**A TOE WALKING WITH CLINICAL INTERPRETATION AND MANAGEMENT – AN OVERVIEW**

**Dr. Chandramohan. R, Assistant Professor, Garden City University, Bangalore.**

**Dr. R. Sedhunivas, Assistant Professor, Garden City University, Bangalore.**

**Dr. Senthilkumar. S, Professor and Research Supervisor, Garden City University, Bangalore.**

INTRODUCTION:

Toe walking is normal for children. Toe-to-toe walking in a 2-year-old is unusual. Chronic toe walking can result from Duchene muscular dystrophy, cerebral palsy, congenital Achilles tendon contracture, and unknown causes. Toe walking may also be caused by problems with development, autism, spinal cancers, myopathy, or neuropathic disorders. The long-term progression of unknown-cause toe walking is unknown. Long-term untreated toe walking can cause structural issues like outward tibia torsion, falls, and ankle mobility issues. However, research suggests that minor heel cord contractures can develop as often as slight regression without treatment. Long-term toe walking doesn't cause foot deformities, pain, or functional disruption.

A separate study links toe walking of unknown cause to learning difficulties, suggesting it may indicate developmental issues. Toe walking of unknown cause is diagnosed by elimination. Children with normal neurological exams and birth histories may develop toe walking for unknown reasons. Some experts believe a congenitally shorter tendon in the Achilles can lead to toe walking of unknown cause. Around 30% of children with toe walking of unknown cause had a positive family history, suggesting autosomal dominance and variable expression. Toe walking of unknown cause is usually diagnosed by medical history and physical examination, but distinguishing it from mild cerebral palsy like mild spastic diplegia can be difficult.

**Characteristic Features of Toe Walking:**

Spastic paralysis is a common cause of toe walking. Cerebral palsy (CP), traumatic brain injury, stroke, and toe walking of unknown cause usually start without heel contact. This toe-to-toe walking style is often caused by plantar flexor spasticity, contractures, and prolonged electromyography ankle activity. Toe walking reduces ground contact, stance stability, velocity, and strides.

Toe walking may benefit upper motoneuron lesions, according to recent research. Kerrigan et al. examined ankle and knee internal moments during toe and conventional heel-toe walking in fit subjects. Their research suggests that toe walking may require less ankle plantar flexor, ankle dorsiflexor, and knee extensor muscle strength than conventional walking, offering compensatory benefits.

Rose et al. used surface EMG to compare heel-toe and toe walking muscle activity. The study found premature gastrocnemius activity during previous swing and early stance while toe walking, and longer tibialis anterior and quadriceps activity during terminal stance than mid stance. These findings suggest that toe walking alters knee extensor and ankle dorsiflexor calf muscle demand and effort.

Gordon et al. found that sarcomere actin and myosin filament overlap affects muscle force output. In short positions, improper filament alignment within the sarcomere reduces force production, especially in muscle fibres with an optimal length. Increased ankle dorsiflexion increases passive plantar-flexor moment from muscles, ligaments, and soft tissues.

The importance of electromyography activity and mechanical moments as joint positions change during walking is crucial. Due to cost, treating equines may not be as important as previously thought, which can affect patient care. Brain palsy, muscular dystrophy, ASD, and global developmental delay are linked to toe walking. Unilateral toe walking, often caused by injuries or tumors, can also prevent the heel from touching the ground.

**Habitual Toe Walking / Idiosyncratic or Toe walking of unknown cause:**

Habitual toe walking is an abnormal tiptoe gait pattern without neurological or orthopaedic causes. It involves physiological toe walking after two. The front of the foot bears weight during gait cycle initial contact instead of the heel. 30% to 42% of habitual toe walkers have a positive family tendency, but 60% of these children's causes are unknown. Children who habitually toe walk prefer walking on their toes. This affects typical neurological and orthopedic children. Walking on the toes is not normal, unlike the typical development of heel strike at 18 months and heel-to-toe by age 3. Some consider toe walking a typical variation for children learning to walk. This phase usually ends three to six months after walking or by age seven. Toe walking has been observed in adolescents and adults.

