyze differences within the group, whereas the independent t-test was utilized to analyze differences between the two groups.

**Results:** Results for pre and post-treatment timed up and go (TUG) scores are presented as means and standard deviations. The values of TUG scores in study group A showed a notable increase ( $p$ -value $<0.05$ ) after treatment with conventional physiotherapy and pelvic control exercises.

**Conclusion:** The results indicated that pelvic control training was found to be beneficial in improving the balance of children with CP.

**Keywords:** balance, cerebral palsy, diplegia, pelvis

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## Introduction

Cerebral palsy (CP), the most prevalent cause of physical disability in children, can affect the child's health in a variety of ways. Primary neuromuscular deficits, such as spasticity, muscle weakness, and decreased selective motor control, are among the motor signs of CP, while secondary musculoskeletal issues include bony malformations and contractures<sup>1</sup>. The most common form of CP is spastic diplegia, which affects 80% of preterm infants and accounts for approximately 44% of the overall incidence of CP<sup>2</sup>. The trunk is noticeably weaker and the extremities are highly spastic in children with spastic diplegia. In comparison to their lower extremities, they demonstrate milder motor impairment in their upper extremities<sup>3</sup>. The primary functional issue is poor posture and movement. Appropriate alignment of each body component and spinal segment with the trunk and neighbouring part is necessary for an upright posture<sup>4</sup>. Children with CP typically have an abnormal alignment of the spine in comparison to children who are developing normally<sup>5</sup>.

The hallmarks of severely affected CP patients include progressive neuromuscular spinal abnormalities accompanied by pelvic obliquity and loss of sitting balance. Key bones between the lower extremities and spine are represented by the pelvis. The pelvis must be horizontal in the frontal plane and somewhat anteriorly tilted in the sagittal plane, more so when standing and less so when sitting, in order to permit a normal spinal form. Any aberrant pelvic position puts the person's ability to maintain their equilibrium at risk and necessitates spinal compensation<sup>6</sup>.

The capacity to recover from an unanticipated threat to equilibrium, like a trip or slip, is known as balance control. An ideal posture involves distributing the body's mass evenly around the centre of gravity, with little energy used by the postural muscles and ligamentous tension, balancing the compression force<sup>7</sup>. Children with CP have

trouble anticipating and making modifications to their body's position in space in order to carry out functional tasks as well as responding to sudden disturbances in their balance<sup>8</sup>. A deficiency in the motor process, manifested as spasticity or weakness in the muscles around the pelvis, results in an aberrant pelvic position<sup>9</sup>. Pelvic spinal analysis is a useful tool for measuring this alignment<sup>10</sup>. Children with spastic diplegia get treatment with an emphasis on maximising gross motor function and minimising the impact of deficits in order to prevent disability. Although a number of experts have recommended that balance training be an essential part of any rehabilitation program for these children<sup>11</sup>, no biomechanical investigation of the pelvis has been completed as of yet. As hip movements are limited in children with spastic CP, pathologic motion of the pelvis occurs either with excessive motion or asymmetric motion<sup>12</sup>. By designing an exercise protocol based on neurophysiological and biomechanical aspects of pelvic stability, coordinated activity between the lower trunk and proximal hip muscles can be achieved. Improvement in the order of muscle recruitment, the rate of agonist/antagonist co-activation, and incoordination of joint segments can further improve balance. Therefore, we made an effort to investigate how balance is affected by pelvic control exercises in children with spastic diplegic CP.

## Material and Methods

### Study design

An experimental study was carried out from August 2023 to November 2023 at the Khushboo Welfare Society and the SGT Medical College Hospital and Research Institute in Gurugram, Haryana. The trial was randomised, single-blinded, and included two groups. The blinded assessor was a qualified physiotherapist with specialised training in this area.

The study was filed with the Clinical Trials Registry of India (ICMR–NIMS) as CTRI/2023/08/055957 after receiving approval from the university’s ethics committee (SGTU/FPHY/2022/438). Parents of participants were consulted beforehand, and their informed consent was obtained in writing.

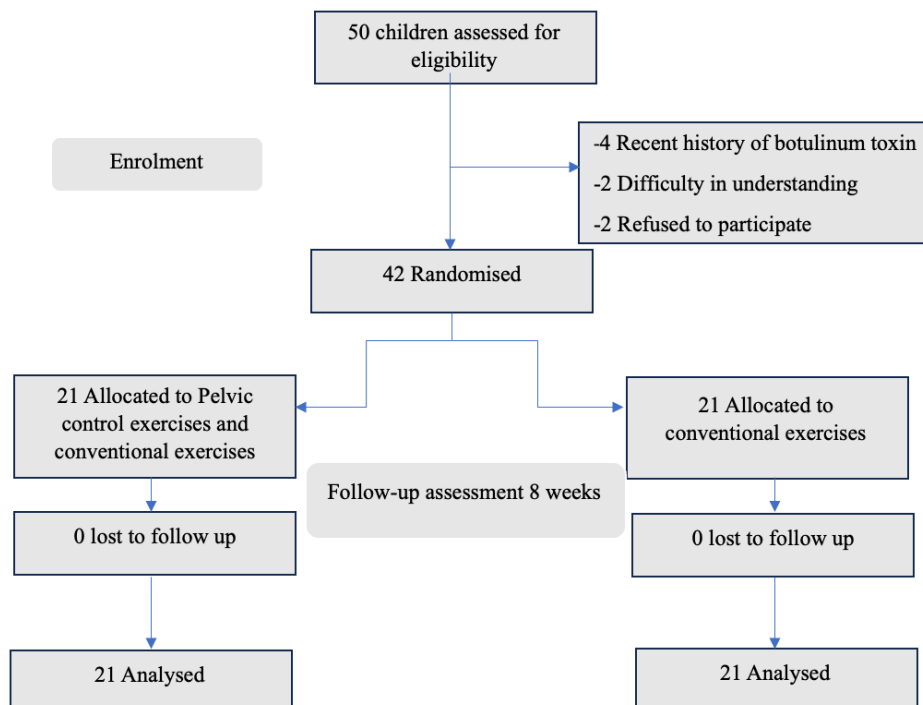
### Participant recruitment and allocation

