



James M. Anderson Center for Health
Systems Excellence

Evidence-Based Care Guideline

Management of Idiopathic Toe Walking¹

in children and young adults ages 2 through 21 years

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Target Population

Inclusions: Children or young adults:

- with onset of toe walking since independent ambulation
- who toe walk bilaterally
- with habitual or idiopathic toe walking
- ages 2 to 21 years

Exclusions: Children or young adults:

- with a central nervous system disorder such as cerebral palsy (CP)
- with Autism/Pervasive Development Disorder (PDD)
- with a myopathy such as Duchenne's Muscular Dystrophy or Becker's Muscular Dystrophy
- with a peripheral neuropathy such as Charcot Marie Tooth
- with a neuromuscular disorder such as Spinal Muscular Atrophy
- with Tethered Spinal Cord Syndrome
- with a congenital orthopedic condition such as Talipes Equinovarus (clubfoot)
- with unilateral toe walking
- with sudden onset of toe walking

Target Users

- Occupational Therapists
- Physical Therapists
- Physicians

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- Other healthcare professionals
- Patients and families who may find this information useful

Introduction

References in parentheses () Evidence strengths in [] (See last page for definitions)

Idiopathic Toe Walking (ITW) is a diagnostic term used to describe the condition in which children ambulate with a bilateral toe-toe pattern without any known reason or pathology (Sala 1999 [5a]). ITW is a diagnosis of exclusion and is used when other possibilities have been ruled out (Stricker 1998 [4b], Sala 1999 [5a]). ITW is also referred to as habitual toe walking, toe walking and congenital short tendo calcaneus (Hall 1967 [5], Sala 1999 [5a]). Toe walking has been associated with spastic cerebral palsy (CP), myopathy, Tethered Spinal Cord Syndrome, peripheral neuropathy, Pervasive Developmental Disorder (PDD), neuromuscular disorders and Talipes Equinovarus (Shulman 1997 [4b], Harris 1999 [5], Caselli 1988 [5], Gourdine-Shaw 2010 [5a]).

The differential diagnosis often occurs between ITW and mild spastic diplegia (Harris 1999 [5]). It is estimated that toe walking not associated with cerebral palsy occurs in 7 to 24 % of the childhood population (Sobel 1997 [4b]). *The Toe Walking Tool* is a series of questions and physical exam items that has been shown to be reliable and valid in distinguishing children with ITW from toe walking caused by other medical conditions (Williams 2010 [4a]). ITW is reported with higher frequency in males versus females (Fox 2006 [4a], Eastwood 1997 [4a], Stricker 1998 [4b], Katz 1984 [4b]). Studies have noted a positive family history of toe walking in children with ITW with a reported incidence of between 10 and 88 % (Fox 2006 [4a]).

In typically developing children, consistent heel strike during initial stance occurs by 18 months or at a mean time frame of 22.5 weeks after the onset of independent ambulation (Sutherland 1980 [5]). Toe walking may present during the development of pre-walking skills, at the start of independent walking, or within six months after the start of independent walking (Shulman 1997 [4b], Sobel 1997 [4b]). Children with ITW or their caregivers may report frequent falls or stumbles with ambulation (Gormley 1997 [4b], Sala 1999 [5a]). Pain in the foot or leg may be a complaint at the initial evaluation (Sobel 1997 [4b], Clark 2010 [5a]). ITW has been described as a normal variant of early gait, however, this has not been supported in the literature (Sutherland 1980 [5]). In typically developing children, gait characteristics are mature or adult-like by 7 or 8 years of age (Breniere 1998 [4a]).

Electromyography (EMG) data of the gastrocnemius and of the anterior tibialis during gait of children with ITW has been found to be out of phase, with abnormal co-contraction of these muscles. Early and predominant firing of the gastrocnemius in swing and stance as well as low amplitude anterior tibialis firing during some of stance and swing was noted (*Griffin 1977 [4b]*). Gait EMG data; however, has not been consistently reliable in differentiating children with ITW from children with CP (*Kalen 1986 [4a]*, *Papariello 1985 [4b]*, *Griffin 1977 [4b]*). Some children with ITW can spontaneously correct their gait to a heel-toe gait pattern, but it is usually temporary (*Crenna 2004 [4a]*, *Sobel 1997 [4b]*). Studies have shown persistent gait kinematics and gait EMG abnormalities in children with ITW when they attempt to walk in a heel-toe pattern (*Westberry 2008 [4a]*, *Griffin 1977 [4b]*).

A positive correlation between language delays (*Accardo 1992 [4b]*) and toe walking and between learning disabilities (*Sala 1999 [5a]*) and toe walking has been noted. Anecdotal reports of a potential link between ITW and sensory processing dysfunction (SPD) have not been confirmed (*Shulman 1997 [4b]*, *Montgomery 1978 [4b]*, *Williams 2010 [5]*).

Gastrocnemius, soleus and Achilles tendon tightness is acquired through years spent toe walking (*Sala 1999 [5a]*). Younger children with ITW have less restriction in ankle dorsiflexion (DF) passive range of motion (PROM) compared to older individuals with ITW (*DiGiovanni 2002 [4a]*, *Sobel 1997 [4b]*). Children who toe walk intermittently have greater ankle DF PROM than children who toe walk exclusively (*Sobel 1997 [4b]*). Limitation in ankle DF PROM is associated with increased frequency of ankle injuries in children (*Tabrizi 2000 [4a]*). Decreased ankle DF PROM is correlated with increased forefoot, midfoot and/or hindfoot pain or pathology in adulthood (*DiGiovanni 2002 [4a]*, *Hill 1995 [4b]*). Avoiding these outcomes in adulthood can be achieved by treatment of limited ankle DF in childhood (*DiGiovanni 2002 [4a]*).

Children with ITW may present with some or all of the following gait deviations: significant ankle plantarflexion (PF) in stance and swing, lack of first rocker (ankle PF immediately after heel strike), lack of second rocker (forward translation of the tibia over the foot in stance with progressive ankle DF), decreased third rocker (push off), premature heel off, out-toeing, knee hyperextension, and increased anterior pelvic tilt (*Westberry 2008 [4a]*, *McMulkin 2006 [4a]*, *Stott 2004 [4a]*, *Hicks 1988 [4b]*, *Clark 2010 [5a]*). Normal loading of the foot and transfer of body weight are absent in toe walking (*Clark 2010 [5a]*). A classification system has been developed to

identify ITW severity by presence of first ankle rocker, timing of third ankle rocker and predominant first ankle moment. This classification system requires motion analysis equipment and force plates, which are not commonly available in the clinic (*Alvarez 2007 [3a]*).

