Review

The 3-Step Pyramid Insole Treatment Concept for Idiopathic Toe Walking

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Abstract: *The idiopathic toe walking (ITW) gait pattern is characterized in children for walking since the beginning on their first steps on the forefoot; however, these children are able to support their whole foot on the ground. ITW can only be diagnosed in the absence of any orthopaedic or neurological condition known to cause tiptoe walking. The aim of this article is to review other references and provide an outline of the different treatment options, including the 3-step-pyramid insole treatment concept for children with ITW.* Methods. *Fifty-four articles in English, German, and Spanish were reviewed. There were comparative, retrospective or case studies, classifications or literature reviews and they were divided according with these categories. All the literature reviewed was published between 2000 and 2015.* Results. *There are some studies that proved the 3-step pyramid insole treatment concept as an effective option compared with other therapeutic modalities such as physical therapy, casting, botolinum toxin type A (BTX), and surgery.* Conclusion. *There is a wide spectrum regarding the therapeutic options for children with ITW, from physical therapy to surgery options. However, any of these treatment modalities have been reported to be fully successful for the whole toe walking population. Some procedures seem to have achieved faster results or seem to have longer lasting effects. Therefore, further research on the causes of ITW is recommended.*

Levels of Evidence: *Therapeutic, Level II: Systematic review, prospective, comparative*

Keywords: pediatric podiatry; age-related problems; diagnostic and therapeutic techniques; forefoot; toe; midfoot; toe walking

Idiopathic toe walking (ITW) or habitual toe walking is a medical condition in which children are able to support their heel on the ground on request; however, the gait is characterized by a support on their forefoot during the double support phase.[1,2] ITW is diagnosed in the absence of a developmental, neurological, or neuromuscular condition known to cause toe walking.[3-5]

The cause of ITW is unknown. There are studies that attribute this to a family predisposition reporting an incidence of 34% to 42%,[5,6] while others claim that ITW has a relationship with a sensory processing disorder.[3,4] However, this has not been proven. ITW is present in either gender; nevertheless, males with family predisposition are more likely to be affected.[6]

The effectiveness of the treatment methods varies widely. There are conservative options and surgical approaches. Several studies report the use of serial casting, sometimes in combination with botulinum toxin type A[5,7-10]; there are surgical procedures that aim to lengthen the Achilles tendon[11,12] and physical therapy along with other conservative treatments.[9,13,14] Ceasing of this idiopathic gait pathology is not always accomplished by these approaches.

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Figure 1.

Pyramidal insole before the start of the treatment.

Figure 2.

Pyramid insoles after treatment. It shows that the whole insole is being used. It means that the foot is making full contact with the ground while walking.

There have been some German publications suggesting that ITW can be treated with a success rate of 60% to 70%.[15,16] A classification system according to the child's clinical signs has been developed. ITW was divided into 3 groups: type I idiopathic toe walkers are characterized by a short Achilles tendon, a wrinkle formation over the calcaneus, a heart-shaped calf, and callous formation on the forefoot; type II idiopathic toe walkers are characterized by having a family predisposition, the calf is hypertrophied, and the Achilles tendon presents a "V" shape during dorsiflexion; and type III idiopathic toe walkers are those who are not as affected as type I and II and their toe pattern is mostly produced by a stressful situation.

According to the literature,[10,14-16] differentiating the clinical signs will help understand the adequate treatment approach in between the different modalities that are currently available.

Three-Step Pyramid Insole Treatment Concept

Children with ITW support the weight of the body on the forefoot. The main goal of the pyramid insoles (Figure 1) is to reposition the muscles and ligaments allowing for foot realignment. This realignment adjusts the walking pattern, and incentivizes the toe walkers to support the weight not just on the forefoot but also on the heel. The treatment is considered successful when the toe walker is able to achieve full foot contact with the ground for about 70% of the walking time. The main indicator that shows positive results with this therapeutic approach is the fact that the insole will get filthy on the front and also on the back. This proves that the weightbearing in taking place on the forefoot and rearfoot (Figure 2).

The pyramid insole treatment is divided into 3 steps[10,14-16]:

Step I: The child wears a pyramid-shaped insole every day for a period of time of 6 to 8 weeks. In some cases, the combination with physical therapy is required (about 15% of the cases). The first follow-up is done after 6 to 8 weeks after the insoles are given to the child.

Step II: After the first examination, the need for night splints is determined. If the child has less than 90° of ankle dorsiflexion, a night splint is used to improve the flexibility of the triceps surae, therefore the ankle's mobility. The next follow-up is done after 12 to 14 weeks. The night splits are used in combination with the pyramid insoles.