The following conditions must be satisfied in order to be included: Spastic diplegic CP as diagnosed by a paediatrician or paediatric neurologist; the age ranged from five to twelve years; Level I and II of Gross Motor Function Classification System (GMFCS); and the ability to understand verbal commands. Exclusion criteria included: botulinum toxin or serial casting to lower limbs within the last three months (or scheduled for the intervention or control period), having completed a core exercise group within the preceding six months, neurological or orthopaedic conditions

unrelated to CP, and behavioural issues restricting group participation.

To calculate the sample size, G Power software was utilised. For the purpose of analysing the mean difference between two independent groups, the t-test was employed, with a sample size of forty-two. On the basis of assumptions, the effect magnitude for the same was considered. It was two-tailed, with a power of 0.80, an alpha error of 0.05, and an effect size of 0.80.

The children were randomly assigned to either the treatment or control group via computerised random assignment. The children were randomly assigned to either the treatment or control group via computerised random assignment (Figure 1). Allocation was hidden by using opaque, sealed and numbered black envelopes made by a researcher not participating in the study. The physical therapist that collected the data was not informed as to group assignments.



**Figure 1** Flow chart of the participants

## Outcome measures

### *Balance evaluation*

Since the Timed Up and Go (TUG) test can distinguish between children at levels I–III of the GMFCS as well as different subtypes of CP, it has been used to assess balance in ambulatory children with CP<sup>13,14</sup>. For GMFCS levels I and II, the TUG has MCIDs of 0.36 and 0.87 (i.e., a large effect size) and has excellent test–retest reliability in children with CP (ICC=0.91–0.98)<sup>15</sup>. There is a significant negative association (Spearman  $p$ -value=-0.88,  $p$ -value<0.01) between the TUG and the Berg Balance Scale overall score<sup>13</sup>. The exercise entails: getting up, walking ten feet, turning at a certain location on the floor, returning to the chair, and finally sitting down. After the instruction “ready, go,” the participants move to stand, and the test is concluded when they sit down in the chair and stop moving.

### **Intervention**

The study group A (n=21) and control group B (n=21) underwent eight weeks of conventional exercises; thirty minutes for each session, three times a week. The study group additionally performed pelvic control exercises for thirty minutes throughout each exercise session. These sessions were conducted at the physiotherapy Out–Patient Department of SGT Hospital and the paediatric physiotherapy unit of Khushboo Welfare Society, Gurugram, India, under the supervision of a physiotherapist with over ten years of experience working with children that have CP. Face–to–face intervention was given to each subject and each subject was treated individually, i.e., one physiotherapist per child. Materials; such as couches, stools, mats, tables, steppers, swiss balls, footballs, different heights of boxes, and 5–7 small objects like toys, staircases and ramps were used in intervention. The protocol of conventional and pelvic control exercises was designed according to

the template for the intervention description and replication. Each exercise was carried out with two sets, and a two minutes interval between sets. An exercise diary was kept to document information regarding the overall number of sessions, the causes of any absenteeism, the incidence of any unfavourable event, and the number of repetitions and therapy adherence was fully delivered as it was planned.

The conventional exercises consisted of strengthening the lower trunk and hip muscles, balance training by movement transitions and activities in standing, like kicking a ball, reaching out, picking up objects from the table and floor, gait training by moving forward, backward and sideways, stair climbing and ramp walking. Stretching of lower extremity muscles was performed by a physiotherapist. The intervention was not modified during the study and a unique “tailor–made” program was created for every child based on their individual abilities. Each exercise was carried out with two sets, with a two minutes interval between sets. A full description of the intervention, including the dosage, can be viewed in Table 1.

The pelvic control exercises program was divided into four phases and each phase was of 2 weeks duration. The most frequently used treatment goals were pelvic mobilisation, pelvic tilting exercises in all three planes, and pelvic facilitation during the stance and swing phase of the gait cycle. Physical therapists facilitated the movement of the pelvis in the desired direction while doing exercises. The intervention was not modified during the study, and a specific ‘tailor–made’ program was designed according to each child’s evaluation; e.g., if the child had anterior tilt of the pelvis, posterior rotation of the innominate bone was performed. Tasks ranging in difficulty from phases 1 to 4 were assigned, based on each child’s capacity. Each exercise was carried out within two sets, with a two–minute interval between sets. An example of the design of pelvic control exercises has been given in Table 2 and Appendix–A.

### Data analysis

The IBM Statistics Package for Social Science (version 20) was used to analyse the raw data and find the mean  $\pm$  standard deviation for each measuring variable in the two groups, both before and after the eight-week

therapy. Independent t-test was used to compare the demographic characteristics as well as the between group comparison. A paired t-test was employed to investigate the within-group change in outcome measure. The level of significance was held at 5% with a 95% confidence range.

