Idiopathic Toe Walking

Children often begin ambulation on their toes before transferring to a normalized heel-to-toe gait pattern. However, some children maintain toe walking past two to three years of age creating a cause for concern.[1-9] Toe walking is defined as the inability to produce a heel strike immediately upon initial contact phase and absence of full foot contact throughout the entire standing phase of the gait cycle, which is commonly observed in typically developing toddlers.[4.10] On average 24% of toddlers toe walk before it spontaneously disappears.[3] One cause of toe walking, with an unknown etiology, is Idiopathic Toe Walking (ITW), also referred to as tip toe walking, or habitual toe walking.[4, 5,11] Idiopathic toe walking occurs in 7-24% of the pediatric population and a diagnosis of exclusion.[4, 12] Fox et al. along with numerous other studies of various sizes have consistently reported a higher incidence of male children are affected by ITW compared to females, with a range of 50-80% of ITW being male.[5] This paper will examine ITW and the various treatment options.

ANATOMY

The triceps surae is located in the superficial posterior compartment of the lower leg and composed of the gastrocnemius, soleus and plantaris muscles.[11, 13] The gastrocnemius originates from the lateral femoral condyle and popliteal femur surface and responsible for primary plantarflexion and secondary knee flexion.[11, 13,14] The plantaris originates on the lateral supracondylar femur line and assists in ankle plantarflexion.[13, 14] Meanwhile, the soleus originates on the posteriosuperior fibula and proximal tibia soleal line to plantarflex the ankle before both the gastrocnemius and the soleus merge to form the Achilles tendon (calcaneal tendon).[13, 14] On average, the Achilles tendon is 2.5cm in diameter and 15cm long, inserts on the calcaneous, and is fairly vascular except for the middle region 2-5cm proximal to its insertion due to tendon spiraling.[11, 13] During ambulation the triceps surae plays a prominent role with tightness leading to compensatory mechanisms observed.

A tight triceps surae causes early heel off, increases ground reaction forces in the forefoot and can result in forefoot overload due to the center of mass shifting forward in relation to the foot.[15] Compensation is accomplished through increasing lumbar lordosis, hip flexion, knee recurvatum, leg external rotation or subtalar joint pronation. [15] These mechanisms bring the heel closer to the ground to improve contact area and reduce contact pressure.[15] When subtalar joint pronation occurs, this increases the tibialis posterior tendon and spring ligament strain and can lead to dysfunction.[15]

BIOMECHANICS

Children typically begin walking between ages 12-18 months.[7, 11] Initial, walking begins with a wide base of support and guarded upper extremities for balance before progressing, to a narrower base of support and reciprocal arm-swing at 22 months (or 11 months after initial independent gait), and consistent heel-toe gait pattern by 24 months or 22.5 weeks after initial independent gait.[5, 7,11] Gait by then should resemble a mature gait with initial weight bearing at the heel and termination with toe off.[3]

Prior to two years old, toddlers demonstrate greater sagittal plane knee flexion and ankle dorsiflexion in stance phase, diminished knee-flexion wave, increased external hip rotation, and decreased swing phase dorsiflexion.[10] As a child's nervous system develops and learning transpires, gait closer resembles an adult's by age seven with observed decreased cadence, increased walking velocity, and increased step length compared to a two to six year old.[10]

Typical mature walking kinematics consists of the stance phase followed by the swing phase.[11, 16] The stance phase represents roughly sixty percent of the cycle and consists of weight loading double stance followed by transfer to single leg stance then a second double stance for weight unloading.[11, 16] During a single gait cycle the right and left foot have initial heel contact followed by flat foot, midstance, heel rise, and lastly toe off before completing the swing phase.[11, 16] Swing phase represents roughly forty percent of the cycle and consists of an initial, mid and terminal swing.[11,16] During this phase the ankle is dorsiflexed for ground clearance.[11, 16] At the same time the right foot is in single leg stance the left foot is in swing phase.[11, 16]