Step III: At the second follow-up visit, it is determined if the use of botolinum toxin type A (BTX) is necessary. BTX will only be applied if the pyramid insole treatment, physical therapy, and the night splints have not shown sufficient improvement of the gait pattern, if the child continues to toe walk, and the ankle joint reaches 90° of dorsiflexion or less. Two applications of BTX on the medial and lateral head of the gastronomies muscle are given in a period of 12 weeks.

At the first visit, it is decided whether or not the child will be treated with the insole concept. In the first step of the therapy, the child uses insoles over a period of 3 to 6 months. Normally, children younger than 3 years, who have received the pyramid insole treatment, will need about 3 months to start supporting weight on their heels while walking.

The aim of this article is to assess the literature regarding ITW treatment options and to present information about the 3-step pyramid insole treatment concept.

Methods

Data Sources and Data Selection

The material reviewed was selected from the following electronic databases: PubMed (2000-2015), MEDLINE (2000-2015), CINAHL (2000-2015), and Med Pilot (2000-2015).

An online search was carried out to identify literature exploring ITW and different treatment approaches. The search was done in German, English, and Spanish and the articles reviewed were all published after 2000. Words such as "idiopathic," "habitual," "toe-toe walking" in combination with "treatment," "Botox," "pyramidal insoles," "physical therapy," and "AFOs" were used in the search.

Articles mentioning ITW with autism or cerebral palsy were excluded. Comparative, retrospective, and case studies were included along with treatment available for toe walkers, classifications and other literature reviews. Table 1 shows the literature reviewed divided by study type. A total of 54 relevant citations were found.

Results

Thirty-seven relevant studies were included and assessed. The studies in Table 2 focus on showing a treatment

Table 1.

Idiopathic Toe Walking Literature.

Comparative Studies	Retrospective Studies	Case Studies	Classifications	Literature Review
Bernhard et al (2010)[17]	Pomarino et al (2011)[18]	Pomarino et al (2011)[19]	Pomarino et al (2011)[20]	Van Kujik et al (2014)[21]
Fox et al (2006)[22]	Pomarino et al (2011)[23]	Pomarino and Pomarino (2010)[24]	Pomarino et al (2010)[15]	Gámez-Iruela et al (2015)[25]
Hemo et al (2006)[11]	Pomarino et al (2011)[26]	Pomarino et al (2009)[27]	Pomarino et al (2012)[16]	Williams et al (2014)[28]
Jahn et al (2009)[29]	Pomarino et al (2010)[30]	Pomarino et al (2009)[31]		Babb and Carlson (2008)[32]
Williams et al (2014)[33]	Pomarino et al (2010)[34]	Külh and Pomarino (2008)[35]		
Brunt et al (2004)[36]	Pomarino et al (2010)[15]	Pomarino, et al (2007)[37]		
Zimbler (2007)[38]	Pomarino and Bernhard (2006)[39]	Pomarino (2004)[40]		
Engström et al (2010)[10]	Bernhard et al (2006)[41]	Clark et al (2010)[13]		
	Hirsch and Wagner (2004)[42]	Lundequam and Buck Willis (2009)[43]		
	Williams et al (2013)[9]	McEwen-Hill and Weber (2009)[44]		
	Stott et al (2004)[14]	Stock and Zörnig (2010)[45]		
	Engström et al (2013)[8]			

solution for children with ITW using the 3-step pyramid insole treatment concept and comparing this approach with other therapeutic modalities.

In a first retrospective study, ITW patterns were classified. Three different types were identified allowing treatment with the pyramid insole concept.[15] The data of 555 children were compiled and analyzed. The children were divided into 3 types according to the clinical signs. A total of 311 children were type I, 222 children were type II, and 22 children were type III. They were treated according to the 3-step pyramid insole treatment concept.

According to Pomarino, the gait pathology resolves spontaneously in about 15% of the children. About 90% of the children with ITW type I and 95% of the children with ITW type II had their ITW resolved in less than 1 year. Children who were 5 years of age or younger when they started the treatment developed a plantigrade gait within the first year of treatment; while children older than 5 years needed about 2 years of treatment to develop a gait pattern in which the heel is in contact with the ground during walking. According to the parents, children walked about 80% of the time with a plantigrade gait pattern at the end of treatment.