**Table 1** Conventional exercises

Aim	Position	Dosage
Stretching		
Stretching of psoas muscle	Supine lying, hip extended	30 sec X 3 Reps X 2 sets
Stretching of hamstring muscle	Supine with hip and knee 90-90 degree	30 sec X 3 Reps X 2 sets
Stretching of gastrocnemius muscle	Supine, passive dorsiflexion	30 sec X 3 Reps X 2 sets
Strengthening		
Strengthening of muscle abdominis obliquus	Supine, rolling against resistance	10 Reps X 2 sets
Strengthening of muscle latissimus dorsi	Short sitting, lifting buttocks from couch	10 Reps X 2 sets
Strengthening of muscle gluteus maximus	Prone, hip extension with knee flexed	10 Reps X 2 sets
Strengthening of muscle gluteus medius	Sidelying, hip abduction	10 Reps X 2 sets
Movement transitions		
Sit to stand	Sitting	10 Reps X 2 sets
Standing balance		
One leg standing	One leg standing	5 left 5 right X 2 sets
Ball kicking	Standing	5 left 5 right X 2 sets
Reach outs	Standing	5 left hand 5 right hand X 2 sets
Pick up an object placed outside the stability limit	Standing with objects lying over the table	10 times X 2 sets
Gait training		
Walking sideways	Sideways walking against a wall	20 steps X 2 sets
Walking backwards	Backwards walking	20 steps X 2 sets
Obstacle course walking	Walkway with 5 cones	20 steps X 2 sets
Stair climbing	Staircase with 10 steps	5 steps X 5 Reps X 2 sets
Ramp walking	Ramp with height around 100 cm	20 steps X 2 sets

Reps=repetitions

**Table 2** Pelvic control exercises

Initial phase	Improvement phase	Advance phase	Maintenance phase	Dosage
1. Pelvic mobilisation A/P rotation of innominate  Central oscillatory P/A movement over the sacrum  Unilateral oscillatory P/A movement over the base of the sacrum  P/A movement to the PSIS  Lateral movement of the PSIS	Pelvic mobilisation  Anterior/posterior rotation of innominate  Central oscillatory P/A movement over the sacrum  Unilateral oscillatory P/A movement over the base of the sacrum  P/A movement to the PSIS  Lateral movement of the PSIS	Pelvic mobilisation  Anterior/posterior rotation of innominate  Central oscillatory P/A movement over the sacrum  Unilateral oscillatory P/A movement over the base of the sacrum  P/A movement to the PSIS  Lateral movement of the PSIS	Pelvic mobilisation  Anterior/posterior rotation of innominate  Central oscillatory P/A movement over the sacrum  Unilateral oscillatory P/A movement over the base of the sacrum  P/A movement to the PSIS  Lateral movement of the PSIS	5 Reps X 2 sets
2. Cat-camel exercise	Quadruped rocking	Isolated flexion-extension of pelvis	Pelvic tilting with knees bent	5 Reps X 2 sets
3. Weight shifting on swiss ball	Selective lateral movement of pelvis	Weight shifts in kneel standing	Weight shifts in standing	5 Reps X 2 sets
4. Bridging	Bridging with hold	Bridging with adductor squeeze	Bridging with one leg straight	5 Reps X 2 sets
5. Diagonal patterns in half kneeling	Diagonal pattern with heavy object	Diagonal pattern half kneeling with catch and throw ball	Rotate upper body away from lower body	5 left to right 5 right to left 2 sets
6. Posterior tilting exercises while kicking football in front	Lateral tilting of pelvis while kicking football sideways	Forward rotation of pelvis while kicking football crossing midline	Pelvic facilitation while kicking football in all directions	5 Reps X 2sets
7. Posterior tilting exercises while taking step forward on a low height box	Anterior tilting of pelvis while taking step backwards on a low height box	Lateral tilting of pelvis while taking step sideways on a low height box	Pelvic facilitation while taking step in all directions on different height of boxes	5 Reps X 2 sets
8. Pelvic stabilisation while maintaining hip-knee in 90-90 position	Pelvic stabilisation while maintaining hip-knee in 90-90 position with object in hand	Pelvic stabilisation while maintaining hip-knee in 90-90 position with reach outs	Pelvic stabilisation while maintaining hip-knee in 90-90 position with reach-outs in different directions	5 Reps X 2 sets
9. Pelvic facilitation during stance phase	Pelvic facilitation during swing phase	Pelvic facilitation during stance and swing phase on irregular surface	Pelvic facilitation during sit to stand	5 Reps X 2 sets

Reps=repetitions, P/A=posterior-anterior, PSIS=posterior superior iliac spine, A/P=anterior-posterior

## Results

The study was successfully completed by a total of forty-two spastic diplegic children, and the same forty-two children were also utilised to analyse the data in accordance with Consolidated Standards of Reporting Trials (CONSORT). Twenty-one children made up group A, while twenty-one children made up group B. The baseline and demographic data did not reveal any noteworthy distinctions between the groups (Table 3).

Within-group comparison of TUG scores post intervention showed statistically significant changes ( $p$ -value $<0.05$ ) for both group (Table 4). For between-groups comparison, the study group, that is, pelvic control exercises training, showed statistically significant

improvement in TUG scores, with a high effect size ( $p$ -value $<0.05$ ), as shown in Table 5.

## Discussion

This study evaluated the effect of pelvic control exercises on the balancing abilities of children with spastic diplegia. Forty-two diplegic children between the ages of 5 and 12 were evaluated, because spastic diplegia is the most prevalent type of CP and it can be difficult for these children to maintain balance while standing up straight. The findings indicate that both the experimental and conventional exercise groups' balances improved after 8 weeks of intervention; however, only the experimental exercise group's improvement was statistically significant.