Toe walking causes include congenital short tendo calcaneus, abnormal soleus muscle, unknown central nervous system defect, autosomal dominant inheritance, delayed cortical spinal tract maturation, normal transient phase of development, vestibular dysfunction, viruses, time spent walking as a baby, and habit. The cause of toe walking is unknown, but muscle biopsies of 25 toe walkers showed common abnormalities in muscle fibers and capillaries, suggesting a neuropathic process. Toe walking is common in cerebral palsy and muscular dystrophy children. This condition has been linked to autism, childhood schizophrenia, delayed language development, and low IQ. Toe walking without cerebral palsy affects 7% to 24% of children.

**Classifications:**

**Alvarez's Classification:**

Alvarez's classification assesses the severity of toe walking based on the presence of ankle rockers.

• Type 1 – Presence of ankle rocker, absence of early third rocker, and predominant first ankle moment.

• Type 2 – Presence of ankle rocker (yes/no), presence of early third rocker (yes/no), and absence of predominant first ankle moment.

• Type 3 – Absence of ankle rocker and predominant first ankle moment, presence of early third rocker.

**Perry's Classification:**

According to Perry, ankle kinetics is divided into three rockers. Toe walkers show alterations in these rockers.

• First rocker: Eccentric contraction of anterior tibia muscle during heel strike, leading to ankle plantar flexion.

• Second rocker: Eccentric contraction of gastrocnemius with dorsiflexion.

• Third rocker: Concentric contraction of gastrocnemius and soleus during push-off action.

**Pomarino Classification:**

Pomarino categorized idiopathic toe walkers based on distinctive clinical traits:

a. Type I: Small triceps surae muscle causing toe walking; recognizable by heart-shaped calves, deep Achilles tendon creases, and forefoot fat deposit.

b. Type II: Positive family history, "V" signs above Achilles tendon, and gastrocnemius muscle hypertrophy.

c. Type III: Heel support during walking; often resolves around ages 4-5, may persist in specific situations.

**Medical and Family History:**

The diagnosis of habitual toe walking excludes ankle equinus, cerebral palsy, and myopathy. A complete medical, family, gait, musculoskeletal, and neurological history is essential. Prenatal, intrapartum, and postnatal histories are needed to rule out neuromotor disorders. Toe walking runs in families, which is significant.

Toe walking evaluation: Consider cerebral palsy and other encephalopathies for differential diagnosis. Cerebral palsy spasticity aids diagnosis. Toe walking can indicate autism, sensory dissociation, PDD, and Asperger syndrome. Examining gait and family history helps rule out other causes.

Toe walking severity can be indicated by ankle rockers and kinetic changes. Diagnostics often require extensive medical and family histories and physical exams to rule out other disorders.

**I.Three equinus gaits:**

1. G1: Long progressive dorsiflexion, followed by plantar flexion until toe-off. This pattern was common in old equinovarus feet, myopathies, and neuropathies.

2. Short-lived dorsiflexion with progressive plantar flexion until toe-off in G2. The series had up to 44% Toe walking of unknown cause patients with this pattern.

G3: Double bump pattern, short-lived dorsiflexion, short-lived plantar flexion, and plantar flexion until toe off (Cerebral palsy pattern).

In GI neuropathy, the entire triceps surae muscle contracted prematurely. The phenomenon is not immediately apparent in early toe walking of unknown cause (ITW) cases. The outcomes in myopathy patients may be due to compensatory mechanisms due to weak quadriceps, anterior tibial muscles, and triceps surae. The clinical observations in children with advanced contractures matched all ITW gait studies. These gait studies showed:

**II. Gait Study Results**

***Gait Parameters Degrees***

1. Average anterior pelvic tilt: +6 degrees

2. Mean external hip rotation: +7.5 degrees

3 Peak Knee Flexion: -4.6 degrees

4 Peak dorsiflexion in stance: -14.8 degrees

5. Swing dorsiflexion: -16.1 degrees

6 Foot Progression Angle / External (+4.7 degrees)

All findings are due to limited dorsiflexion. Trying to plantigrade the limb causes adaptive external rotation of the hip and tibia.

**Gait Evaluation**

A gait analysis is essential for assessing and treating children who frequently walk on their toes. Careful gait observation starts this process. Analyze the child with and without shoes because shoes can hide a child's natural walking pattern. The following observations while the child is barefoot support the diagnosis of habitual toe walking:

The child walks well-coordinated, balanced, and efficiently on their toes.

