The differential diagnostic of Idiopathic Toe Walking

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Abstract:

Idiopathic toe walking (ITW) is the persistence of the tip-toe walking pattern after two years of age. The diagnosis is made by ruling out any neurological or orthopedic condition which causes this walking anomaly. There are other medical conditions in which the weight bearing occurs on the forefoot which can lead to misdiagnosis and misguided treatment. The main goal of this publication is to provide a concise review of idiopathic toe walking and its classification according to clinical characteristics found among children with a tip-toe walking pattern. In addition, we will point out some physical characteristics that may help to differentiate idiopathic toe walking from other medical conditions in which the gait pattern occurs on the forefoot as well. Typical conditions which are commonly known to cause a pathological forefoot gait, like autism and tethered cord, are intentionally excluded from this article. This review highlights the importance of the observation of the foot features, shape of the M. gastrocnemius and gait analysis during the clinical examination to distinguish idiopathic toe walking from other conditions.

Keywords: Idiopathic Toe Walking, ITW, Pomarino, Classification of ITW

1. Introduction:

Toe walking (TW) is a gait pattern in which there is an absence of full foot contact, affecting the heel strike during initial contact (1). Normally the diagnosis is made after two years of age, when there is no evidence of a neurological or orthopedic medical condition that causes this gait anomaly.

The etiology is still unknown, sensory processing dysfunction (SPD) (3) has been suspected, a positive family predisposition (4, 5, 6, 7, 8,) and a short calcaneal tendon (9) have been described as causes for this walking pattern. However, none of these theories have been proven for 100% of the individuals affected by toe walking. This suggests that the tip-toe walking pattern could be caused by different underlying medical conditions.

The tip-toe walking pattern is characterized by being symmetrical and bilateral, the gait pattern looks well-coordinated and the children have the capability to walk and run with a normal speed (10). Toe walkers also have the capability to adjust the walking pattern when concentrating on the gait, so they can achieve heel contact with the ground while walking when concentrating (3,4).

In order to find out if a child is really affected by idiopathic toe walking, it is important to determine the causes of this gait pattern. A tip toe gait pattern can be caused by idiopathic, neurological or muscular reasons. The main goal of this paper is to provide a clinical review of different conditions that can mimic idiopathic toe walking.

It is also important to recognize that not all the individuals affected by idiopathic toe walking have the same physical characteristics. Consequently, Pomarino (11, 12, and 13) developed a classification based on the clinical examination and the features found among idiopathic toe walkers (Figure 1).