**Table 3** Baseline characteristics of the spastic diplegic children in the study

Characteristics	Group A (n=21) mean±S.D.	Group B (n=21) mean±S.D.	t-value	p-value
Gender	0.29±0.46	0.33±0.48	-0.32	0.746
Age	10.71±2.86	10.29±2.47	0.51	0.607
Height	1.29±0.46	1.43±0.50	-0.95	0.346
Weight	39.81±12.36	42.19±12.52	-0.62	0.539
GMFCS	1.76±0.43	1.90±0.30	-1.23	0.224

S.D.=standard deviation, GMFCS=gross motor function classification system, n=number of children

**Table 4** Comparison of TUG within groups

Group	Pre-mean±S.D.	Post-mean±S.D.	mean difference±S.D.	t value	Effect size cohen's D	p-value
Group A	14.14±1.49	11.05±1.46	6.63±1.07	47.15	2.09	0.001*
Group B	15.23±2.91	14.19±2.65	15.01±1.92	9.64	0.37	0.001*

\*significant difference, TUG=time up and go, S.D.=standard deviation

**Table 5** Comparison of TUG between the groups

Variable	Time frame	mean±S.D.		t value	Effect size cohen's D	p-value
		Group A	Group B			
TUG	Baseline	14.14±1.49	15.23±2.91	-1.53	0.47	0.133
	8 <sup>th</sup> week	11.05±1.46	14.19±2.65	-4.74	1.46	0.001*

\*significant difference, TUG=time up and go, S.D.=standard deviation

The enhanced balance, as determined by TUG, was indicative of the benefits of pelvic control training. The capacity to adjust one's posture and balance is the foundation of all movement. When doing various activities that are essential for everyday living, the centre of gravity within the base of support (BOS)'s helps to maintain balance and posture. The postural adjustment mechanism helps the balance adjust to new circumstances as the BOS shifts<sup>17</sup>. Damage to the neuromusculoskeletal system can lead to issues with stability maintenance, weight load adjustment, and deterioration in standing posture; all of which can negatively impact functional recovery and cause balance and functional issues<sup>18</sup>.

During lateral and anterior-posterior weight transfers, the pelvis, a part of the lower trunk, offers dynamic postural stability. To do lateral flexion and rotation of the trunk when seated, a person must have better dynamic stability of the lower trunk and pelvis. Asymmetrical or excessive pelvic motion are examples of pathological pelvic motion. Greater than 10° on the kinematic measure in any of the three directions is considered excessive pelvic motion. This is typically caused by elevated tone, which has stiffened the hip joint and restricted hip motion<sup>12</sup>. Desloovere et al. observed a higher anterior pelvic tilt of 22.58° in a

group of children with diplegia that had not had any prior intervention<sup>19</sup>. In an effort to enhance their standing posture, the spastic diplegic children also exhibit lateral displacement of the spine<sup>20</sup>.

TUG task involves components like sitting, standing, walking and turning. After training, an improvement was seen in all the components of the TUG tasks, resulting in an improvement in the overall TUG score. This improvement is attributed to the pelvic control exercises, which included exercises such as weight shifting, and pelvic facilitation during sit-to-stand, stance and swing phases. They involved pelvic motions in the sagittal, coronal and transverse planes. As range of motion is essential for many movement patterns, including walking, action sequencing and balancing, it also helps a child develop a posture that supports postural alignment. Limitations on the range of motion will also affect the availability of dynamic and postural reactions, which cooperate to preserve balance and adjust for movement (the standard postural control mechanism). These exercises improved range of motion and proximal dynamic pelvic stability, which may have improved intra-limb coordinated synergistic motions involving the knee, hip and ankle joints. Additionally, the selective contraction of the proximal hip and lower trunk muscles may have



overcome the stereotyped movement patterns by reducing the excessive co-contraction and stiffness of the relevant lower limb muscles. The results of Dina, Said et al. also revealed that children with spastic CP benefit from pelvic stability training in terms of improving their balance<sup>8</sup>. This improvement was further favoured by Sharma et al.'s conclusion that proprioceptive neuromuscular facilitation, a type of pelvic training exercise, aids in improving pelvic control, which is crucial for preserving trunk control, gait and balance<sup>21</sup>.

The therapeutic exercise program focuses on a series of exercises that support maintaining a regular, upright posture and may have contributed to the improvement observed in the control group (B). This is consistent with research by Campbell et al., which showed that the traditional approaches to treating children with CP focus on assisting them in meeting developmental milestones in a sequential manner and encouraging normal movement patterns, so they can pick up practical skills<sup>22</sup>.

The study group (A) that had received pelvic control exercises had significantly improved after therapy; according to the two groups' post-treatment outcomes. The results of Ibrahim et al., that discovered a substantial association between balance and pelvic alignment in children with diplegic CP provided support for this<sup>7</sup>. Seon Woong Kong et al. examined how stroke patients' pelvic displacement affected their gait and balance. They found that training to correct pelvic tilting may improve balance ability. In addition to stroke, patients' reduced gait speed and balance ability are caused by greater pelvic displacement<sup>23</sup>. The control of the pelvis to execute the motions of the upper and lower extremities is necessary for the performance of functional tasks. It follows that therapies focused on the pelvis are thought to improve gross motor function and, consequently, TUG performance.

### Limitations

This study included no second long-term follow-up assessment; therefore, more research is required to evaluate long-term effects. This study included only spastic diplegic children. Additional research with varying GMFCS levels should be conducted on various CP subtypes. Though TUG is a valid and reliable scale to assess balance, objective measures; such as the biodex balance system, could not be used in the study.