Foot pronation, which might include significant foot abduction, is the most common form of compensation for an ankle equinus deformity (*Hill 1995 [4b]*, *Reimers 1995 [4b]*, *Hicks 1988 [4b]*). Older children with a history of toe walking demonstrate excessive external tibial torsion evidenced by an increased positive thigh foot angle (*Hicks 1988 [4b]*). Out toeing to accommodate the PF contracture may be noted in older children and may account for the reported “outgrowing” of toe walking (*Sala 1999 [5a]*).

A normal gastrocnemius muscle is largely made up of Type II muscle fibers. Histologically, children with ITW have been shown to have a predominance of Type I muscle fibers in the gastrocnemius, which are tonic, slow-contracting and fatigue resistant. The increase of Type I fibers may be due to adaptive changes from prolonged periods of use or training-induced adaptation (*Eastwood 1997 [4a]*).

A distinction should be made in the treatment of the child with ITW with a loss of ankle DF and without loss of ankle DF as well as between children who are obligatory toe walkers and those that can walk heel-toe (*Taussig 2001 [4b]*). The amount of ankle DF PROM may not correlate directly with the amount of ankle DF in gait (*Stott 2004 [4a]*). Some children with ITW and full ankle DF PROM continue to walk on their toes (*Engstrom 2010 [4a]*, *Katz 1984 [4b]*). Prevention of a gastrocnemius contracture in children with persistent toe walking through early intervention by a pediatric physical therapist may improve outcomes (*Sobel 1997 [4b]*, *Harris 1999 [5]*). Education of the parents or caregivers in a HEP to manage this disorder is also paramount (*Harris 1999 [5]*).

Physical Therapy management of the child with ITW may include: stretching the ankle plantarflexors, strengthening the anterior tibialis and other lower extremity/trunk muscles, taping, augmented auditory feedback, neuromuscular electrical stimulation, manual therapy, ankle joint mobilizations, orthotic intervention, gait training, treadmill training, night splinting, shoe modifications, serial casting and home exercise program (HEP) development (*Brunt 2004 [4b]*, *Conrad 1980 [4b]*, *Harris 1999 [5]*, *Caselli 1988 [5]*, *Gourdine-Shaw 2010 [5a]*, *Sala 1999 [5a]*). The efficacy of these specific interventions with children with ITW have been studied: augmented

auditory feedback, motor control intervention, serial casting, Botox injections and surgery (Sala 1999 [5a]).

Augmented auditory feedback, provided with a pressure sensitive heel-switch, resulted in improved heel-toe walking in two children with ITW (Conrad 1980 [4b]). The feedback was provided for an hour a day over a mean of 3 months (Conrad 1980 [4b]).

Strengthening of the gastrocnemius to function in an eccentric capacity during second rocker was the emphasis in motor control interventions by Clark (Clark 2010 [5a]). Improvements in ankle DF PROM occurred at the end of treatment episode (18 visits), but heel-toe walking during spontaneous gait did not change significantly (Clark 2010 [5a]).

Serial casting for children with ITW has been shown to be an effective treatment to gain ankle DF PROM as well as to improve gait EMG variables. Specifically, reciprocal contraction of anterior tibialis and gastrocnemius during heel-toe gait was demonstrated by EMG after 6 weeks of serial casting (Griffin 1977 [4b]). In a study by Fox, 66 % of children with ITW treated with serial casting had improvement in their ankle DF PROM and gait pattern at a six week follow up. In these subjects, if the soleus contracture did not improve with serial casting, the gait pattern of the child did not improve. Ankle DF PROM with knee flexion may be an important clinical measure after an episode of serial casting and may relate to diminished outcomes in this population (Fox 2006 [4a]). After serial casting for 3 to 6 weeks, children with ITW had increased DF PROM gains and no changes in the amount of gastrocnemius force production except that the most forceful contraction occurred in more ankle dorsiflexion (Brouwer 2000 [4a]). After an episode of serial casting, an ankle foot orthotic (AFO) has been used to maintain range of motion gains and improve the gait pattern. An articulated AFO and/or DF assist ankle foot orthosis can be used to achieve a heel-toe gait pattern (Jacks 2004 [4b], Sala 1999 [5a], Tidwell 1999 [5a]).

Botox injections to the gastrocnemius and soleus muscles in conjunction with physical therapy treatment and/or serial casting have improved outcomes in some children with ITW (Brunt 2004 [4b], Jacks 2004 [4b], Gormley 1997 [4b]). Botox injections must be prescribed by a physician. Some patients require more than one round of Botox injections in conjunction with other conservative treatment measures to achieve a heel-toe gait pattern (Jacks 2004 [4b], Gormley 1997 [4b]).

Surgical intervention for ITW may include lengthening of the Achilles tendon or gastrocnemius or a recession of

part or all of the gastrocnemius to significantly improve ankle DF PROM (Hemo 2006 [4a]). Surgery, typically reserved for older children whose ITW has not resolved with conservative treatment, might improve gait kinematics and ankle range of motion (Hemo 2006 [4a]). Toe walking can recur after intervention, including after surgical intervention (Stricker 1998 [4b]).

Key Recommendations:

- Early identification and treatment of children with ITW is needed to prevent adaptive shortening of the gastrocnemius and the development of persistent abnormalities in gait and balance.
- The efficacy of conservative treatment of children with ITW is dependent on the amount of gastrocnemius and soleus contracture, the percentage of time spent toe walking and the age of the child at initial evaluation.
- Older children are more likely to have a significant gastrocnemius contracture and might not respond with equal success to conservative treatment measures as a younger child with ITW.
- Ankle DF PROM may not correlate with the amount of ankle DF in gait. Use of articulated AFOs to encourage heel strike, and normal first, second and third rocker is recommended in children who continue to toe walk despite having adequate ankle DF PROM.
- After weaning the child from use of the articulated AFO, a foot orthotic may be necessary to improve foot alignment in gait and to prevent recurrence of gastrocnemius and/or soleus contracture.
- Botox injections to the gastrocnemius and soleus may improve ankle DF PROM and gait kinematics and may be used in conjunction with physical therapy treatment, serial casting and/or AFOs.
- Surgical treatment is typically reserved for older children with significant ankle equinus who have not improved after conservative measures.