2. Classification of Idiopathic toe walking according to Pomarino

Figure 1

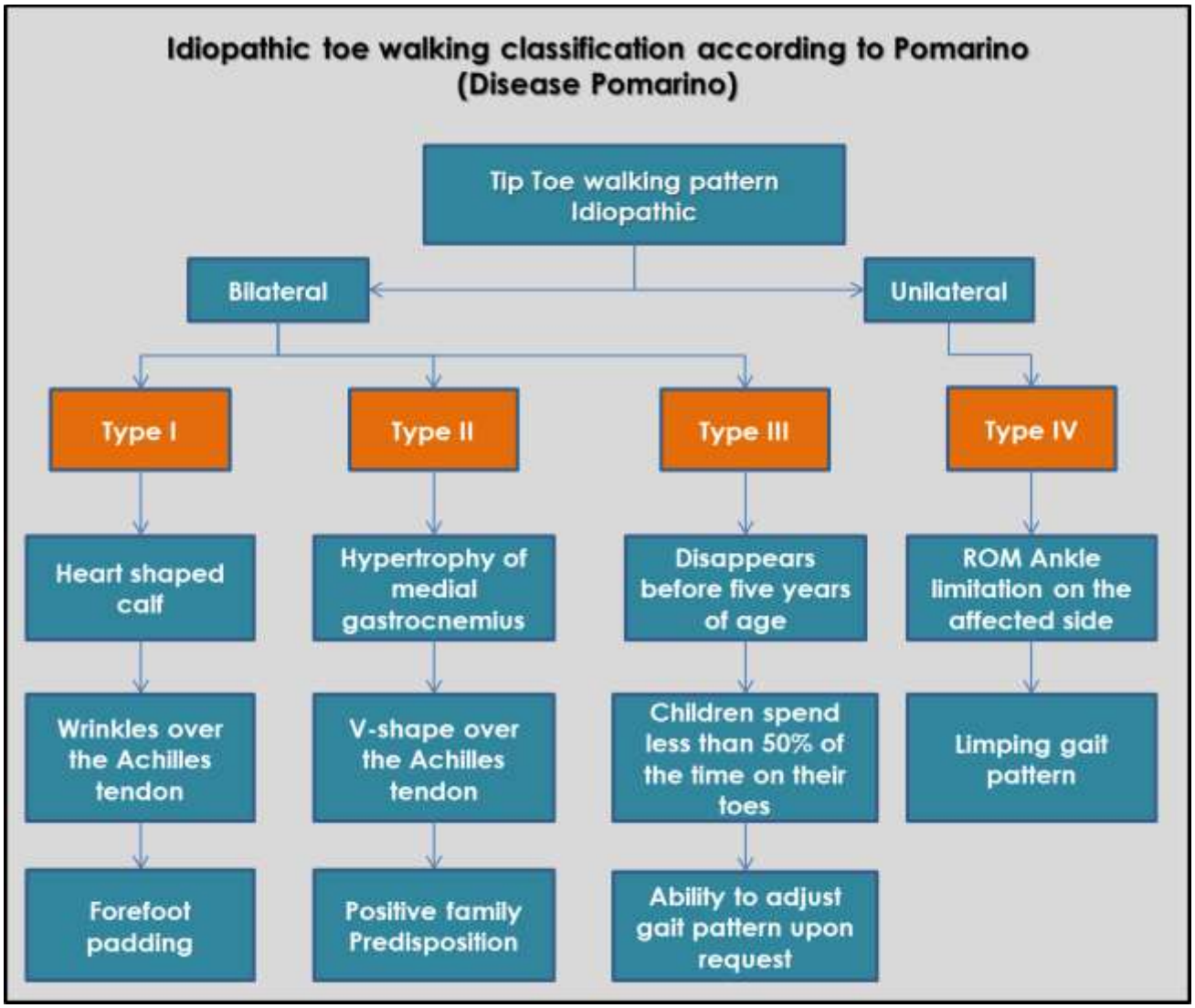

Figure 1: Pomarino's classification of Idiopathic toe walking (ITW). According to the classification there are four types of toe walkers and each type exhibits different clinical characteristics.

2.1 Toe walking caused by Idiopathic conditions

According to Pomarino, idiopathic toe walkers are divided into different groups according to physical characteristics. The main characteristics that were taken into account for this classification were the shape of the M. gastrocnemius, the shape of the Achilles tendon, the family predisposition and the foot features. Idiopathic toe walkers can be classified into 4 distinct types (4, 13, 35, and 36).

2.2 Pomarino's Classification of disease Pomarino

Type I: in this type the M. gastrocnemius is heart-shaped (Figure 2), the skin of the Achilles tendon has deeper wrinkles and there is a foot-padding (fat deposit) on the sole of the foot located between the first and third metacarpophalangeal joints. Other common features found were a pointy heel, a pes cavus, and a shorter M. adductor magnus (35).

Figure 2

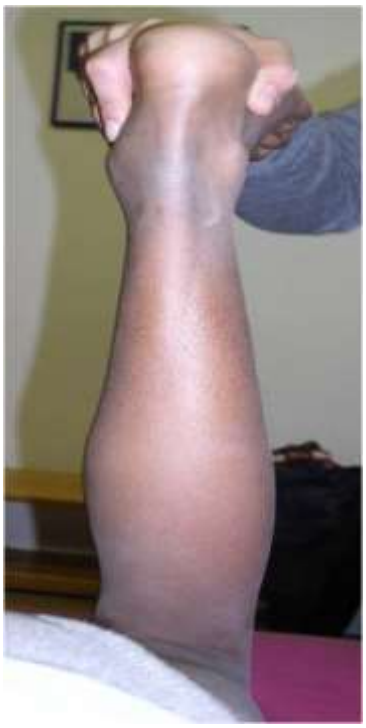

Figure 2: Idiopathic toe walking type I. This picture shows a heart shaped M. gastrocnemius. This is a typical characteristic of toe walkers type I

Type II: there is a hypertrophy of the M. gastrocnemius, a V-pattern on the Achilles tendon (which is formed by the tendon itself) (Figure 3), and there is a positive family predisposition (father, mother or other relatives are affected by toe walking) (4, 13, 35, 36).

Figure 3

Figure 3: Idiopathic toe walking type II. This picture shows the V-pattern on the Achilles tendon and the hypertrophy of the M. gastrocnemius which characterize the toe walkers type II.

Type III: these children do not exhibit any abnormal physical characteristics other than the tip-toe walking pattern which disappears at around five years of age. These children spend less than 50% of the time walking on the toes and are able to adjust their gait pattern upon request. However, the toe walking pattern may appear in situations of fear, anxiety, tiredness or stress (13, 35).