### Conclusion

The results of this current study showed that adding pelvic control exercises is crucial for enhancing balance. Therefore, they ought to be included in the therapy programme for every child with spastic diplegic CP.

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There are no identified conflicts of interest that could prejudice this investigation. The authors declare that no commercial organisation, with a direct financial interest in any topic covered in this work has any financial link, including financing for research or interaction with us.

### Conflict of interest

There are no potential conflicts of interest to declare.

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## APPENDIX–A

### Pelvic control exercises for children with spastic diplegic cerebral palsy

#### Initial phase (2 weeks)

##### 1. Pelvic mobilisation

###### Posterior rotation of the innominate

Patient is in the side-lying position, with their bottom leg extended (to maintain a more neutral lumbar spine) and the top leg is flexed. Starting posture for the therapist involves supporting the patient's bent leg while standing in front of their hips. One hand is put on the posterior surface of the ischial tuberosity, while the heel of the other is positioned over the anterior iliac spine. Using both arms at once, push the anterior iliac spine posteriorly and superiorly, while pulling the ischial tuberosity down and forward, to perform the innominate's posterior rotation.

5 Reps X 2 sets



###### Anterior rotation of the innominate

Patient is in the side-lying position, with the top leg slightly extended and the bottom leg flexed to 90 degrees (to make the lumbar spine more neutral). Starting posture for the therapist is to stand behind the patient and place one hand on the iliac crest and ASIS of the top leg, while placing the heel of the other hand beneath the PSIS and buttocks of the same leg. Application of forces: Using both arms at once, push the PSIS superiorly and posteriorly, while pulling the ASIS and iliac crest's anterolateral border forward and down, to perform the anterior rotation of the innominate.

5 Reps X 2 sets



###### Central oscillatory P/A movement over the sacrum

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs grade 3 P/A oscillations at S1 (base), S3 (middle), S5 (apex).

5 Reps X 2 sets



###### Unilateral oscillatory P/A movement over the base of the sacrum

Patient lies in the prone position, the therapist, by standing on the side with the heel of hand, performs grade 3 P/A oscillations at S1 level on each side.

5 Reps X 2 sets



###### P/A movements to the PSIS

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs Grade 3 P/A oscillations on each PSIS.

5 Reps X 2 sets



**Initial phase (2 weeks)****Lateral movement of the PSIS**

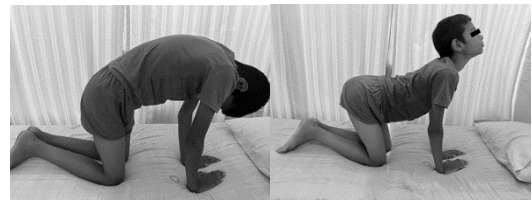
Patient lies in the prone position, the therapist, by standing on the side with both thumbs performs, Grade 3 lateral oscillatory translation on PSIS.

5 Reps X 2 sets

**2. Cat-camel exercise**

Place the patient in the quadruped position. Ask the patient to slump his shoulders down towards the floor, arch his spine like a camel, tuck his tailbone in, and produce a cat-like curve with his spine.

5 Reps X 2 sets

**3. Weight shifting on swiss ball**

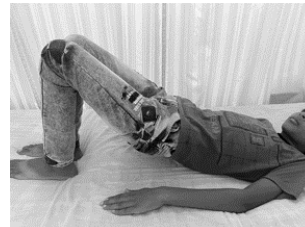
Place the patient on the swiss ball in a supported sitting position. Gently rock the ball from side to side and forward to back, while supporting their trunk or hips.

5 Reps X 2 sets

**4. Bridging**

Place the patient in a supine position and ask him to bend his knees and raise his pelvis.

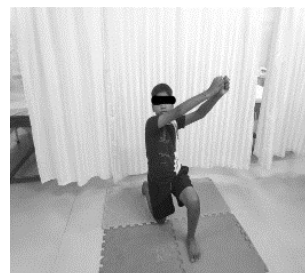
5 Reps X 2 sets

**5. Diagonal patterns in half kneeling**

Patient is in a half kneeling position, and does chopping patterns

5 left to right X 2 sets

5 right to left X 2 sets



**Initial phase (2 weeks)****6. Posterior tilting exercises while kicking football in front**

The patient stands with his weight on his left leg and moves or kicks a football with his right foot. The only thing he does is kick the ball hard enough to maintain control of the right leg and stop it from pushing into the full extension pattern, whether it's towards a wall or someone else. The therapist facilitates the movement by tilting the pelvis posteriorly.

5 Reps X 2 sets

**7. Posterior tilting exercises while taking step forward on a low height box**

The patient, while standing, steps forward and places one foot on the small step. He carefully places it on the stair, without hurrying or slamming it, while the therapist standing beside the patient tilts the patient's pelvis posteriorly.

5 Reps X 2 sets

**8. Pelvic stabilisation while maintaining hip-knee in 90-90 position**

The patient is in the standing position. While supporting the patient's body with one arm, the therapist stands behind the patient and lifts his foot up; while flexing his knee. With the aid of their hands, they support the lower leg between the knees, while allowing the thigh to fall towards the opposite knee; while maintaining a level pelvis. They carefully lower the foot to the floor once they sense that the injured leg is no longer pressing down into extension or pulling up with hip flexion. The patient tries to let their toes rest lightly on the ground behind them rather than forcing the foot downward.

5 Reps X 2 sets

**9. Pelvic facilitation during stance phase**

The patient is in standing position. The therapist places her hands on each side of the patient's pelvis to tilt the pelvis up at the front by placing her thumbs or the ball of her palm over the gluteal muscles to encourage hip extension and prevent knee hyperextension.