During the first twelve percent of the gait cycle the first ankle rocker (heel rocker) occurs from initial foot contact to foot flat as the tibialis anterior eccentrically plantarflexes the foot. In the second ankle rocker the tibia progressed forward over the foot by eccentric triceps surae contraction from foot flat to heel rise.[1, 11, 16] The third rocker (forefoot rocker) occurs from heel rise to toe off with the ankle plantarflexed and the triceps surae concentrically contracting for push off after 40% of the gait cycle is complete.[11, 16] The combined ankle motions require the triceps surae to be active during 75% of each stance phase and allow for a minimum of 10° of ankle dorsiflexion.[1, 11, 16]

However, with ITW weight loading, transfer and weight unloading from heel-toe is missing, frequently due to limited dorsiflexion range.[3] Kelly et al. further determined ITW presents only with limited passive ankle dorsiflexion (mean +5°, range -10° to +15°) during the clinical examination.[17]

Alvarez et al. developed an ITW classification system based on severity with Type 1 mild, Type 2 moderate, and Type 3 severe idiopathic toe walking. [1] The three criteria are first ankle rocker presence greater than 5° of plantarflexion at initial contact, early third ankle rocker presence ≤ 30% of the gait cycle, and first ankle moment (initial stance peak plantarfexor to late stance peak plantarflexor moment ratio greater than one.[1] Children are categorizes as type 1 when there is only presence of the first ankle angle.[1] Type 2 has presence of the first ankle rocker and/or early third ankle rocker, while Type 3 has presence of an early third ankle rocker and first ankle moment.[1] Alvarez et al demonstrated significant difference in severity type variable and significant within severity type group differences (p >0.05) for variables.[1]

Compared to Other Conditions with Toe Walking

The diagnosis of ITW is challenging to differentiate from other causes of toe walking, but mild diplegia cerebral palsy is perhaps the hardest to differentiate according to Sola et al, especially, if surgery is being considered .[15] Clinically, ITW and CP observed gait can appear almost identical although there are a few key presentations that help to separate the two disorders.[15, 18] Cerebral palsy typically causes primary tight or contracted hamstrings with normal triceps surae muscle tone and secondary equinus.[15] However, limited dorsiflexion due to primarily tight or overactive triceps surae is present in ITW.[15,18] Kelly et al. assessed 50 children toe walking, 23 due to mild spastic diplegia cerebral palsy, 22 with ITW, and five typical children.[17] They found knee and gait patterns differed between spastic diplegia and ITW while the children with ITW has demonstrated the same gait pattern as typical children.[17] The main differences seen were cerebral palsy caused ankle dorsiflexion excursion during the swing phase while ITW caused initial dorsiflexion excursion until mid-swing then changes to active plantarflexion.[17] Another by Hicks et al. demonstrated that children with ITW and CP both have absent heel strike although the kinematics differ.[19] Idiopathic toe walking increased plantarflexion caused initial toe or flat foot contact and cerebral palsy's knee flexion caused initial flat foot contact.[19] O'Sullivan et al. further demonstrated that ITW typically presents with normal knee patterns while spastic diplegia cerebral palsy presents with knee flexion patterns.[12]

Toe walking, when observed with Autism, is difficult to determine the mechanism.[20] Accardo et al. examined whether the cause was sensory, language, or motor.[20] Motor involvement may have a stronger relationship with toe walking, since the tonic labyrinthine reflex (P = .04222) was associated while sensory symptoms (P = .5298) and language age (P = .6142) demonstrated no association.[20] An interesting report, by Armand et al., on the analysis of the percentage of toe walking deviation relation to diseases report cerebral palsy (62%), myopathy (51%), idiopathic toe-walking (83%), and arthrogryposis (65%) had over 50% of toe walking present, plus the control group of able-bodied children (100%).[2] Many other diseases with toe walking had below 50% deviation: neuropathy (44%), clubfoot (29%), spina bifida (18%), gait with internal rotation (17%), pes cavus (20%), scoliosis (6%) and agenesis (3%).[2]