There is another type of toe walkers that has not yet been described. This is ***Type IV***. These children exhibit an asymmetric toe walking pattern since only one side is affected (Figure 4). The ankle range of motion is limited and is the only situation where toe walkers present a limping gait pattern.

Figure 4:

Figure 4: Idiopathic toe walker type IV. This picture shows an asymmetric toe walking pattern.

Pomarino is not the only author who makes a distinction between the different characteristics among toe walkers. Furren and Deonne (14) identified and divided the toe walkers into different groups as well: 1. toe walkers with a neurological impairment; 2. toe walkers with neither motor delay nor limited dorsiflexion, 3. toe walkers with a congenitally short Achilles tendon and limited ankle dorsiflexion. In this group the toe walkers develop the restriction on the ankle motion with time; 4. toe walkers with mixed or unclassified characteristics. A positive family predisposition in toe walkers is discussed.

Consequently, different clinical characteristics have been found by different researchers among toe walkers. Figure 1 shows Pomarino's classification of ITW.

3. Toe walking pattern caused by Neurological conditions

3.1 Hereditary Motor & Sensory Neuropathy I (HMSN I)

Hereditary motor and sensory neuropathy is a rare disease with onset in childhood and a prevalence of 1:2.500 (15).

HSMN I shows a decline of motor performance due to fatigue and a loss of strength. Children affected by this form of neuropathy develop foot and ankle deformities that cause pain and affect balance (16).

Patients affected by this neuropathy exhibit a symmetrical pattern, with muscular atrophy (distal atrophy), a retraction of the Achilles tendon, and areflexia in ascending order, (so the first reflex to be affected is the Achilles reflex) also sensitivity is impaired and deformities like pes cavus on the foot (figure 5) and claw hands develop (15, 17,18, 19).

Figure 5:

Figure 5: This picture shows the characteristics of a typical hereditary motor sensory neuropathy foot. The foot has a pes cavus form.

During walking the main limitation in the sagittal plane is the instability of the ankle during the initial contact, during the stance phase there is a higher dorsiflexion, a loss of an active push-off and elevated knee and hip flexion to compensate for the plantar-flexed ankle or drop foot (16). These children often trip and fall (18, 19). In the medio-lateral plane, there is asymmetric hip movement and a decrease of the adduction (19).

3.2 Cerebral Palsy:

Cerebral palsy is a disorder of movement and posture that usually does not progress, however it changes in appearance. It has an incidence of 2 to 2.5 per 1000 live births with a higher incidence in premature babies. Causes may be congenital, genetic, inflammatory, infectious, traumatic or metabolic (20).

Due to damage of the central control system the following abnormalities are produced: 1. loss of selective muscle control; 2. dependence on primitive reflex patterns; 3. abnormalities of muscle tone; 4. imbalance between agonist and antagonist muscles; 5. deficiency of the equilibrium reactions (21).

Cerebral palsy has been classified according to the topography into monoplegia (0%), hemiplegia (20%-30%), diplegia (30%-40%) and quadriplegia (10-15%). Hemiplegia, diplegia and tetraplegia show a tip-toe walking pattern (20). The gait patterns are influenced by severity, topography and age. Typical gait variations are tip-toe walking, foot inversion and a stiff knee during swing phase (22).

a. Quadriplegia or tetraplegia: involves all four limbs and the trunk. The upper limbs are more affected than the lower limbs and it is usually associated with acute hypoxic intrapartum asphyxia (20). Some of the individuals affected by tetraplegia are able to walk, but balance and motor control are severely impaired.

b. ***Hemiplegic:*** this is a unilateral paralysis where the upper limbs are often more affected than the lower limbs. In the upper limb the grasp of the thumb, the extension of the wrist and the supination of the forearm may be affected. In the lower limb dorsiflexion and aversion may be affected (20). During gait analysis deviations may be observed in the affected limb as well as in the unaffected limb. Changes in step length of the affected extremity, a wider base of support and a decrease in velocity are some of the characteristics of this gait. The affected side has a tendency for heel support and the stance phase is shorter, while the swing phase is little longer. (23).

c. ***Diplegia:*** the lower limbs are more severely affected and they may present a toe walking pattern due to dorsiflexion impairment with an increased muscle tone of the M. gastrocnemius. Idiopathic toe walkers usually have normal walking onset, while children with diplegia are delayed. Typically a child affected by spastic diplegia will exhibit an abnormal knee flexion in the terminal swing phase of gait (10).