5 Reps X 2 sets



Reps=repetitions, PSIS=posterior superior iliac spine, ASIS=anterior superior iliac spine, P/A=posterior-anterior



**Improvement phase (2 weeks)****1. Pelvic mobilisation****Posterior rotation of the innominate**

Patient is in the side-lying position, with their bottom leg extended (to maintain a more neutral lumbar spine) and the top leg is flexed. Starting posture for the therapist involves supporting the patient's bent leg while standing in front of their hips. One hand is put on the posterior surface of the ischial tuberosity, while the heel of the other is positioned over the anterior iliac spine. Using both arms at once, push the anterior iliac spine posteriorly and superiorly, while pulling the ischial tuberosity down and forward, to perform the innominate's posterior rotation.

5 Reps X 2 sets

**Anterior rotation of the innominate**

Patient is in the side-lying position, with the top leg slightly extended and the bottom leg flexed to 90 degrees (to make the lumbar spine more neutral). Starting posture for the therapist is to stand behind the patient and place one hand on the iliac crest and ASIS of the top leg, while placing the heel of the other hand beneath the PSIS and buttocks of the same leg. Application of forces: Using both arms at once, push the PSIS superiorly and posteriorly, while pulling the ASIS and iliac crest's anterolateral border forward and down, to perform the anterior rotation of the innominate.

5 Reps X 2 sets

**Central oscillatory P/A movement over the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs grade 3 P/A oscillations at S1 (base), S3 (middle), S5 (apex).

5 Reps X 2 sets

**Unilateral oscillatory P/A movement over the base of the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of hand, performs grade 3 P/A oscillations at S1 level on each side.

5 Reps X 2 sets

**P/A movements to the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs Grade 3 P/A oscillations on each PSIS.

5 Reps X 2 sets

**Lateral movement of the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with both thumbs performs, Grade 3 lateral oscillatory translation on PSIS.

5 Reps X 2 sets



**Improvement phase (2 weeks)**

**2. Quadruped rocking**

The patient is in a quadruped position. Ask the patient to place their hands directly under the shoulders, whilst their knees should be directly under the hips. Rock backwards as far as they can without arching the lower back.

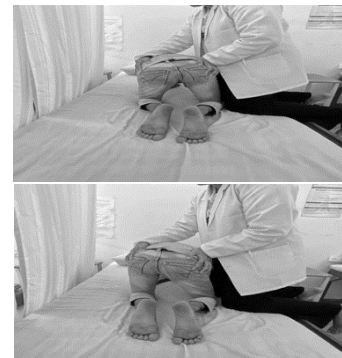
5 Reps X 2 sets



**3. Selective lateral movement of pelvis**

Patient is in a quadruped position and their weight is evenly distributed between the hands and knees. The patient is asked to tilt their pelvis up while the therapist places their hands on either side of it: shortening that side of the trunk. Then facilitates the other side of his pelvis by switching the direction of their hands' motion.

5 Reps X 2 sets



**4. Bridging with hold**

Same as in bridging, along with maintenance of position for 5 seconds

5 Reps X 2 sets



**5. Diagonal pattern with heavy object**

Patient is in a half kneeling position and does chopping patterns, while carrying a heavy object in their hands.

5 Reps X 2 sets

5 Reps X 2 sets



**Improvement phase (2 weeks)****6. Lateral tilting of pelvis while kicking football sideways**

5 Reps X 2 sets

The patient is in the standing position and moves or kicks a football sideways with their right foot, while standing with their weight over the left leg. The only thing they do is kick the ball hard enough to maintain control of the right leg and stop it from pushing into the full extension pattern; whether it's towards a wall or someone else. The therapist facilitates the movement by tilting the pelvis laterally.

**7. Anterior tilting of pelvis, while taking step backwards on a low height box**

5 Reps X 2 sets

While standing, the patient steps backward and places one foot on the small step. They carefully place it on the stair without hurrying or slamming it, while the therapist standing beside the patient tilting the patient's pelvis anteriorly.

**8. Pelvic stabilisation while, maintaining hip-knee in 90-90 position: carrying an object**

5 Reps X 2 sets

The patient stands with an object their hands. While supporting the patient's body with one arm, the therapist stands behind the patient and lifts their foot up, while flexing the knee. With the aid of their hands, they supports the lower leg between their knees while allowing the thigh to fall towards the opposite knee, while maintaining a level pelvis. They carefully lower the foot to the floor once they senses that the injured leg is no longer pressing down into extension or pulling up with hip flexion. The patient tries to let their toes rest lightly on the ground behind them rather than forcing the foot downward.

**9. Pelvic facilitation during swing phase**

5 Reps X 2 sets

The patient is in the standing position and releases their hip and knee, while allowing the heel to slide inward or in outward hip rotation in order to get ready to swing. The therapist applies pressure to the pelvis forward and downward along the femur's line as the hip and knee bend. They assist the pelvis rotate forward as the leg swings forward by preventing the patient from hitching up the side of it.



Reps=repetitions, PSIS=posterior superior iliac spine, ASIS=anterior superior iliac spine, P/A=posterior-anterior



**Advance phase (2 weeks)****1. Pelvic mobilisation****Posterior rotation of the innominate**

Patient is in the side-lying position, with their bottom leg extended (to maintain a more neutral lumbar spine) and the top leg is flexed. Starting posture for the therapist involves supporting the patient's bent leg while standing in front of their hips. One hand is put on the posterior surface of the ischial tuberosity, while the heel of the other is positioned over the anterior iliac spine. Using both arms at once, push the anterior iliac spine posteriorly and superiorly, while pulling the ischial tuberosity down and forward, to perform the innominate's posterior rotation.