The **objectives** of this guideline are to:

- provide optimal skilled care to patients
- promote appropriate referrals
- improve functional outcomes
- decrease unwarranted variation in care
- improve patient/family satisfaction
- decrease/delay the need for invasive procedures

Expected Outcomes:

- PROM of ankle DF at least 10 degrees with knee extended measured in subtalar neutral (STN) (Tabrizi 2000 [4a], Local Consensus [5]).
- Heel strike 75% of the time or greater during spontaneous gait without AFOs by parent report and/or clinician observation (Local Consensus [5]).

Note : Patient may need foot orthotics to improve foot alignment during gait and prevent recurrence of gastrocnemius and/or soleus contracture after resolution of toe walking (Local Consensus [5]) .

- Gross motor and balance skills within age appropriate limits (Local Consensus [5]).

Risks and Benefits

Risks:

- Use of ankle foot orthotics, night splints and/or serial casts increase risk for changes in skin integrity (Stott 2004 [4a], Gourdine-Shaw 2010 [5a]).
- There is a risk of over lengthening and functionally weakening the gastrocnemius with surgery to correct ITW (Hemo 2006 [4a], Hill 1995 [4b], Katz 1984 [4b]).
- There are inherent risks associated with surgery and with any invasive procedure, such as Botox injections (Hemo 2006 [4a], Gormley 1997 [4b], Katz 1984 [4b]).

Benefits:

- Early identification and treatment of children with ITW may decrease potential for loss of ankle PROM, and improve development of mature gait (Brunt 2004 [4b], Local Consensus [5]).
- Early identification and conservative management of children with ITW may result in decreased necessity of more invasive treatments such as serial casting, Botox injections or surgery in later childhood (Katz 1984 [4b], Local Consensus [5]).
- Avoiding pathological outcomes in adulthood can be achieved by treatment of limited ankle DF in childhood (DiGiovanni 2002 [4a]).

therapy (Burnett 1971 [4b], Sutherland 1980 [5], Tidwell 1999 [5a]).

2. It is recommended that a comprehensive Physical Therapy Examination be completed, including the components named in table 1: (Williams 2010 [4a], AmericanPhysicalTherapyAssociation 2003 [5])

Table 1: Components of physical therapy examination history

History	
Parent report of history	<ul style="list-style-type: none"> • Obtain birth history (hx) (Hicks 1988 [4b]) • Obtain medical hx (AmericanPhysicalTherapyAssociation 2003 [5]) • Obtain developmental hx <ul style="list-style-type: none"> ○ Gross Motor (GM) skills (Furrer 1982 [4b], Clark 2010 [5a]) ○ Determine balance concerns (Sobel 1997 [4b]) ○ Onset of toe walking • Family hx of toe walking and/or of medical conditions associated with toe walking (Williams 2010 [4a], Katz 1984 [4b], Sala 1999 [5a]) • Review current and past therapeutic interventions for ITW: i.e. PT, OT, Orthopedics, Podiatrist, Neurologist, PM&R (Hill 1995 [4b], AmericanPhysicalTherapyAssociation 2003 [5])
Pain Assessment	<p>Systems Review</p> <ul style="list-style-type: none"> • Utilize appropriate pain scale • Localize pain • What improves/worsens pain? (Sobel 1997 [4b], Clark 2010 [5a])
Integument	<ul style="list-style-type: none"> • Presence of calluses, bunions, or redness on feet
Speech and language screen	<ul style="list-style-type: none"> • Communication subsection of Ages and Stages Questionnaire (for ages: 4 months to 60 months) if indicated (Accardo 1992 [4b])
Sensory processing screen	<ul style="list-style-type: none"> • Short Sensory Profile (for ages 3 years to 10 years 11 months) (Montgomery 1978 [4b]) by first treatment visit
Neurological exam	<p>Physical Assessment</p> <ul style="list-style-type: none"> • Assess muscle tone <ul style="list-style-type: none"> ○ Modified Ashworth (ankle plantarflexors & knee flexors) ○ Clonus (Brouwer 2000 [4a], Rose 1999 [4a])
Musculoskeletal exam	<ul style="list-style-type: none"> • Ankle DF PROM in STN with knee flexed and extended (Brouwer 2000 [4a], Rose 1999 [4a], Hill 1995 [4b], Caselli 1988 [5], Local Consensus [5]).

Guideline Recommendations

Assessment (see Appendix 1: Screening Algorithm)

1. It is recommended that children 2 years of age or older who toe walk are referred to physical

	<ul style="list-style-type: none"> • Ankle DF AROM with knee extended • Muscle length tests: Thomas test (hip flexors), Hamstring length test (<i>Clark 2010 [5a]</i>) • LE alignment: Thigh foot angle (TFA) (<i>Stott 2004 [4a]</i>), Hindfoot/forefoot alignment in STN (non-weight bearing) (<i>Stott 2004 [4a]</i>, <i>Local Consensus [5]</i>) • Standing Posture (<i>McMulkin 2006 [4a]</i>, <i>Clark 2010 [5a]</i>) • Assess LE strength (MMT and/or functional assessment) <ul style="list-style-type: none"> ○ anterior tibialis ○ gastrocnemius (<i>Hemo 2006 [4a]</i>, <i>Brouwer 2000 [4a]</i>) • Assess Trunk/Core strength (<i>Local Consensus [5]</i>)
Gait exam	<ul style="list-style-type: none"> • Observational Gait Scale (OGS) (<i>Stott 2004 [4a]</i>, <i>Mackey 2003 [4a]</i>) • Parent report of percentage of time toe walking (<i>Rose 1999 [4a]</i>, <i>Griffin 1977 [4b]</i>, <i>Clark 2010 [5a]</i>)
Gross motor skills assessment	<ul style="list-style-type: none"> • Squatting to/from standing, position of foot in squatting • Transition floor to stand • Stairs • Balance <ul style="list-style-type: none"> ○ Static and dynamic standing balance ○ Single limb stance ○ Balance beam • Jumping/Hopping • Coordination • Determine need for standardized testing (<i>Clark 2010 [5a]</i>)

Screenings and recommended referrals to other disciplines (*Shulman 1997 [4b]*, *Caselli 1988 [5]*).