Children toe walk with a normal angle and base of gait.

The child runs without tipping or falling.

The child can toe-walk forward and backward easily.

The child can stand with heels on the ground.

The child may start with heel-to-toe or full-foot contact and switch to rise-to-toe only as they walk faster.

In conclusion, a child who habitually walks on their toes should have gait observations similar to a normal, well-coordinated child who occasionally does so. A normal child will tire much faster walking on their toes than a habitual toe walker. Tread mats and video recording can help diagnose and track habitual toe walking. These methods record permanently and objectively.

**1. TREAD MAT:** A tread mat is a cost-effective way to record a child's gait pattern permanently. Creating a tread mat requires:

a. The roll of dark paper is about 20 inches wide.

b. Talcum or plaster powder.

c. A can of hairspray to permanently attach the powder to the paper.

The tread mat is made by placing powder at the end of a 15–25-foot paper strip. After powdering, the child is encouraged to walk on the mat. A powder imprint is left on the paper as the child walks or runs to the other end. You can assess a child's habitual toe walking forefoot and heel contact by watching the powder spread on the paper. The tread mat can measure gait angle, base, step length, and stride width.

**2. VIDEO GAIT ANALYSIS:** Evaluates toe walking and other gait disorders. This method evaluates gait patterns in stop-frame and slow-motion. To compare heel elevation at different gait phases between visits, straight-line comparison drawings can be made. This analysis helps keep treatment progress records.

**PHYSICAL EXAMINATION:**

Conduct a thorough musculoskeletal assessment for all patients with persistent toe walking as a major complaint. The static lower extremities exam of habitual toe walkers should show normal foot and leg alignment and appearance. There should be no sagittal, transverse, or frontal abnormalities or muscle atrophy. Attention is needed when measuring ankle dorsiflexion.

With the knee extended and the subtalar joint neutral, habitual toe walkers have at least 5–10 degrees of passive ankle dorsiflexion. Some new habitual toe walkers may have a slight ankle equinus, but this may be an adaptation to prolonged toe-walking. Large ankle equinus does not appear to be the main cause of habitual toe walking. As part of their age-appropriate neuromotor development, regular toe walkers should have normal deep tendon reflexes, vibratory sensitivity, positional sensation, pain sensation, temperature sensation, and muscle power.

Griffin et al. found that habitual toe walkers and normal walkers engage their gastrocnemius and soleus muscles during the swing phase of toe-to-toe gait using electromyography. Regular toe walkers had higher amplitude and duration of tibialis anterior muscle activity during heel-to-toe gait. The habitual toe walker's electromyography gait pattern normalized after successive castings.

**DIFFERENTIAL DIAGNOSIS:**

To distinguish habitual toe walking from other neuromuscular, psychiatric, and skeletal disorders, early assessment is crucial. Excluding other causes, habitual toe walking is diagnosed. Neuromuscular disorders like cerebral palsy and pseudoscissor gait must be ruled out.

**Cerebral palsy**: This non-progressive neurological disorder can occur before, during, or after birth. Movement issues and gait abnormalities can result. The spastic type of cerebral palsy usually causes toe walking. Children with cerebral palsy often have delayed independent ambulation, increased muscle tone, hyperactive reflexes, and other neurological symptoms.

**Pseudoscissor Gait:** This type of toe walking is different from cerebral palsy's scissor gait. Habitual toe walking and adducted limbs, often caused by femoral ante torsion, cause pseudo scissor gait. Pseudo scissor gait children are more stable than cerebral palsy children and may trip and fall more often but do not have spasticity or neuromata deficiency.

**Mental retardation**: Toe walking may cause mental retardation. Mental retardation can cause cognitive deficits, social adaptation issues, behavioral issues, hyper tonicity, ataxia, and seizures in children. **Rocking and head banging may also occur.**

**Autism:** Autism is mostly emotional and behavioral. Autism can cause isolation, anger when routines are disrupted, daydreaming, and sensitivity to criticism. Some children with autism toe walk, but they also have other autism-related behaviors.

**Diastematomyelia:** Tissue in the spinal canal divides the spinal cord. Neurological deficits affect bladder, bowel, and gait around age two or three. Foot and lower extremity deformities may be present.