5 Reps X 2 sets

**Anterior rotation of the innominate**

Patient is in the side-lying position, with the top leg slightly extended and the bottom leg flexed to 90 degrees (to make the lumbar spine more neutral). Starting posture for the therapist is to stand behind the patient and place one hand on the iliac crest and ASIS of the top leg, while placing the heel of the other hand beneath the PSIS and buttocks of the same leg. Application of forces: Using both arms at once, push the PSIS superiorly and posteriorly, while pulling the ASIS and iliac crest's anterolateral border forward and down, to perform the anterior rotation of the innominate.

5 Reps X 2 sets

**Central oscillatory P/A movement over the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs grade 3 P/A oscillations at S1 (base), S3 (middle), S5 (apex).

5 Reps X 2 sets

**Unilateral oscillatory P/A movement over the base of the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of hand, performs grade 3 P/A oscillations at S1 level on each side.

5 Reps X 2 sets

**P/A movements can also be applied to the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs Grade 3 P/A oscillations on each PSIS.

5 Reps X 2 sets



**Advance phase (2 weeks)****Lateral movement of the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with both thumbs performs, Grade 3 lateral oscillatory translation on PSIS.

5 Reps X 2 sets

**2. Isolated flexion-extension of pelvis in sitting position**

The patient is in a short sitting position, and the therapist places one hand on the patient's lumbar spine while standing or sitting in front of them. They pull the trunk forward until the hips are sufficiently flexed and it is vertically over his pelvis.

5 Reps X 2 sets

**3. Weight shifts in kneel standing position**

The patient is in a kneel standing position and shifts their weight from one leg to the other in turns. The therapist aids the pelvis' lateral mobility with their hands.

5 Reps X 2 sets

**4. Bridging with adductor squeeze**

Same as in bridging. Along with that, squeeze the thighs.

5 Reps X 2 sets



**Advance phase (2 weeks)****5. Diagonal pattern Half kneeling with catch and throw ball**

5 Reps X 2 sets

5 Reps X 2 sets

In a half kneeling position, the patient does diagonal chopping patterns, while catching and thrown ball.

**6. Forward rotation of pelvis while kicking a football crossing the midline**

5 Reps X 2 sets

The patient is standing and moves or kicks a football with their right foot towards the left foot, while standing with their weight over the left leg. The only thing they do is kick the ball hard enough to maintain control of the right leg and stop it from pushing into the full extension pattern; whether it's towards a wall or someone else. The therapist facilitates the movement by forward rotating the pelvis.

**7. Lateral tilting of pelvis while taking step sideways on a low height box**

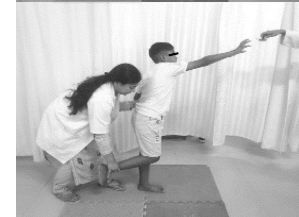
5 Reps X 2 sets

The patient is standing and steps sideways and places one foot on the small step. They carefully place it on the stair, without hurrying or slamming it, while the therapist standing beside the patient tilts the patient's pelvis laterally.

**8. Pelvic stabilisation while maintaining hip-knee in 90-90 position with reach-outs**

5 Reps X 2 sets

The patient is standing, while doing reach outs in front. While supporting the patient's body with one arm, the therapist stands behind the patient and lifts the foot up while flexing the knee. With the aid of their hands, they support the lower leg between the knees, while allowing the thigh to fall towards the opposite knee while maintaining a level pelvis. They carefully lower the foot to the floor once they senses that the injured leg is no longer pressing down into extension or pulling up with hip flexion. The patient tries to let their toes rest lightly on the ground behind them rather than forcing the foot downwards.



**Advance phase (2 weeks)****9. Pelvic facilitation during stance phase on an irregular surface**

5 Reps X 2 sets

The patient is standing on an irregular surface. The therapist positions their hands on each side of the pelvis for the patient, who still needs help extending the hip in order to prevent knee hyperextension. They tilt the pelvis up at the front by placing their thumbs or the ball of the palm over the gluteal muscles to encourage hip extension.

**10. Pelvic facilitation during swing phase on an irregular surface**

5 Reps X 2 sets

The patient is standing on an irregular surface. The patient releases their hip and knee, while allowing the heel to slide inward or in outward hip rotation in order to get ready to swing. The therapist applies pressure to the pelvis forward and downward along the femur's line as the hip and knee bend. They assist the pelvis rotate forward as the leg swings forward by preventing the patient from hitching up the side of it.



Reps=repitions, PSIS=posterior superior illiac spine, ASIS=anterior superior iliac spine, P/A=posterior-anterior

**Maintenance phase (2 weeks)****1. Pelvic mobilisation****Posterior rotation of the innominate**

5 Reps X 2 sets

Patient is in the side-lying position, with their bottom leg extended (to maintain a more neutral lumbar spine) and the top leg is flexed. Starting posture for the therapist involves supporting the patient's bent leg while standing in front of their hips. One hand is put on the posterior surface of the ischial tuberosity, while the heel of the other is positioned over the anterior iliac spine. Using both arms at once, push the anterior iliac spine posteriorly and superiorly, while pulling the ischial tuberosity down and forward, to perform the innominate's posterior rotation.