Examination

A detailed history that includes any pregnancy and birth complications, milestones reached, age with first ambulation, medical history, and any family history of toe walking.[11] Every child with possible ITW should undergo a thorough neurological, orthopedic and gait pattern examination. [11] The neurological examination should examine for contracture or tone in the extremities, strength and sensation, deep tendon reflexes, and pathological reflexes to exclude any neurological condition. [11] During the orthopedic examination cutaneous abnormalities, pelvic asymmetry, leg length discrepancy, foot deformities, knee and ankle joint range of motion, abnormal muscle development and muscle asymmetry need to be assessed to rule out a primary or secondary cause of toe walking. [11] Lastly, an observation of the child's gait while barefoot should be performed to allow lower extremity evaluation for gait deviations. [11]

The Engelbert et al. cross-sectional study with children age ranging 8.0 - 19.9 reported 9% of children had decreased ankle range of motion and self-reported toe walking.[4] These children had significant decrease in quantitative bone density, significant increase in muscle strength, and three times higher risk for severe dorsiflexion restrictions. Furthermore**,** clinical observation of preschool children with ITW reveals toddler gait qualities: running rather than walking, poor pace modulation, and jumping or hopping instead of controlled steps.[3] Play observation may reveal avoidance of transition movements, which need eccentric lower extremity muscle control.[3] Theses characteristics may indicate slow reciprocal dorsiflexion–plantar flexion development and failure to achieve full upright trunk posture.[3] With a forwardly displaced trunk, the weight-bearing point of contact is confined to the forefoot, and heel-toe weight transfer is absent.[3]

Idiopathic toe walking is a diagnosis of exclusion that requires differential diagnostic screening to rule out neurological, musculoskeletal, developmental and pervasive disorders.[4, 18] Possible central nervous system disorders include cerebral palsy, lesion of the tractus corticospinalis, hyperkinesia disorders, and transient dystonia. [2, 4,7,8,11, 20, 21] Peripheral neurological disorders include congenital/acquired spinal cord lesion, diastematomyelia, spina bifida, and spinal tumor, and sensory processing disorders. Peripheral neuromuscular disorders include muscular dystrophy and neuropathy. [2, 4,7,8,11, 20, 21] Musculoskeletal disorders include congenital contracture or shortness of the Achilles tendon or triceps surae, clubfoot, arthrogryposis, and leg length discrepancies. [2, 4,7,8,11, 20, 21] Developmental and pervasive disorders include autism spectrum, pervasive developmental disorder, and language or learning developmental disorders.[2, 4,7,8,11, 20, 21] One less common cause that can be mistakenly diagnosed as ITW is a venous malformation of the posterior calf, which causes pain with walking and appears as unilateral or bilateral asymmetrical toe walking.[11, 22]

Outcome measures

These are a few of the outcome measures that are specifically related to toe walking or commonly completed in ITW studies. These by no means represent all the outcome measures used to assess ITW, but bring up ones that are not seen as often. The Normalcy Index (NI) is a relatively new tool to determine the gait deviation in patients compared to a typical person (found in appendix). [23] Romei et al. developed the measure using a small sample size and demonstrated the NI could differentiate between ITW, plegic limb in cerebral palsy, and typical subjects reliably for quantitative gait evaluation.[11, 23, 24] Another reliable and validated outcome is the online Toe Walking Tool (found in appendix) that has been utilized to identify medical and idiopathic related toe walking.[24] The tool was developed by Williams et al. and consists of a 28-item exclusion questionnaire to aid physicians in identifying medical conditions related to toe walking.[24] It breaks down in to demographics, trauma, and neuromuscular indicator questions that prompt further questioning or medical referral.[24] Lastly, a subjective parent questionnaire, the Five to Fifteen is used to identify strengths and concerns associated with neuropsychiatric symptoms through 181 question in eight different domains.[21,25] Engstrom et al. used a score above the 90th percentile to classify a child as having difficulty with tasks.[21,25]

