Review

Literature Review of Idiopathic Toe Walking

Etiology, Prevalence, Classification, and Treatment

David Pomarino, Juliana Ramírez Llamas, MSc, Stephan Martin, MD, and Andrea Pomarino, MD

Abstract: Purpose: *The main objective of this review is to gather the information available about idiopathic toe walking (ITW), its prevalence and classification, and possible therapeutic approaches. In addition, this review aims to clarify the differences between idiopathic toe walkers and tiptoe walkers with underlying neurological or muscle deficiency as primary conditions. Understanding its causes and learning to make a differential diagnosis will help determine the adequate therapeutic approach.* Methods: *This is a review of different articles and case studies from 1967 to 2016. The information was gathered to update and unify all the information about ITW that has been published.* Conclusion: *The literature offers limited research regarding the possible etiology, prevalence, classification, and evaluation of ITW. This review puts together all the information regarding the etiology, prevalence, classifications, evaluation, and treatment of ITW.*

Levels of Evidence: *IV*

Keywords: review; idiopathic toe walking; tiptoe walking pattern; classification; prevalence; etiology; treatment; evaluation

Introduction

Idiopathic toe walking (ITW) was first described as a congenitally short Achilles tendon[1] and currently is defined as a pathological gait pattern on the tiptoes with no neurological or orthopedic cause.[2,3] It is also described as the abnormal persistence of primarily physiological toe walking after 2 years of age.[4] An absence or limitation of heel strike during the initial contact of the gait cycle is observed[2]; weight bearing occurs on the front of the foot. Usually, the toe-toe gait pattern is characterized by an onset from the beginning of walking; nevertheless, toe walkers can support their feet flat on the ground when concentrating on their gait or on request.[5-7]

The dorsiflexion range of motion of some children is limited (0°'5°),[1,4] whereas others have a decreased or normal dorsiflexion between 5° and 20°,[8,9] and Achilles tendon contractures may or may not be present.[9-11] The gait pattern looks well coordinated and symmetric, and the children can run at normal speed.[4]

> "A positive family predisposition has been reported in 30% to 42% of the children with habitual toe walking, but for about 60% of these children, the cause is unknown."

Etiology

A congenital short Achilles tendon was described by Hall et al[12] in 1967. The

DOI: 10.1177/1938640016687370. From Praxis Pomarino, Hamburg, HH, Germany (DP, JRL, AP), and Diakiniekrankenhaus Annastift GmbH, Hannover, Germany (SM).
Address correspondence to: Juliana Ramírez Llamas, MSc, Praxis Pomarino, Rahlstedter Bahnhofstrasse 9, 22143 Hamburg, Germany; e-mail: julir83_ramirez@yahoo.com.

Table 1.

Classification of Idiopathic Toe Walking Based on Gait Analysis (Alvarez et al).[20]

Toe Walking Severity Group	Primary Criteria and Definitions		
	Presence of Ankle Rocker	Presence of Early Third Rocker	Predominant First Ankle Moment
Type 1	Yes	No	No
Type 2	Yes or no	Yes or no	No
Type 3	No	Yes	Yes

subjects of the study were described as children who had a bilateral contracture of the calf muscles but were able to bear weight on their heels on request. These children were most comfortable walking on their toes. There were 2 families that reported more than one affected child, but no family predisposition was described in the study. The only deformity reported was in the equinus of both ankles, from 30° to 60°, with neither muscle weakness nor decrease of sensation.

A positive family predisposition has been reported in 30% to 42% of the children with habitual toe walking,[9,13-16] but for about 60% of these children, the cause is unknown. So even though family predisposition plays an important role, currently, the causes of this gait anomaly are still not understood.

It has been suggested that a sensory processing dysfunction can cause toe walking.[7] The explanation for this is that the integration of the vestibular, proprioceptive, and tactile systems does not provide adequate information to the brain. Feedback that normally occurs during and after every activity does not function properly. In this case, a sensory processing dysfunction should be diagnosed. However, this theory is still under investigation and further studies are suggested.[4,7,17,18]

All the definitions found in the literature rule out orthopedic or neurological reasons for toe walking. In many studies of toe walkers, the children are described as healthy individuals who walk on tiptoes. Their strength, reflexes, and sensation are normal. In addition, the pattern is described as bilateral, and the children are able to place the heel on the ground when asked to do so. They are able to modify their walking pattern when concentrating on it.