4. Toe walking pattern caused by Muscular conditions

A toe walking pattern may be exhibited in muscular disorders. Examples are Duchenne Muscular Dystrophy (DMD) and the muscle glycogenosis type V also called McArdle disease.

4.1 Duchenne Muscular Dystrophy (DMD):

Duchenne muscular dystrophy is a severe progressive disease with an incidence of 1:3600-6000 live male births (24, 26). DMD produces structural and functional impairments which lead to muscle weaknesses and restrictions of the walking abilities (24, 25)

A typical sign of children affected by DMD is the proximal muscle weakness which results in the use of Gowers' maneuver while rising up from the ground to a standing position. There is a massive enlargement of the calf muscles from abnormal muscle tissue or scar tissue causing pseudo hypertrophy. (26)

In DMD's gait an excessive anterior tilt of the pelvis and an abnormal knee pattern is observed during the loading response (25). During the swing phase the ankle is plantiflexed, and there is high hip flexion and an abduction that helps to compensate. The step length is decreased while the width is increased (25). Children lose the ability to walk around 9 years of age (27).

4.2 Muscle Glycogenosis Type V or McArdle disease

McArdle´s disease is a genetic Type V Glycogen storage disease located on the chromosome 11 (28). It has a prevalence of 1:100.000-1:167.000 (29, 30).This deficiency causes muscle cramps and injuries. Individuals affected with this medical condition exhibit low exercise tolerance and fatigue during physical activity (28, 29, and 30).

Patients show hypotrophy of the shoulder girdle muscles (31) and the presence of the second wind phenomenon during physical activity (28, 29). This phenomenon occurs in 100% of adult individuals affected with McArdle´s disease (28, 32).

The second wind phenomenon is a spontaneous recovery that occurs during the first 10 minutes of physical activity. This metabolic pathway shift allows the fatty acids to be used to provide energy to continue with physical performance (28, 29).

Other physical characteristics found in some individuals affected by this genetic disorder are the hypertrophy of the M. gastrocnemius; the

forefoot seems to be wider around the metatarsophalangeal joint. However, those characteristics have been barely described in literature (33). Another clinical characteristic of this medical condition is the hypotrophy of the shoulder girdle muscles. For many of those individuals this is noticeable when they perform shoulder abduction (Figure 6).

Figure 6:

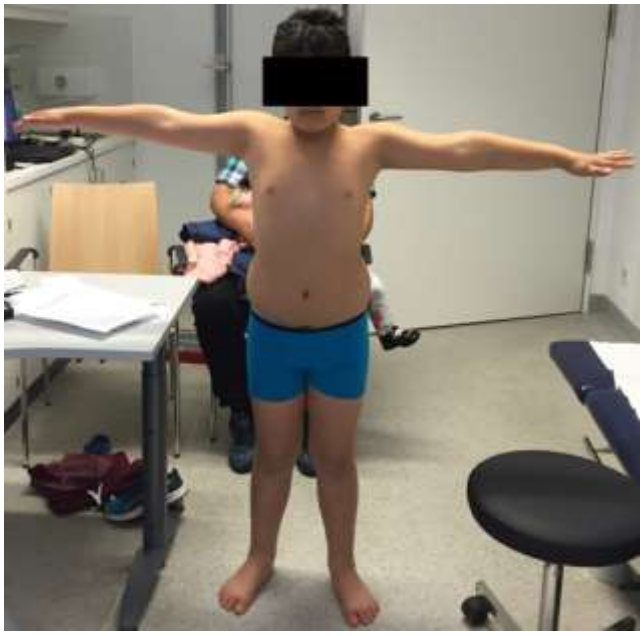

Figure 6: This picture shows the clinical characteristic of McArdle disease. Here the deltoid muscle seems to be normal, but there is an evident hypotrophy of the biceps and triceps bachii.

There is no literature available that describes the gait pattern in individuals with McArdle´s disease; however, some of the children present a toe walking pattern (33). Many of them avoid physical activity or sports due to the fatigue and the multiple aches they experience.

Figure 7 summarizes the conditions which can be accompanied by a forefoot gait pattern and therefore helps to make a differential diagnosis for toe walking.