- It is recommended that a recommendation for referral to the appropriate specialist be made to the primary care provider if: (*AmericanPhysicalTherapyAssociation 2003 [5]*)
 - sensory processing dysfunction is reported or observed (Occupational Therapy) (*Montgomery 1978 [4b]*)

Note 1: Use of the Short Sensory Profile by first treatment visit (*Local Consensus [5]*).

 - speech and language delay is reported or observed (Speech Language Pathology) (*Accardo 1992 [4b]*).

Note 1: Use of the Communication subsection of the Ages and Stages Questionnaire if indicated (*Local Consensus [5]*).

- Signs/symptoms of a central or peripheral nervous system disorder, a neuromuscular disorder or a myopathy are noted (PM&R or Neurology) (*Rose 1999 [4a]*, *Hicks 1988 [4b]*, *Harris 1999 [5]*, *Caselli 1988 [5]*)
 - presence of significant structural equinus or congenital orthopedic condition (Orthopedics) (*Hemo 2006 [4a]*, *Caselli 1988 [5]*, *Local Consensus [5]*)
 - child does not achieve 10 degrees of ankle DF PROM with knee extended despite conservative therapeutic interventions (Orthopedics and/or PM&R) (*Local Consensus [5]*)
- It is recommended that physical therapy intervention be initiated when an individual exhibits any of the following:
 - limitations in ankle DF PROM or AROM (*Brouwer 2000 [4a]*, *Rose 1999 [4a]*, *Hill 1995 [4b]*)
 - limitations in ankle DF strength (*Hemo 2006 [4a]*, *Brouwer 2000 [4a]*)
 - gait abnormalities (*Rose 1999 [4a]*, *Griffin 1977 [4b]*)
 - decreased balance (*Local Consensus [5]*)

Treatment Recommendations

(See Appendix 2: Intervention and Treatment Frequency algorithm)

Overall considerations:

Initial Treatment Visit:

- It is recommended that the initial treatment of ITW include:
 - **Review:** HEP given at PT evaluation (*Local Consensus [5]*)
 - **Reassess/assess:**
 - DF PROM with knee flexed and extended, measured in STN (*Brouwer 2000 [4a]*, *Rose 1999 [4a]*, *Hill 1995 [4b]*)
 - gait (*Mackey 2003 [4a]*, *Caselli 1988 [5]*)
 - percent of time spent toe walking at home (document with shoes or barefoot) (*Local Consensus [5]*, *Clark 2010 [5a]*)
 - gross motor skill screen to determine if standardized testing is appropriate (*Shulman 1997 [4b]*, *Furrer 1982 [4b]*)
 - **Initiate:** orthotics or serial casting (see Appendix 2) (*Local Consensus [5]*, *Gourdine-Shaw 2010 [5a]*).
 - **Provide instruction:** gastrocnemius and soleus stretch; trunk and/or LE strengthening (*Tabrizi 2000 [4a]*, *Tidwell 1999 [5a]*)

- Provide education: etiology of ITW, treatment plan and goals (*Local Consensus [5]*)

Note: Education to include:

- impact of decreased ankle PROM including potential for foot pain or injury (*DiGiovanni 2002 [4a], Tabrizi 2000 [4a], Gourdine-Shaw 2010 [5a]*)
- muscle length needed for age appropriate gait pattern (*Tabrizi 2000 [4a], Gourdine-Shaw 2010 [5a]*)
- changes in muscle composition and function due to toe walking (*Sobel 1997 [4b]*)
- motor learning process to attain mature gait pattern (*Sutherland 1980 [5], Clark 2010 [5a]*)
- discussion with options of treatment (such as night splinting versus serial casting) (*Fox 2006 [4a], Brouwer 2000 [4a], Griffin 1977 [4b]*)

(*AmericanPhysicalTherapyAssociation 2003 [5]*)

Subsequent Visits: Every visit or after serial casting episode

6. It is recommended that all subsequent visits include:
 - Re-assess:
 - DF PROM with knee flexed and extended, measured in STN and DF AROM (*Brouwer 2000 [4a], Rose 1999 [4a], Hill 1995 [4b]*)
 - gait (*Caselli 1988 [5]*)
Perform Observational Gait Scale when positive or negative changes occur in gait (*Mackey 2003 [4a]*)
 - report of percent of time spent heel-toe walking during spontaneous gait (with shoes or barefoot) (*Clark 2010 [5a]*)
 - Review/modify HEP (parent demonstration) (*Tabrizi 2000 [4a], Tidwell 1999 [5a]*)
 - PT interventions may include: stretching of the gastrocnemius and soleus and other trunk/LE muscles, trunk/LE strengthening (including possible taping or NMES), manual therapy (including joint mobilizations), balance and coordination training, gait/treadmill training (including augmented auditory feedback), orthotic intervention and development of a HEP. (*Westberry 2008 [4a], Hemo 2006 [4a], Tabrizi 2000 [4a], Jacks 2004 [4b], Sobel 1997 [4b], Hill 1995 [4b], Katz 1984 [4b], Conrad 1980 [4b], Caselli 1988 [5], Local Consensus [5], Gourdine-Shaw 2010 [5a], Tidwell 1999 [5a]*).

- Standardized testing of gross motor skills if indicated (*Furrer 1982 [4b], Clark 2010 [5a], Gourdine-Shaw 2010 [5a]*).
- PT frequency may be increased at any point due to difficulty with HEP or PT treatment or decreased progress towards goals. PT treatment frequency may be decreased at any point due to accelerated progress towards goals and/or independence with HEP (*Local Consensus [5], Bailes 2008 [5a]*).

(*AmericanPhysicalTherapyAssociation 2003 [5]*)

Frequency and Progression of Intervention:

Individuals with less than or equal to 0 degrees ankle DF PROM with knee extended measured in STN:

7. It is recommended that a recommendation for serial casting be made to the primary care provider. Therapy intervention to focus on serial casting (with or without Botox) on a weekly basis. (*Fox 2006 [4a], Brouwer 2000 [4a], Griffin 1977 [4b], Local Consensus [5], Tidwell 1999 [5a]*).

Goal is to increase ankle DF with knee extended (measured in STN) to greater than or equal to 10 degrees.

Note 1: Botox in conjunction with serial casting may improve outcomes (*Jacks 2004 [4b], Gormley 1997 [4b]*).