TREATMENT OPTIONS

i. Physical Therapy

Physical therapy is often a first approach, especially with younger children to correct the ITW and prevent future problems due to tight triceps surae. Treatment involves stretching to improve tissue length and decrease Achilles tendon contractures if present.[11] Physical therapy is often combined with other conservative treatment methods and incorporates more functional mobility and play for younger children to complete with therapist and in parent directed home exercise programs.[9, 25, 26, 27]

ii. Motor Learning/ Motor Control Physical Therapy

In young children (under seven years) motor learning and control occurs regularity as children develop skills.[3] Motor control is the ability to regulate mechanisms necessary for movement and motor control interventions work towards improving movement capacity.[3] Clark et al. designed and implemented a physical therapy protocol aimed at influencing gait and preventing or reversing muscle contracture.[3] Therapy activities focused on muscle activation, posture deficiencies, and maintenance of ones center of mass atop the feet.[3] In theory, the gains in stance would produce a spontaneous heel to toe gait pattern and avoid or reverse ITW in their five pre-school-aged subjects.[3] Physical therapy consisted of 2x1hr sessions per week for nine week and addressed stair-step standing, dynamic standing balance, stooping, transitions, controlled stepping, heel to toe practice, sensory and intrinsic foot activities that were age appropriate.[3] The results indicate statistical significance between pre- and post-intervention ($p = 0.007$ and $p = 0.005$). Although, the intervention did not cause a shift in gait pattern as predicted.[3] This approach is quite difference than traditional orthopedic physical therapy that aims to improve dorsiflexion range of motion through passive stretching, but the protocol did manage to improve dorsiflexion. A combination of therapy methods may be beneficial at stretching posterior calf tissues and training children to not rely on ITW.

In another study, Houx et al. examined muscle activity adaptation patterns for normal children fitted for right ankle orthosis under five induced conditions, 10° dorsiflexion, 0°, 10°, 20°, and maximum plantar flexion.[28] Their results demonstrated significant shifts muscle activation and co-activation once plantar flexion reached 10° for the right orthosis limb and again with maximum plantar flexion in the left limb.[28] Interestingly, soleus activation was premature in terminal swing, increasing with equinus severity.[28] Terminal swing tibialis anterior activation decreased but increased for initial and midswing.[28] During loading response at 20° plantar flexed hamstring activity increased and during stance phase the vastus lateralis and rectus femoris activation increased.[28] Furthermore, the Williams et al. study investigated motor skill and sensory processing abilities in children four to eight years old and found that those with ITW had inferior performance on the Bruininks–Oseretsky Test of Motor Proficiency and Standing Walking Balance subtest of the Sensory Integration and Praxis Test while also demonstrating a lower vibration perception threshold that non toe walkers.[19]

iii. Orthoses

Orthoses come in a variety of styles and are external devices frequently used to prevent compensation, improve alignment, correct deformities, increase gait efficiency and mobility.[30] The Ankle Foot Orthosis (AFO) with 90° plantar flexion block is used to prevent plantarflexion and decrease gastrocnemius activity.[30] Herrin et al compared the results of eighteen children with ITW wearing AFO or Foot Orthosis (FO) for six weeks.[26] Interestingly, ITW gait was controlled by the AFO when worn 100%, but the less restrictive and controlling FO had significant out-of-brace gait pattern effects when removed ($p<0.001$).[26] The AFO had poor carry-over results ($p = 0.175$) due to its restrictive nature and does not indicate a learning effect occurs when the child were using a heel-toe gait pattern.[26] However, the FO allowed for a greater learning effect and may have decreased the sensory-perceptual effects that can cause the child to resort to ITW.[26]

iv. Casting

A common conservative method for children with ITW is casting or serial casting because it gradually stretches the gastrocnemius and posterior compartment and ankle soft tissue leading to increased ankle dorsiflexion.[5] Clinically, dorsiflexion with knee flexed is of greater importance then knee extended due to its necessity in the gait cycle.[5] Fox et al treated children with ITW with below the knee serial walking casts followed by physical therapy instructing parents on passive Achilles tendon stretching exercises.[5] The method was used to treat 44 children (2 -14.3 years) with ITW.[5] Afterwards there was a 66% improvement in gait, clinical outcomes, and significant improvements in ankle dorsiflexion with the knee flexed ($p = 0.001$), although not with the knee in extension ($p = 0.23$).[5] An independent case study of an18 month old ITW also demonstrated success with serial below the knee casts and AFO bracing that improved bilateral passive ankle dorsiflexion to +10° and created a heel-toe walking pattern.[31] At 12 month post-treatment, mild left ankle ROM was the only diminished outcome.[31]