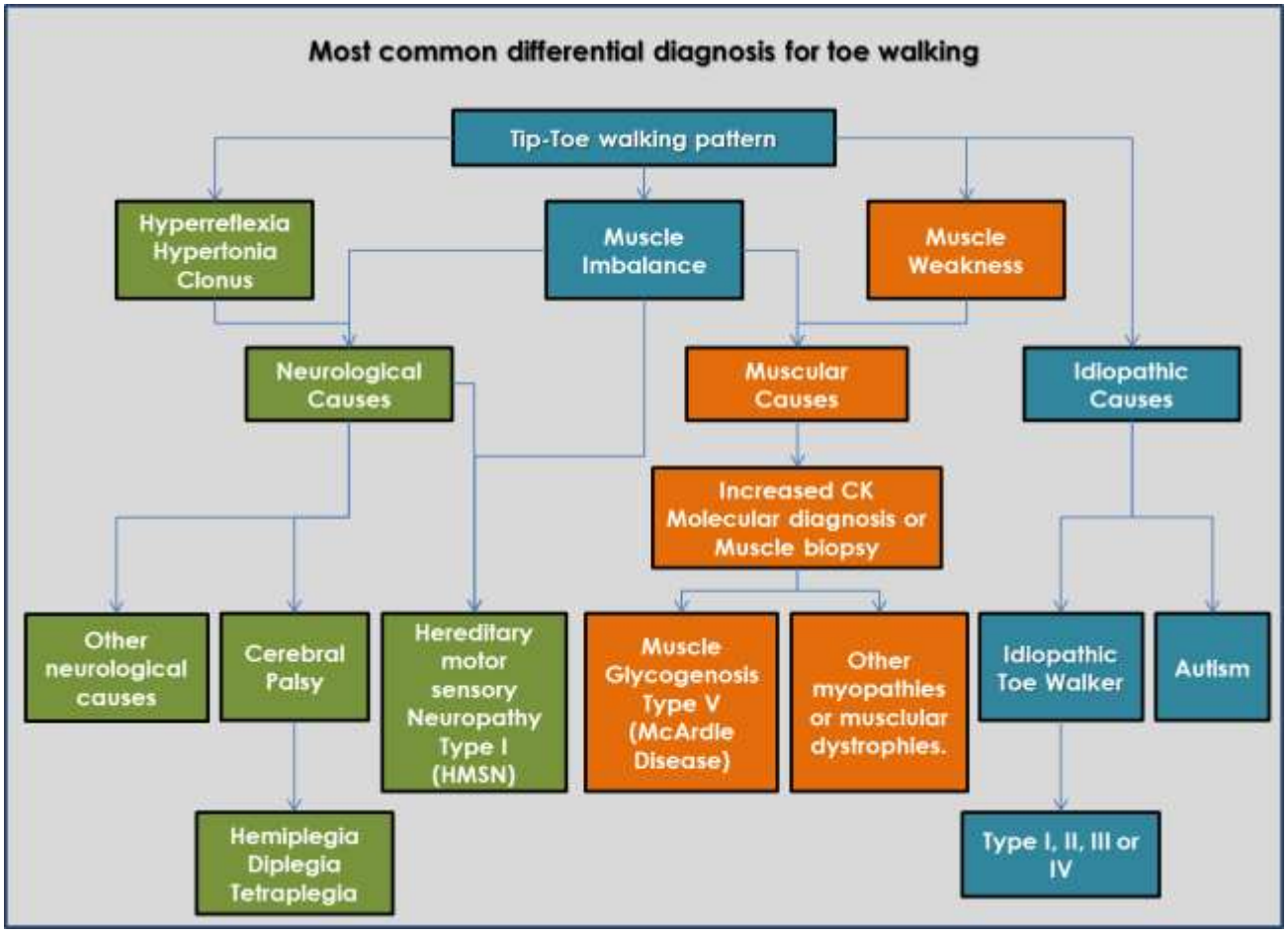

Figure 7: Most common differential diagnosis for toe walking. (37: Chart partially taken from " Der habituelle Zehenspitzengang – Diagnostik, Klassifikation, Therapie" D. Pomarino, N. Veelken, S. Martin, 2012 Schattauer GmbH)

5. Conclusion

Idiopathic toe walking is diagnosed by ruling out any underlying neurological or orthopedic condition. Therefore, finding the clinical characteristics that identify this medical condition such as foot features, the shape of the M. gastrocnemius and gait analysis are the key factors to differentiate idiopathic toe walking from other medical conditions in which the weight bearing takes place on the toes.

Other factors that take an important role are the family predisposition and the features of the upper body. Therefore a detailed history and clinical examination are essential to properly diagnose idiopathic toe walking.

However, a lot of research is still needed to conclude whether idiopathic toe walking is a medical condition with different subtypes or a group of different underlying conditions with a common phenotype.

Disclosure

There has been no funding for this manuscript. The authors declare no conflict of interest in preparing this article. The manuscript and its submission have been approved by all the authors.

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