Classifications

Idiopathic toe walkers can be classified into 2 types. One is the Alvarez classification, which is based on the kinematic of the ankle while walking, and the second is the Pomarino classification, which is based on clinical features found in toe walkers.

Alvarez's Classification

Alvarez's classification determines the severity of toe walking according to the presence of ankle rockers According to Perry,[18] the ankle kinetic is divided into 3 rockers. On the first rocker, the heel meets the ground and heel strike takes place followed by an ankle plantiflexion; during this instant, there is an eccentric contraction of the anterior tibial muscle. At the second rocker, there is an eccentric contraction of the gastrocnemius with some dorsiflexion; at the third rocker, the pushoff action takes place, the ankle plantiflexes, and there is concentric contraction of the gastrocnemius and soleus muscles. In toe walkers, the rockers are modified. There is an absence of the first rocker, so the foot strike occurs on the sole or on the forefoot instead of the heel; the second rocker is inverted, and during the swing phase, disruptions with increased plantiflexion take place.[19] Therefore, the Alvarez classification categorizes 3 severity types according to the presence of the rockers (Table 1).

Westberry et al[19] studied the kinematic and kinetic differences of toe walkers, and they identified differences in the knee and the ankle compared with mild cerebral palsy. They also identified that about 70% of toe walkers are able to adjust or normalize either the stand or the swing phase, and just about 17% of the children were able to normalize both variables (stand and swing phase).

Pomarino's Classification

According to Pomarino, children who tiptoe walk exhibit a range of different characteristics; therefore, this gait anomaly may be a result of different conditions. Pomarino et al[21] classified the toe walkers according to the physical features found during clinical examination. According to this classification, idiopathic toe walkers are divided into 3 types:

Type I: This group of toe walkers is born with a short triceps surae muscle, which produces the tiptoe walking pattern. They are recognized by having a heart shaped calf (Figure 1) deep wrinkles (Figure 2) over the Achilles tendon area, and a fat deposit on the forefoot (Figure 3) under the second and third metatarsal bones. Other common features are a pointy heel, a pes cavus, and a short adductor magnus muscle.

Figure 1.

Heart-shaped calf: the gastrocnemius muscle's belly is heart shaped. The 2 bellies show up on the sides.

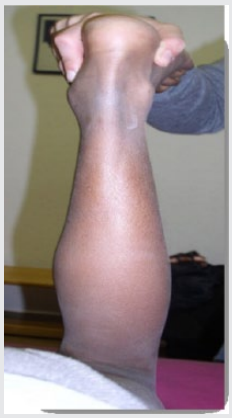
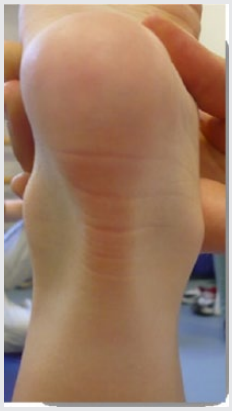


Figure 2.

Wrinkles on the Achilles tendon area: there are deep wrinkles on the Achilles tendon area; usually, they are observed also during the dorsiflexion motion.



Type II: This group has a positive family predisposition, they present with a "V" sign over the Achilles tendon area (Figure 4), and the gastrocnemius muscle is hypertrophied (Figure 5).

Type III: This group usually can support the heel on the ground while walking. Frequently between 4 and 5 years of age, the tiptoe gait pattern resolves spontaneously. The pattern may continue to appear in some situations such as fear, anxiety, tiredness, or stress.

Figure 3.

Forefoot padding: this padding formation located under the second and third metatarsal bones.

Figure 4.

V-shape on the Achilles tendon: a V-shaped on the Achilles tendon is observed when the foot is dorsiflexed.

Differential Diagnoses

There are 2 other groups of children who walk on the forefoot who are often diagnosed as idiopathic toe walkers.