**Maintenance phase (2 weeks)****Anterior rotation of the innominate**

Patient is in the side-lying position, with the top leg slightly extended and the bottom leg flexed to 90 degrees (to make the lumbar spine more neutral). Starting posture for the therapist is to stand behind the patient and place one hand on the iliac crest and ASIS of the top leg, while placing the heel of the other hand beneath the PSIS and buttocks of the same leg. Application of forces: Using both arms at once, push the PSIS superiorly and posteriorly, while pulling the ASIS and iliac crest's anterolateral border forward and down, to perform the anterior rotation of the innominate.

5 Reps X 2 sets

**Central oscillatory P/A movement over the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs grade 3 P/A oscillations at S1 (base), S3 (middle), S5 (apex).

5 Reps X 2 sets

**Unilateral oscillatory P/A movement over the base of the sacrum**

Patient lies in the prone position, the therapist, by standing on the side with the heel of hand, performs grade 3 P/A oscillations at S1 level on each side.

5 Reps X 2 sets

**P/A movements can also be applied to the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with the heel of their hand, performs Grade 3 P/A oscillations on each PSIS.

5 Reps X 2 sets

**Lateral movement of the PSIS**

Patient lies in the prone position, the therapist, by standing on the side with both thumbs performs, Grade 3 lateral oscillatory translation on PSIS.

5 Reps X 2 sets

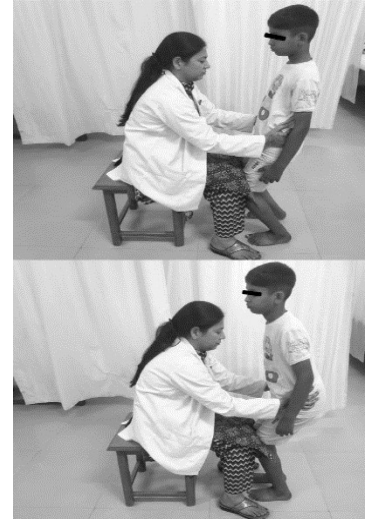




**Maintenance phase (2 weeks)****2. Pelvic tilting with knees bent**

The patient is flexing both knees while standing with his feet apart. While keeping his upper body, shoulders, and head stationary, they rhythmically tilt the pelvis anteriorly and posteriorly. The therapist helps them through the exercise with their hands and several verbal cues, until they succeed. They bend the lumbar spine and they place a hand under the buttocks, tightening the gluteal group; as if tucking in a tail. The lower abdominal muscles are helped to contract by the other hand. This gives them the impression that the lower abdominals are stretching and the buttocks are being raised at the rear when they are extending the lumbar spine

5 Reps X 2 sets

**3. Weight shifts in standing**

The patient, while standing, rotates their body as if they were skiing, shifting their weight from one side to the other while standing up straight with the hips and knees slightly bent. They relax the arms at their sides. With their hands on either side of his pelvis, the therapist helps the patient move by maintaining the supporting hip forward, while also facilitating the body's rotation.

5 Reps X 2 sets

**4. Bridging with one leg straight**

Same as in bridging. Along with that, the patient keep one leg straight.

5 Reps X 2 sets



**Maintenance phase (2 weeks)**

**5. Rotate upper body away from lower body**

Ask the patient to twist their upper body and pelvis in the opposite directions while holding a block between their legs.

5 Reps X 2 sets



**6. Pelvic facilitation while kicking football in all directions**

The patient uses their foot to kick a football in various directions with enough force to maintain control of their leg and keeps it from pushing into the full extension pattern; whether it is up against a wall or towards another person. The therapist facilitates the pelvic movement.

5 Reps X 2 sets



**7. Pelvic facilitation while taking step in all directions on different height of boxes**

The patient carefully places their foot on different heighted steps, placed in different directions, without hurrying or slamming the foot. The therapist, standing beside the patient, facilitates the pelvis accordingly.

5 Reps X 2 sets

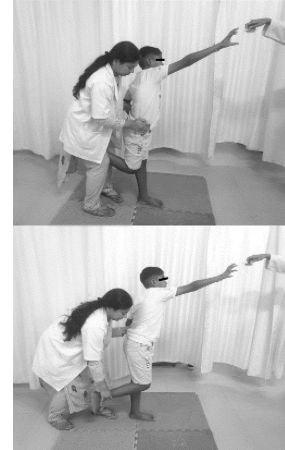


**Maintenance phase (2 weeks)****8. Pelvic stabilisation while maintaining hip-knee in 90-90 position with reach-outs in different directions**

5 Reps X 2 sets

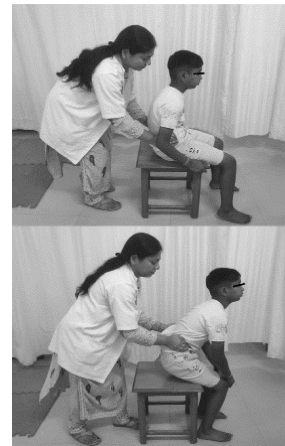
The patient is in the standing position.

While supporting the patient's body with one arm, the therapist stands behind the patient and lifts their foot up while flexing the knee. With the aid of their hands, they support the lower leg between the knees, while allowing the thigh to fall towards the opposite knee: while maintaining a level pelvis. They carefully lower the foot to the floor once they sense that the injured leg is no longer pressing down into extension or pulling up with hip flexion. The patient tries to let their toes rest lightly on the ground behind them, rather than forcing the foot downwards. While maintaining this position, the patient does reach outs in different directions.

**9. Pelvic facilitation during sit to stand**

5 Reps X 2 sets

The therapist facilitates the pelvis from posterior to anterior while patient does sit to stand.



Reps=repetitions, PSIS=posterior superior iliac spine, ASIS=anterior superior iliac spine, P/A=posterior-anterior