v. Botulinum Toxin

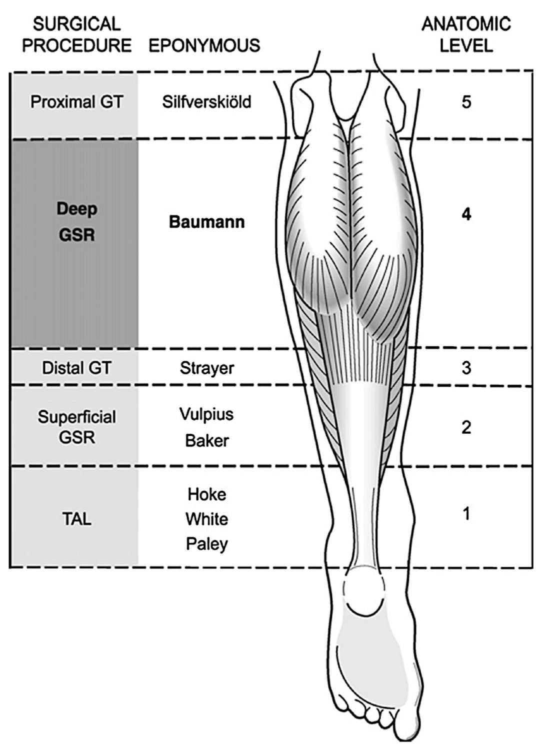
Botulinum toxin (BTX) is a highly poisonous biological neurotoxin that is created by the *Clostridium botulinum* bacteria.[32] It has eight antigenic exotoxin serotypes (A, B, C_1, C_2, D, E, F, and G) that block the release of the neurotransmitter Acetylcholine at the neuromuscular junction, producing muscle paralysis. [32] The effects of BTX are used to treat a variety of medical conditions including toe walking. [32] BTX- A has the most potency followed by types B and F toxin and causes striated muscle weakness by inhibiting alpha motor neuron transmission. [32] A sterile lyophilized form of BTX-A is used for injections. [32]

Engstrom et al. compared children treated with a walking circular cast (CA) to an experimental group who received botulinum toxin-A (CA +BX) prior to casting.[25] Both groups afterwards also completed a physical therapist instructed home exercise program. [25] After 12 months post-treatment there were no significant differences between the two groups ($p = <0.001$). [25] Both groups improved stance and swing phase maximal ankle dorsiflexion (CA -3.4°

to 6.7°, CA+BX -3.3° to 7.9°) and maintained dorsiflexion later in the gait cycle (12 month post percentage of gait cycle - CA 33.9, CA+BX 38.1), which is closer to the typical 30 percent seen in children.[25]

vi. Surgery

Currently, surgery for ITW is either a minimally invasive open or endoscopic technique.[13] The endoscopic technique leads to fewer complications and more cosmetically aesthetically. [13] A percutaneous technique has also been used for ITW, but there is risk for over-lengthening the Achilles tendon and usually reserved for non-ambulatory patients.[6] There are five anatomical levels for surgical release of the triceps surae complex to occur. They are distal to proximal with the Silfverskiöld test used to determine isolated gastrocnemius or gastroc-soleus complex contracture. [13,15]



- Level 1: Located at the calcaneal (Achilles) tendon and uses a direct percutaneous or open tendo-Achilles lengthening (TAL) technique.[11, 13]
- Level 2: Located at the common aponeurotic tendon of the gastroc-soleus to the proximal soleus muscle and uses the Vulpius and Baker technique- gastrocnemius recessions. [11,13]
- Level 3: Located from the merger of gastrocnemius muscle bellies to the proximally merged gastroc-soleus aponeurosis and uses the Strayer technique - an open gastrocnemius, endoscopic gastrocnemius recession, or gastrocnemius intramuscular aponeurotic recession. [11,13]