Genetic Sensorial Neuropathy Type I. These children tend to be misdiagnosed as idiopathic toe walkers; however, the tiptoe walking pattern is

Figure 5.

Hypertrophy of the medial gastrocnemius: the medial head of the gastrocnemius muscle is hypertrophied.

Figure 6.

Claw hand and foot.

caused by a neuropathy. These children often present with a claw hand (Figure 6) and foot deformity and a hypotrophy of the gastrocnemius muscles (Figure 7). So far, there has been just 1 case study that describes this neuropathy.[22]

Mc Ardle Disease. Many children with Mc Ardle disease are diagnosed as idiopathic toe walkers. The general features observed in these children are hypotrophy of the girdle muscles (Figure 8) a wider forefoot (Figure 9), and a more proximal belly of the gastrocnemius muscle.[10] However, there are just 2 case studies that report children with Mc Ardle disease who walked on their toes.

Even though these last 2 groups of children walk on their toes, they do not belong to the group of children with idiopathic toe walking because the first one is caused by a neurological condition and the second by a muscular condition. However, there is still more to

Figure 7.

Calf hypotony: the gastrocnemius belly is much thinner and the calf looks slimmer.

Figure 8.

Girdle muscles hypotrophy: The shoulder muscles are hypotrophied, and during shoulder abduction there is a hypotrophy of the lateral portion of triceps brachii or the long head of the biceps.

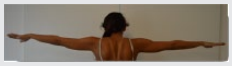


Figure 9.

Wider forefoot.

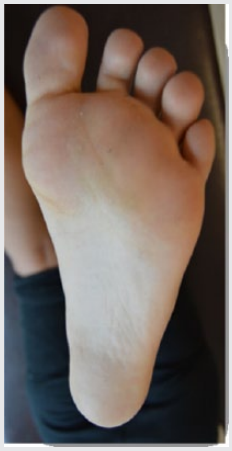
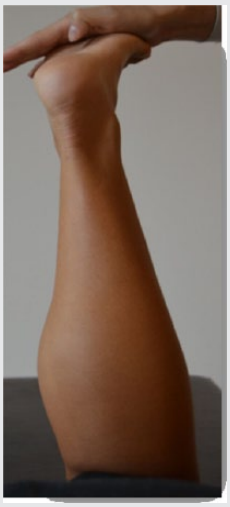


Figure 10.

Gastrocnemius muscle with proximal orientation: the gastrocnemius muscle has a proximal orientation and seems to be hypertrophied.



investigate in this area, and the reasons why these children exhibit the tiptoe walking pattern are still unknown.

Pomarino and colleagues were not alone in acknowledging different characteristics among the toe walkers. In a study of 28 children, Furrer and Deonna[23] identified different toe walker groups: (1) children who toe walk as a result of a neurological impairment; (2) habitual toe walkers with neither motor delay nor limited dorsiflexion; (3) children with a congenital short Achilles tendon and limited ankle dorsiflexion, where the "congenital short Achilles tendon" that causes the limitation may evolve later; and (4) a last group with mixed or unclassified characteristics. In addition, a positive family predisposition is discussed. There are also other authors who have observed and identified different characteristics among toe walkers.

Evaluation

The severity of the tiptoe walking pattern can be measured by any of 5 tests. These are reported in Pomarino et al.[24]

Performance of Spin Test

The patient is requested to spin around fast in one spot for a maximum of 10 spins. The number of spins in which the patient gets on the toes is recorded. The test is positive when the tiptoe walking pattern appears. The earlier the tiptoe walking appears, the more affected the patient is by toe walking.

Performance of Walking After Spin Test

Immediately after the spinning test, the patient is requested to walk 10 steps in a straight line. The step at which the toe walking appears is recorded. The earlier the tiptoe walking reappears, the more affected the patient is by toe walking. These last 2 tests were designed to evaluate the equilibrium and to provoke the tiptoe walking pattern.