Note 2: Serial casting to be conducted according to the companion guideline: Evidence-based Care Guideline for Serial Casting of the Lower Extremity (*Woosley 2007 [5]*).

Note 3: Knee immobilizers may be worn in conjunction with serial casting if tolerated by client to improve gastrocnemius length gains (*Local Consensus [5]*).

8. It is recommended that consideration of a referral to Physical Medicine and Rehabilitation (PM&R) for possible Botox injections or Orthopedics for potential surgical intervention when PROM continues to be less than or equal to neutral following serial casting (*Hemo 2006 [4a], Jacks 2004 [4b], Cottalorda 2000 [4b], Gormley 1997 [4b], Caselli 1988 [5], Local Consensus [5]*).

Individuals with 0 to 5 degrees of ankle DF PROM with knee extended measured in STN:

9. It is recommended that weekly therapy intervention focus on night splinting. Additional PT interventions may include: stretching gastrocnemius and soleus, trunk & LE

strengthening, manual therapy, gait/treadmill training, balance training, possible orthotic intervention, and/or HEP (Tabrizi 2000 [4a], AmericanPhysicalTherapyAssociation 2003 [5], Local Consensus [5]).

Goals are to increase ankle DF with knee extended to greater than or equal to 10 degrees measured in STN (Tabrizi 2000 [4a], Gourdine-Shaw 2010 [5a]) and to decrease the reported frequency of toe walking by individual or caregiver (Local Consensus [5], Clark 2010 [5a]).

10. It is recommended that night splinting be initiated (Local Consensus [5]).

Note: Night splinting to be attempted for 4 to 6 months (Local Consensus [5]).

11. It is recommended that if ankle DF PROM with knee extended continues to be less than or equal to 5 degrees after 4 to 6 months of night splinting, serial casting with or without Botox is indicated on a weekly basis (Local Consensus [5]).

Goal is to increase ankle DF PROM with knee extended, measured in STN to greater than or equal to 10 degrees (Tabrizi 2000 [4a], Gourdine-Shaw 2010 [5a]).

Note 1: Consultation with the referring physician regarding initiation of serial casting (Local Consensus [5]).

Note 2: Serial casting to be conducted according to the companion guideline: Evidence-based Care Guideline for Serial Casting of the Lower Extremity (Woosley 2007 [5], Local Consensus [5]).

Note 3: Knee immobilizers may be worn in conjunction with serial casting or night splinting if tolerated by client to improve gastrocnemius lengthening (Local Consensus [5]).

Individuals with 5 to 10 degrees of ankle DF PROM with knee extended measured in STN:

12. It is recommended that every other week weekly PT intervention focus on articulated AFO, possible night splint, stretching, trunk/LE strengthening, manual therapy, gait/treadmill training, balance training, and HEP development (Hemo 2006 [4a], Stott 2004 [4a], Tabrizi 2000 [4a], Jacks 2004 [4b], Stricker 1998 [4b], Gormley 1997 [4b], Sobel 1997 [4b], Hill 1995 [4b], Katz 1984 [4b], Caselli 1988 [5], Local Consensus [5], Gourdine-Shaw 2010 [5a], Tidwell 1999 [5a]).

Goals of intervention are to:

- increase ankle DF range of motion with knee extended to greater than 10 degrees (Tabrizi 2000 [4a], Sutherland 1980 [5], Tidwell 1999 [5a])
- increase heel toe gait pattern with or without AFOs (Caselli 1988 [5], Local Consensus [5])
- demonstrate second rocker during stance phase of gait (Local Consensus [5], Clark 2010 [5a])
- improve higher level balance skills (Local Consensus [5])

13. It is recommended that after 4 to 6 months without improvement in PROM or gait, consider increasing frequency of treatment or referral to PM&R. (Engstrom 2010 [4a], Brunt 2004 [4b], Jacks 2004 [4b], Local Consensus [5], Bailes 2008 [5a], Tidwell 1999 [5a]).

Note: Communication with primary care provider regarding referral to PM&R. (local consensus)

14. It is recommended that after 12 months of PT intervention, reassessment of progress toward goals be completed. When goals are met discharge is indicated. When patient/family demonstrates non-compliance with HEP or PT treatment, discharge may be indicated. When individual is not making progress toward goals or having difficulty with HEP or PT treatment, increased frequency of treatment may be indicated. When patient continues to progress towards goals, continue PT plan of care. (Local Consensus [5], Bailes 2008 [5a]).

Note: Need for articulated AFOs, foot orthotics, night splints and/or HEP should be established prior to discharge (Local Consensus [5]).

Note 2: Periodic follow-up by PT may be required for orthotics (local consensus).

Individuals with greater than 10 degrees in ankle DF PROM with knee extended measured in STN:

15. It is recommended that if the individual demonstrates heel-toe walking greater than 75 % of the time during spontaneous gait that he/she is discharged with HEP (Local Consensus [5], Bailes 2008 [5a], Tidwell 1999 [5a]).

Note: Foot orthotics may be needed to provide neutral foot alignment and prevent recurrence of ankle plantarflexor contracture (Local Consensus [5]).

16. It is recommended that when an individual performs heel-toe walking less than 75 % of the time physical therapy continue on a every other

week basis for 4 to 6 months. Treatment focus may include: daytime articulated AFO's, night splinting, stretching, trunk/LE strengthening, manual therapy, gait/treadmill training, balance training, and HEP (*Hemo 2006 [4a], Tabrizi 2000 [4a], Jacks 2004 [4b], Sobel 1997 [4b], Hill 1995 [4b], Katz 1984 [4b], Caselli 1988 [5], Local Consensus [5], Bailes 2008 [5a], Tidwell 1999 [5a]*).

Goals of intervention are to:

- maintain or increase ankle DF PROM with knee extended measured in STN to at least 10 degrees (*Tabrizi 2000 [4a]*)
- improve heel-toe ambulation frequency to 75% of spontaneous gait as reported by parent/caregiver (*Local Consensus [5]*)
- improvement in OGS score (*Stott 2004 [4a]*)
- increase heel toe gait pattern when not wearing AFO (*Local Consensus [5]*)

Note : Patient may need foot orthotics to improve foot alignment during gait and prevent recurrence of gastrocnemius and/or soleus contracture (*Local Consensus [5]*).