- Level 4: Located at the medial and lateral gastrocnemius muscle bellies and uses the Baumann technique of deep gastrocnemius or soleus recession. [11,13]
- Level 5: Located at the proximal insertion and tendons of the medial and lateral gastrocnemius heads and uses the Silfverskiöld original procedure; a transfer of the proximal gastrocnemius insertion from the femur to the tibia. [11,13]

The surgical method used for lengthening the triceps surae complex was done for patients with limited ankle dorsiflexion using the Silfverskiöld test results to determine the necessity and release level.[11] Oetgen et al. recommends those identified with a fixed equinus contracture undergo lengthening surgery followed by 6 weeks of short walking cast(s). [11] All 15 children who underwent percutaneous Achilles tendon lengthening in Kogan et al. (1993-1999) followed by 1 month of below the knee casts had no toe walking reoccurrence, painful scar, or noticeable weakness.[6]

Treatment Outcomes

Conservative treatment through physical therapy, casting, and bracing have a short term (2 years or less) effect on ITW, but have not proven to have long-term treatment effects for preventing tight triceps surae.[27, 33] Botulinum toxin A, as well, has not proven to demonstrate post-treatment improvement in relation to pre-treatment measurements.[25, 27, 33] Corrective orthotics, either AFO's or FO's may be beneficial in treating ITW to normalize gait in the long-term, but further research is needed to demonstrated its success and determine the exact length of time for the best results. The AFO prevents ITW when worn by mechanically preventing gross adaptation in proximal joints, such as excessive hip and knee flexion, but the reduced return leads to question its treatment value because of the poor return rate.[25] The FO requires less adaptation for the child to achieve initial toe contact, is easier for parents to don/doff their child, and may correlate to increased frequency of wearing compliance, indicating this may be the best overall choice for the family.[25] However, clinicians must remember, the FO does not control ITW from occurring. Conservative treatment for ITW in Hirsch et al. 7-21 year follow-up for physiotherapy, casting, orthoses, or a combination demonstrate long-term results did not stop toe walking, which may spontaneously stop.[33]

The results for botulinum toxin - A suggests injections are not necessary for treating idiopathic toe walking because it does not improve ITW limitations.[25, 27] However, children with ITW have a good chance of benefit from non-surgical casting treatment to improve their maximum dorsiflexion, ankle kinematics, improve ankle rocker, and decrease ITW classification severity. There is not enough research on physical therapy passive stretching alone to determine if this is an adequate stand-alone ITW treatment option. Physical therapy stretching in combination with casting and/or orthosis does demonstrate improvements in ambulation, maximum passive dorsiflexion, and reduction of ITW in the short term. It appears further conservative treatment would be necessary to continue maintenance of improved dorsiflexion and ambulation. Van Kuijk et al. systematic review of ITW treatment options demonstrates physical therapy results in 5°-10° casting results in neutral ±5°, and surgery results in -5° to -10° of post-intervention maximum dorsiflexion ITW treatment success.[27] The greatest maximum passive dorsiflexion was seen in physical therapy since the children were the youngest, around 5 years old when being treated.[27] Casting treatment occurred around 7 years old and surgical treatment children were older (>7 years) and demonstrates the most severe maximum passive dorsiflexion limitations prior to treatment.[27]

Conservative treatment alone is effective at improving walking kinetic and kinematics, although normal gait appears not to be achieved and the effect is short lasting. Surgical treatment for ITW does create long-term results, however lengthening surgeries should be reserved for children demonstrating a fixed ankle-joint contracture.[11, 15, 33] The risk for complication following surgery is low, passive dorsiflexion post-operatively may not reach neutral, and gait is improved but does not create a normalize gait pattern.[15] There are several surgical options available for children with ITW triceps surae contracture and a surgeon may prefer to complete a gastrocnemius release over an Achilles lengthening to create overall better results.[15]