Performance of the Heel Walking Test

The patient is requested to heel walk. Compensations such as flexion and/or external rotation of the hip or a decrease in ankle dorsiflexion are allowed. The test is considered positive for toe walking if the patient is unable to heel walk or heel walks exhibiting trunk, knee, and ankle compensations. This test was designed to measure the tibialis anterior strength while walking. The observation of compensatory movements that help achieve the heel flexion is important.

Range of Motion for the Ankle Joint in Dorsiflexion

Measurement of ankle dorsiflexion with flexed knee and extended knee has been used in different studies. The greater the ankle limitation, the more affected the patient.

Angle Degree of the Lumbar Lordosis

The lumbar lordosis is measured with a goniometer. It is placed at the greatest convexity of the lumbar spine. The patient is more affected if the lordosis is more

pronounced. This test was chosen because earlier studies showed that toe walkers exhibit an increased lumbar lordosis angle.

Therapeutic Approaches

A large variety of treatments can be recommended for idiopathic toe walkers. The options vary from conservative to surgical approaches. However, results vary in terms of their long-term effectiveness.

Physical Therapy

Physical therapy is one of the most common treatment options for children with idiopathic toe walking. The aim is to stretch the gastrocnemius muscle using exercises and to increase active dorsiflexion.[14,25] However, the literature about technique, methods used, and treatment results is limited.

Casting

There are multiple studies related to the use of casting. The aim of the casting is to elongate the noncontractile structures, and the duration is about 2 to 10 weeks. There are a wide variety of casting methods, but the casts used are always below the knee. One of the disadvantages of casting is walking with the casts because this is challenging when retraining a walking pattern. Also, the number of participants in the studies was limited (15 or fewer participants),[26-29] and the effectiveness did not seem to be of long duration.[14,30]

Botulinum Toxin A (BTX)

BTX has been used in combination with other treatment modalities such as casting or physiotherapy.[31,32] The effect of BTX lasts about 2 to 12 months; thereafter, the children can resume their tiptoe walking pattern. BTX causes a weakness of the calf muscles. It results in the achievement of the heel strike or a near heel strike.[7]

Three-Step Pyramid Insole Treatment Concept

The main goal of the pyramid insole treatment is repositioning the foot bones, muscles, and ligaments, allowing forefoot realignment. The pyramid insoles offer support under the second, third, and fourth metatarsal bones, having an impact on the forefoot and the rear foot, adjusting the gait, and allowing the full support of the foot (heel and toes) while walking.

The insole treatment comprises 3 steps[3,21,33,34]:

Step I: This starts with the use of the pyramid insole every day for a period of 6 to 8 weeks; immediately afterward, a follow-up examination takes place. In some cases, physical therapy along with the insoles is needed (about 15% of the cases).

Step II: During the first examination, the need for night splints in addition to the pyramid insoles is determined. When the range of ankle dorsiflexion is less than 90°, a night splint is used in order to increase ankle mobility. The next follow-up is done after 12 to 14 weeks.

Step III: At the second follow-up after 12 to 14 weeks of therapy with pyramid insoles and night splints, the need for BTX is determined. BTX is used only when the pyramid insoles, physical therapy, and night splint do not show enough impact on tiptoe walking or the ankle joint reaches 90° of dorsiflexion or less. In this case, 2 applications of BTX on the medial and lateral head of the gastrocnemius muscle are done in a period of 12 weeks.

The treatment with this step-by-step approach with pyramid insoles has shown a success rate of 70%.[3,21,33]

Surgery

Surgery is the last option for idiopathic toe walkers. The aim is to lengthen the triceps surae muscle tendon complex when the ankle dorsiflexion angle is limited or decreased. There are several surgical procedures such as Achilles tendon lengthening, the Valpius procedure, or percutaneous Achilles tendon lengthening. There is no specific procedure that will always be recommended. The number of patients in the studies is limited,[35,36] and these studies do not compare the surgical outcomes with other therapeutic approaches. However, surgery seems to be the best option when there is an equinus contracture.

Conclusion

Gathering information about this medical condition will help researchers and health care practitioners make an adequate classification and differential diagnosis of patients with idiopathic toe walking. However, a lot of information about toe walking is still missing, and further investigation is important to understand its causes, learn more about the differential diagnosis, and develop more appropriate treatment approaches. FAS

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