17. It is recommended that after 4 to 6 months without improvement in heel-toe frequency during spontaneous gait, referral to PM&R be considered. Continue to provide plan of care while awaiting specialty consult (*Engstrom 2010 [4a], Brunt 2004 [4b], Jacks 2004 [4b], Local Consensus [5], Bailes 2008 [5a], Tidwell 1999 [5a]*).

Note: Communicate with primary provider regarding referral to PM&R (local consensus).

18. It is recommended that after 12 months of total PT intervention, reassess progress toward goals. Continue PT plan of care when patient continues to make progress towards goals. When pt has reached a plateau towards goals, it is recommended that patient be referred to PM&R. Discharge when goals are met or when individual/caregiver is noncompliant with HEP or PT treatment (*Engstrom 2010 [4a], Brunt 2004 [4b], Jacks 2004 [4b], Local Consensus [5], Bailes 2008 [5a]*).

Note: Communicate with primary care provider regarding referral to PM&R if indicated (*Local Consensus [5]*).

Note : Patient may need foot orthotics to improve foot alignment during gait and prevent recurrence of gastrocnemius and/or soleus contracture (*Local Consensus [5]*).

19. PT frequency may be increased at any point due to difficulty with HEP or PT treatment or decreased progress towards goals. PT treatment frequency may be decreased at any point due to accelerated progress towards goals and/or independence with HEP.

Discharge from Therapy

20. It is recommended that a child be discharged from therapy when the child/caregiver is noncompliant with PT treatment or HEP or when the following therapy goals have been met (*Local Consensus [5], Bailes 2008 [5a]*):

- ankle DF PROM greater than or equal to 10 degrees with knee extended, measured in STN (*McMulkin 2006 [4a], Tabrizi 2000 [4a], Sutherland 1980 [5], Tidwell 1999 [5a]*)
- heel-toe ambulation greater than 75% of spontaneous gait and/or parent/caregiver satisfaction (*Bailes 2008 [5a]*)
- improvement in OGS score (*Local Consensus [5]*)
- independence in home exercise program (*Local Consensus [5]*)
- maximization of gross motor skills (*Local Consensus [5], Clark 2010 [5a]*)

21. It is recommended that children with persistent toe walking due to lack of progress with above interventions or lack of compliance discontinue physical therapy with instruction to continue ankle plantar flexor stretches, use of AFOs or foot orthotics and/or night splints (*Local Consensus [5], Bailes 2008 [5a]*).

Note: PT intervention may be needed on a periodic basis to manage orthotic needs (local consensus).

22. It is recommended that parents be instructed that plateaus in ankle passive or active ROM and/or regression to toe walking may occur during times of:

- growth spurt
- anxiety
- fatigue/illness
- lack of follow through at home

(*Local Consensus [5]*)

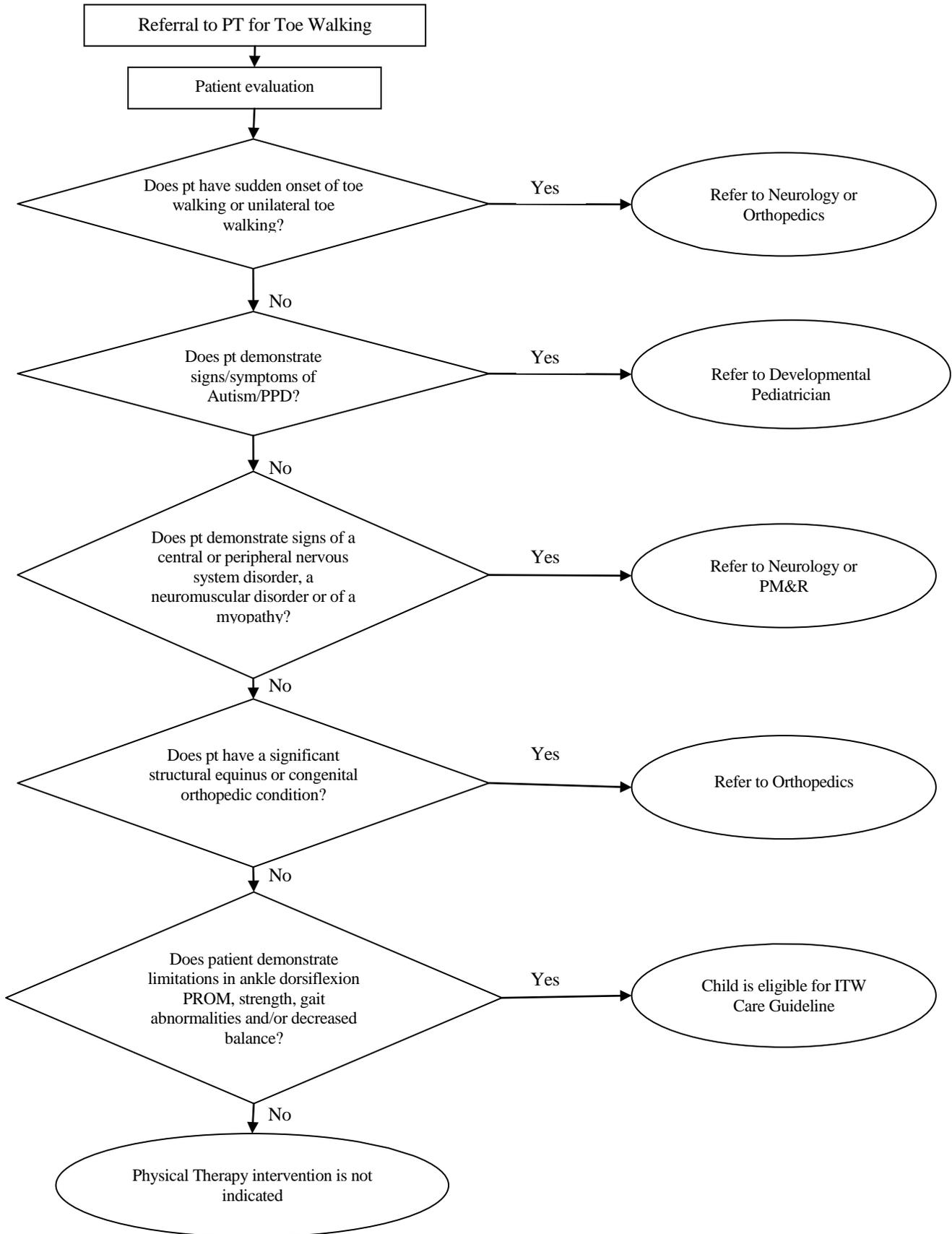
During these instances if no improvements are seen after resuming HEP over 4 weeks, therapy reassessment may be indicated (*Local Consensus [5]*).