**Muscular Dystrophy:** Duchene and mild limb-girdle muscular dystrophy can cause toe walking. Toe walking and pointed feet result from muscle imbalances and contractures. Temporal indicators help distinguish muscular dystrophy from habitual toe walking.

Each disorder is unique, so a healthcare professional must carefully evaluate it to make a diagnosis and determine treatment. The differential diagnosis process eliminates these and other conditions to diagnose habitual toe walking.

**Gastrocnemius Soleus Muscle Equinus:** Tight calf muscles (gastrocnemius and soleus) limit ankle dorsiflexion. This can cause toe walking. The Silfverskiold test evaluates this condition. Limited dorsiflexion when the knee is flexed and extended may indicate a gastrocnemius-soleus muscle equinus. Kids with this condition may also have knee hyperextension (genu recurvatum), midtarsal pronation, and an abducted stance angle when standing. Their gait may be bouncy due to early heel lift-off.

**Genetic Sensory Neuropathy Type I:** This neuropathy can cause toe walking in children. These kids may be misdiagnosed with idiopathic toe walking. They may have clawed hands, feet, and calf muscle hypotrophy. The condition is linked to neuropathy and has few case studies.

Kids with Mc Ardle illness, a muscular disorder, may toe walk. Their girdle muscles may be hypo trophic, their forefoot wider, and their calf muscles altered. However, the causes of toe walking in these cases need further study.

These conditions show how difficult it is to diagnose toe walking in children. To accurately diagnose and treat toe walking, medical professionals must evaluate each case.

The management of toe walking of unknown cause (ITW) in children without a diagnosis is controversial. While cerebral palsy, myopathies, and neuropathies are treated with physical therapy, exercises, bracing, casts, Botox, and surgery, "normal" children with ITW are uncertain.

Anecdotes and limited literature reviews suggest that non-operative ITW methods are no better than observation. This is because ITW causes premature firing of the gastrocnemius and soleus, which hinders anterior tibial muscle function. Older children over five respond poorly to non-operative treatment. Positive outcomes are more likely in 3–5-year-olds with mild ankle dorsiflexion restrictions. When uncorrected sensory issues cause recurring deformities and ankle dorsiflexion loss, surgery is considered.

Over 50% of ITW cases respond to physical therapy, daytime or nighttime bracing, Botox, and corrective casts. Treatments for two to four growth cycles yield better long-term results for younger children. Contracture improvement and restoration require sustained calf muscle stretching over 1-3 years of growth. Maintaining anterior tibial function and accommodating tibia and fibular growth requires constant muscle-tendon complex tension.

Recent orthopaedic research suggests surgery is the best option for ITW children who do not respond to non-surgical treatments. A specific group of ITW patients struggling with non-surgical interventions showed improved ankle motion after Vulpius-type releases or Achilles tendon lengthening. The full recovery of plantar flexion power was inconsistent.

Osteochondritis dessicans and increased lumbar lordosis may result from prolonged treatment delays. Surgical intervention is usually the best option after non-operative treatments fail. Accurate diagnosis requires thorough pre-treatment evaluation and gait analysis during key treatment phases.

Internal limb rotation abnormalities can cause tripping and falling during habitual toe walking, which is often considered a developmental phase. Accelerating the transition from toe walking to heel-toe gait may prevent chronic toe walking-induced structural ankle equinus. Orthotics, serial casting, cognitive muscle management, shoe modifications, and surgery have been used to treat habitual toe walking.

Shoe therapy restricts metatarsal-phalangeal joint dorsiflexion with rigid-soled, straight-last shoes. Incorporate high-top shoes and heel lifts. Heel lifts, gait plates, and ankle-foot orthoses treat habitual toe walking. Toe walking can be reduced with auditory feedback. When structural equinus is severe, Achilles tendon lengthening surgery is considered.

Intervention needs and ankle dorsiflexion limitations must be observed. Dorsiflexion reduction requires stretching. Children with good ankle dorsiflexion range of motion benefit from gait re-education and motor control interventions. Auditory feedback establishes normal gait patterns, and footwear treatment limits metatarsal-phalangeal joint dorsiflexion.

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