Conclusion

Early identification of children with ITW and expedited treatment creates a better chance of optimizing outcomes and preventing lasting effects.[7] Children over two years who demonstrate ITW without contracture should first be treated with passive stretching, motor control, bracing or casting in combination to improve maximum passive ankle dorsiflexion and a heel-toe gait pattern. In order for children to maintain their increased maximum dorsiflexion, clinicians must strongly iterate repetitively the necessity of parent(s)/child to continue their home exercise program. This is especially true for children who experience rapid growth in height and weight, as the tissue to bone length ratio may not be equal. Clinicians need to communicate to parents that conservative treatment may later require another round of treatment as the child ages to prevent an increase in ITW. Older children (age >7 years) with triceps surae contracture should be referred to an orthopedic surgeon for surgical release or tendon lengthening procedure possibility. The preconceived effect of any treatment by parents or clinicians should be cautioned as creating too high and expectation will lead to treatment effect failure. The best option for clinicians is to provide the parent(s) and child with research backing up the various treatment methods for ITW and their results.

Resources

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Appendix

Normalcy Index[34]

"To evaluate whether a specific gait variable is normal, abnormal, or improved following treatment, the natural correlation that exists between gait variables must be determined. For this reason multivariate statistical techniques are used to develop a measure of how closely an individual gait pattern approaches normal. This 'closeness' is referred to as the normalcy index."

"In simplest terms, the normalcy index can be considered a measure of the distance between the set of discrete variables describing a patient's gait pattern and the average of those variables in persons with no gait abnormalities. Because the discrete gait variables are correlated, a simple distance calculation between the original discrete variables and the mean value that is expected for a normal gait pattern would not be expected to accurately represent the degree of gait abnormality. However, using techniques from multivariate statistics it is possible to uncorrelate the discrete variables and calculate the distance in a new uncorrelated coordinate system. The normalcy index is the square of this uncorrelated distance."

Toe Walking Tool[24]

Toe Walking Tool questions and order of progression.

Question	Theme	Response that may indicate a medical cause
Name	Demographics	Not Applicable (N/A)
Date of birth	Demographics	N/A
Gender	Demographics	N/A
Does the child toe walk	Demographics	N/A
Does the child have a condition that you have sought medical assistance for and/or been diagnosed with a condition causing toe walking?	Demographics	N/A
Does the child have a diagnosis of autism spectrum disorder?	Neurogenic	Yes
Does the child have a diagnosis of cerebral palsy?	Neuromuscular	Yes

Does the child have a diagnosis of muscular dystrophy?	Neuromuscular	Yes
Does the child's family have a history of muscular dystrophy?	Neuromuscular	Yes
Does the child have a diagnosis of global developmental delay?	Neurogenic	Yes
When the child was born, was their birth weight over 2500 g?	Neuromuscular	No
When the child was born were they over 37 weeks of gestation?	Neuromuscular	No
Was the child admitted to special needs nursery/neonatal intensive care after birth?	Neuromuscular	Yes
Did the child independently walk prior to 20 months of age?	Neuromuscular / Neurogenic	No
Does the child have a family member that toe walks with no other medical condition?	Demographic	N/A
Does the child toe walk on one foot only?	Traumatic	Yes
Is the child toe walking in response to pain?	Traumatic	Yes
Did the child previously walk flat footed and only recently start to toe walk?	Traumatic/ Neuromuscular	Yes
When you ask the child to walk on their heels are they able to?	Traumatic/ Neuromuscular	No
On testing the ankle or hamstring range of motion is there a clonus and/or catch?	Neuromuscular	No
When asking the child to get up from the floor is there a positive Gower's sign?	Neuromuscular	Yes
Is there a normal knee jerk reflex?	Neuromuscular	No
Is there a normal Babinski reflex?	Neuromuscular	No
a. Are the hip flexors tight for the child's age (Thomas test)?	Neuromuscular	Answer of Yes for 2 of the questions
b. Are the hamstrings tight for the child's age (Popliteal Angle)?		
c. Is the gastrocnemius and soleus tight for the child's age (Lunge Test)?		
Does the child have more than 2 significant delayed developmental milestones?	Neurogenic	Yes
Does the child have limited eye contact, have strict rituals or ritual related behavior, i.e., lining up toys, rocking or spinning	Neurogenic	Yes