Future Research Agenda

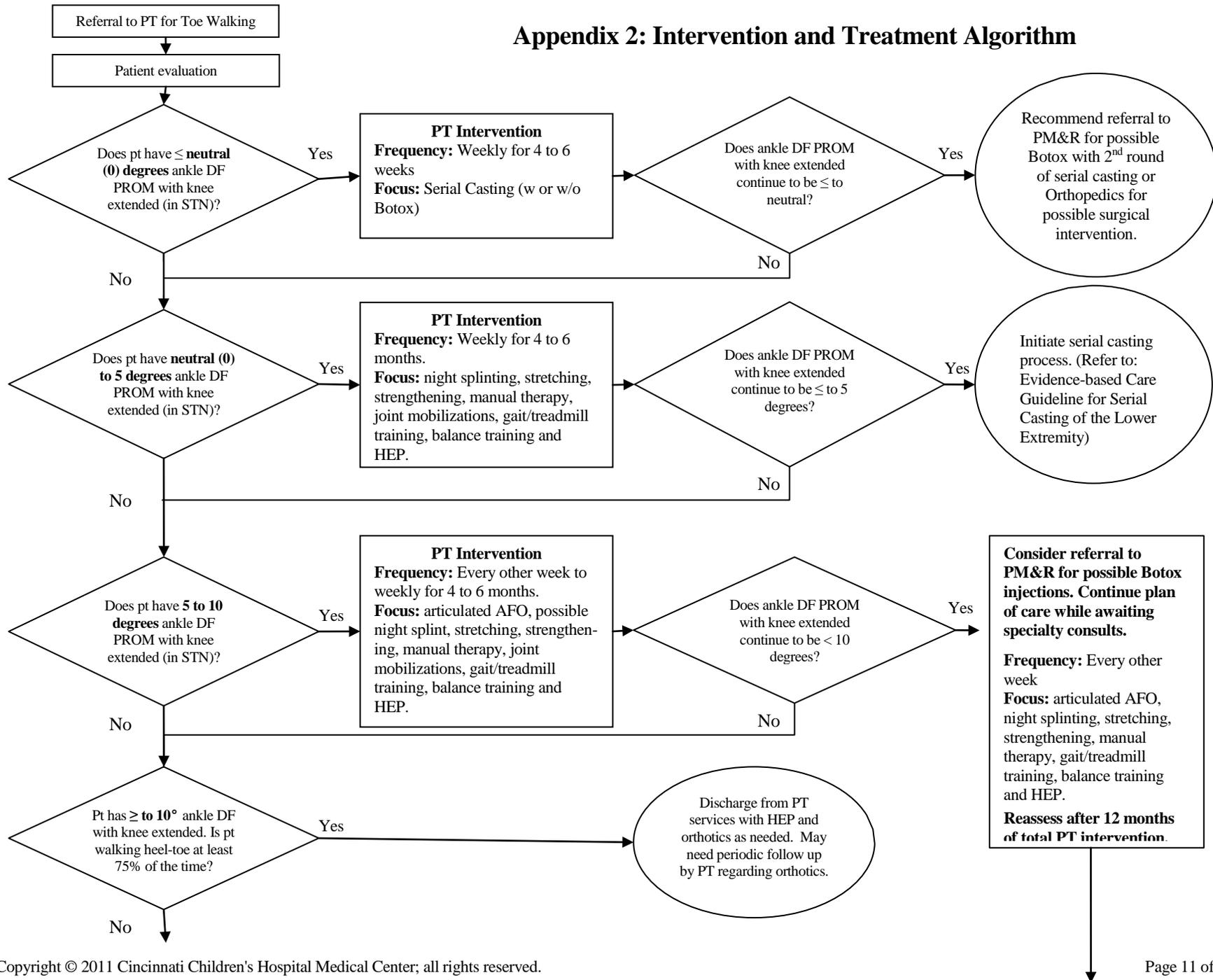
Suggestions for further research in this area include:

- What are the most effective stretching techniques with ITW?
- In children with ITW who are being treated with serial casts or night ankle splints, does wearing knee immobilizers improve gastrocnemius length more quickly or effectively than not wearing knee immobilizers?
- In children with ITW, how does the development of balance and higher level gross motor skills differ from typically developing children?
- In children with ITW, what is the amount of time with conservative treatment needed to resolve toe walking and/or contractures of the ankle plantar flexors?
- In children with ITW and full ankle PROM, what length of time (months) in day time articulated AFOs is needed to develop a heel strike without AFO?
- In children with ITW who have 10 degrees or greater of ankle dorsiflexion and heel-toe gait 75 % of the time, what is the effect of foot orthotics on maintaining heel strike and ankle PROM?
- What is the reliability and/or validity of the OGS with children with ITW?
- In adults who were diagnosed with ITW as a child, what is the incidence of foot, ankle or knee arthritis compared to the average adult population?