It was concluded that for children with ITW who need treatment, about 2% needed to be treated with BTX, insoles, physical therapy, and night splints (step 3); about 5% of the ITW children needed to be treated with insoles, physical therapy, and night splints (step 2) and about 80% of the children can be treated only with insoles and physical therapy (15%) (step 1). About 13% of the children drop out from this treatment modality (Figure 3).

In another study, Bernhard et al[17] compared different conservative and invasive treatment option for children with ITW. The therapeutic treatment options compared were physical therapy, splints, insoles as conservative treatments, and BTX injections and surgery as invasive options.

In the study by Bernhard et al,[17] the main objectives of physical therapy for children with ITW, are to obtain stability of the trunk muscles, and to

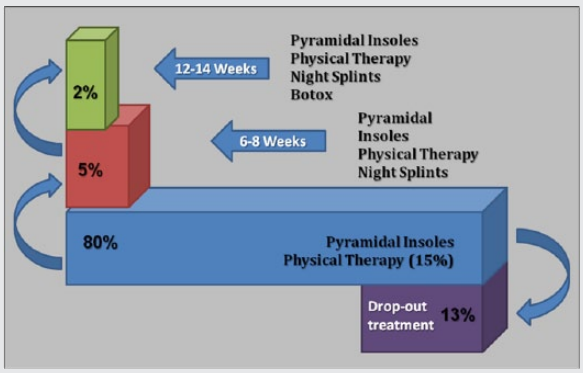
Table 2.

Literature Selected for Review.

Study Authors	Title	Study Type
Pomarino D, Klawonn M, Stock S, Zornig L, Martin S, Pomarino A (2010)[15]	Stufentherapie des habituellen Zehenspitzenganges. (The 3-step therapy for idiopathic toe walking)	Retrospective study
Bernhard MK, Neef M, Merkenschlager A (2010)[17]	Idiopathisher Zehenspitzengang—eine wichtige kindliche Gangvariante. (Idiopathic toe walking pattern—an important pattern variation)	Comparative study
Stock S, Zörnig L (2010)[45]	Habitueller Zehenspitzengang. Einlagenversorgung und Therapie bei einem Kind mit Ganganomalie. (Idiopathic toe walking. Insoles and therapy in a child with gait anomaly)	Case study

Figure 3.

The 3-step pyramidal insole treatment concept for idiopathic toe walkers (Pomarino et al[15]).



elongate the Achilles tendon; the exercises or therapy have to be done regularly. Splints are an alternative treatment option, which aim to reposition the ankle in neutral position for at least 6 weeks.

An additional conservative option given by Bernhard et al are the pyramid insoles that offer a special support under the second, third, and fourth metatarsal bones, having a major impact not only on the forefoot but also on the rear foot, allowing the child to support the whole foot while walking. The results show an improvement in 70% of the children with ITW.

In addition to the conservative options, ITW can be treated with BTX in the gastrocnemius and soleus muscles, this causes weakening of the plantiflexion movements which is one of the main causes of this idiopathic gait abnormality.

The last option studied by Bernhard et al is surgery, in which the Achilles tendon is lengthened. This is usually the last treatment option because of the general risk of surgery. In addition, there is a risk that the correction may not be optimal and that gait stability could be affected.

In a case study by Stock and Zörnig,[45] the toe walking children were divided into 3 categories according to the 3-step pyramid insole treatment concept. After the examination, 1 of the following 3 options was adopted:

1. Observation during the first 3 months: The children are observed by their parents and be seen for follow-up examinations
2. Treatment with insoles and physical therapy: The children wear the special insoles and undergo physical therapy
3. Insoles treatment comes to an end: Once the patients reach a plantigrade gait, the use of insoles will cease and a follow-up control in 6 months will be scheduled.

The physical therapy sessions aim to

- lengthen the triceps surae muscle
- stretch the hamstring muscles
- mobilize the ankle joint through manual therapy
- strengthen the antagonist of the triceps surae and the foot muscles
- improve posture, balance, and coordination

This study illustrates the case of a 6-year-old child with ITW type I. At the first examination the child walked on the

forefoot, the calf was heart shaped, presented wrinkles on the skin over the Achilles tendon area, and had a lumbar lordosis of 40°. The ankle range of motion was 5°/0°/50° and the mother reported that the child walked on the forefoot about 70% of the time. After analyzing the gait pattern and electromyogram, it was found that the heel support was present only during the first steps and was absent during the following steps. Most of the weight was supported on the forefoot. Also there was elevated activity of the anterior tibial muscle.

After undergoing the 3-step pyramid insole treatment concept for 10 weeks and receiving physical therapy, the ankle range of motion increased to 10°/0°/50°. The mother reported that the child reduced toe walking; the insoles showed that there was weight support on the heel and the electromyogram showed a decrease on the anterior tibial muscle activity. During gait analysis, it was observed that the heel received some weight during the stance phase.

Discussion

Presently, there is a wide spectrum of possibilities for the treatment of ITW, ranging from different conservative options to BTX and surgery. There are also different approaches and combinations of treatments; however, there is no single solution that offers 100% reliability for children affected with ITW.

Physical therapy is one of the most accepted options at the present time to treat this condition; however, there is a lack of information about the treatment in order to evaluate the results.[8] Many studies explain the main goals of physical therapy such as the lengthening of the gastrocnemius muscle, the mobilization of the ankle, and balance and coordination exercises. Nevertheless, the studies are not precise on the protocols used during the treatment sessions.[41] Also the literature regarding the successful if physiotherapy does not discuss long-term effects, success rate, or number of sessions needed to achieve a positive effect or ceasing of the tiptoe gait.

In the case of casting, there are a variety of methods that are used in every study (below or above the knee). The main idea of wearing a cast is to lengthen the calf muscles. However, it is hard to walk with the cast; therefore, it is hard to help the child to adopt a different walking pattern. Serial casting has shown a reduction of the resistance to passive dorsiflexion and a stretching effect on the gastrocnemius muscle.[22] Other studies have shown that the effect is not lasting so that the long-term success from this treatment technique is controversial.[5] The samples in these studies were rather small.

Pähr Engström[46] compared 2 groups of ITW patients that received treatment with BTX. One group received BTX plus casting and the other group was treated only with BTX. The conclusion of this study was that adding a treatment with BTX prior to casting does not improve the outcome.

There have been some studies in which BTX is injected in the calf muscles and the treatment was combined with bracing or with bracing and physical therapy. This option seems to be effective; it has shown improvements of the gait pattern and the range of motion of the ankle 3 months after the treatment.[35,47] Here also the number of subjects studied was limited.

The main goal of surgery is to lengthen the triceps surae muscle tendon complex in order to increase the dorsiflexion of the ankle; there are various surgical techniques. With methods like Achilles tendon lengthening and the Valpius procedure, children who toe-walk had an improvement of the gait parameters and an improvement of the ankle dorsiflexion when studied 13 months after surgery. Surgery seems to be a good solution for this gait pathology; however, it has the risk inherent to surgery and the majority of the parents prefer casting and conservative treatments over invasive procedures.

Compared with the reviewed articles the 3-step pyramid insole treatment concept has proven to be an efficient treatment for children with ITW. The combination of physical therapy and insoles, and in some cases the night splints, has shown to be effective and does not have general risks or contraindications. According to Bernhard these insoles have shown an improvement of gait in 70% of the subjects studied. According to Pomarino and Bernhard,[39] about 64.5% of the children react positively to the pyramid insole treatment, in about 26.5% of the children the insoles do not have any therapeutic effect, and about 9.6% of the children refuse to use the insoles.

Anecdotal references have demonstrated an improvement when gait is analyzed.[45] Before treatment the child supported the heel just during the first step of ambulation, but for the subsequent steps the forefoot received the whole weight during walking. It was found that after 10 weeks of treatment a child exhibited a different gait pattern in which it consistently supported the heels on the ground while walking.

In a retrospective study, Pomarino et al[16] observed and treated 700 children with the pyramid insole concept. In the study, the activity of the anterior tibial muscle was found to be markedly increased in the electromyographic examination of a 4-year-old girl during walking. The results show that before the treatment the anterior tibial muscle was active during stance phase and swinging phase, after 8 weeks of treatment the activity of the muscle had decreased significantly.

Conclusion

Presently, there are a large variety of treatment options to treat ITW. Physical therapy, serial casting, BTX type A, step-by-step treatment approach and surgery were reviewed. However, none of these therapeutic options seem to offer a definitive solution to the affected children. Some of these approaches seem to be more effective than others; however, in literature the information about the long-term effect is missing.

Three of the studies that were reviewed seem to support the 3-step pyramid insole treatment concept. The treatment with pyramid insoles seems to be an effective treatment solution in about 64% to 70% of the cases. It seems that classifying the clinical characteristics among toe walkers and finding the reason of toe walking help determine the adequate treatment approach. However, more research is suggested on the fields of finding the causes.

The number of subjects in the studies in many of the studies is limited. A lot of uncertainty remains regarding this gait pathology and there is still a vast territory to learn and explore concerning this idiopathic condition.

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