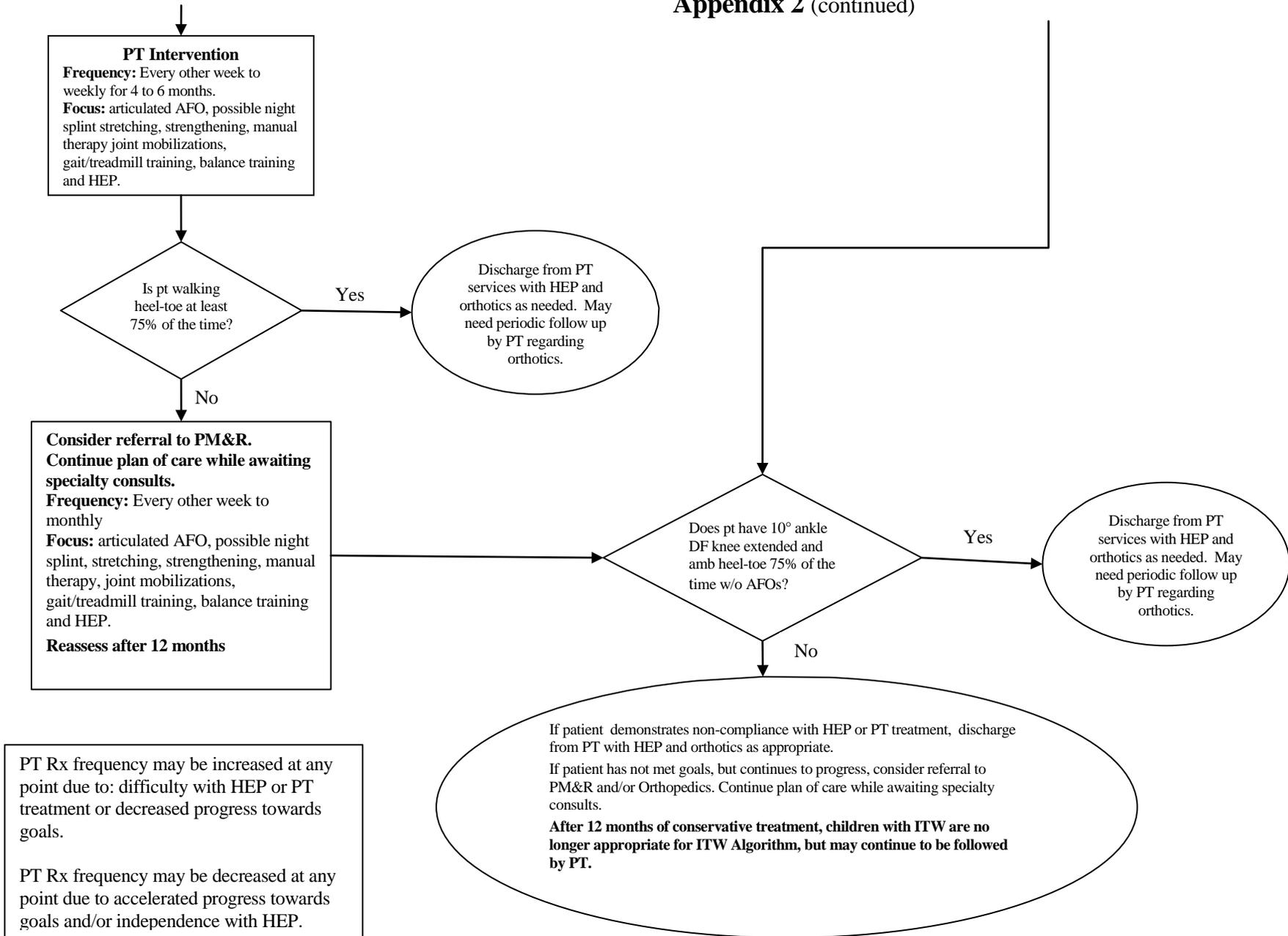
Appendix 1: Screening Algorithm (*AmericanPhysicalTherapyAssociation 2003 [5]*)



Appendix 2: Intervention and Treatment Algorithm



Appendix 2 (continued)



PT Rx frequency may be increased at any point due to: difficulty with HEP or PT treatment or decreased progress towards goals.

PT Rx frequency may be decreased at any point due to accelerated progress towards goals and/or independence with HEP.

Appendix 3: Initial Clinical Questions to guide search and selection of evidence

PICO Questions

1. In children 2 to 21 years with a primary diagnosis of ITW, what evaluation findings should pediatric physical therapists use to differentiate ITW from other primary diagnoses that may present with toe walking (such as Autism, Cerebral Palsy, Duchene's Muscular Dystrophy) to determine appropriate treatment plan and/or make appropriate referrals to other health care practitioners?
2. In children with a primary diagnosis of ITW, what gait characteristics differentiate ITW from other primary diagnoses that may demonstrate toe walking (such as Cerebral Palsy) in order for pediatric physical therapists to determine appropriate treatment plan(s) and/or outcome measurements?
3. In children aged 2 to 21 years, what gait parameters indicate an immature walking pattern versus a mature/adult pattern?
4. In patients with a primary diagnosis of ITW, is prolonged stretching as effective as night splinting in improving ankle PROM, ambulation, and/or balance parameters?
5. In patients with a primary diagnosis of ITW, is serial casting more effective than no serial casting in improving ankle PROM, ambulation and/or balance parameters?
6. In patients with a primary diagnosis of ITW, is serial casting with Botox injections more effective in improving ankle PROM, ambulation, and/or balance parameters?
7. In patients with a primary diagnosis of ITW, is strengthening the anterior tibialis more effective than the gastrocnemius in improving ankle PROM, ambulation and/or balance parameters?

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All Team Members listed above have signed a conflict of interest declaration and no financial conflicts of interest were found.

Development Process

The process by which this guideline was developed is documented in the [Guideline Development Process Manual](#); a Team Binder maintains minutes and other relevant development materials. The recommendations contained in this guideline were formulated by an interdisciplinary working group which performed systematic and critical literature reviews, using the grading scale that follows, and examined current local clinical practices.

To select evidence for critical appraisal by the group for this guideline, the Medline, Cinahl, Google Scholar and the Cochrane databases were searched for dates of January 1948 to August 2010 to generate an unrefined, “combined evidence” database using a search strategy focused on answering clinical questions relevant to ITW (see Appendix 3) and employing a combination of Boolean searching on human-indexed thesaurus terms (MeSH headings using an OVID Medline interface) and “natural language” searching on searching on human-indexed thesaurus terms (MeSH headings using an OVID Medline interface) and “natural language” searching on words in the title, abstract, and indexing terms. The citations were reduced by: eliminating duplicates, review articles, non-English articles, and adult articles. The resulting abstracts were reviewed by a methodologist to eliminate low quality and irrelevant citations. During the course of the guideline development, additional clinical questions were generated and subjected to the search process, and some relevant review articles were identified.

Note: Full tables of evidence grading system available in separate document:

- [Table of Evidence Levels of Individual Studies by Domain, Study Design, & Quality](#) (abbreviated table below)
- [Grading a Body of Evidence to Answer a Clinical Question](#)
- [Judging the Strength of a Recommendation](#) (abbreviated table below)

Table of Evidence Levels (see note above)

<i>Quality level</i>	<i>Definition</i>
1a† or 1b†	Systematic review, meta-analysis, or meta-synthesis of multiple studies
2a or 2b	Best study design for domain
3a or 3b	Fair study design for domain
4a or 4b	Weak study design for domain
5	Other: General review, expert opinion, case report, consensus report, or guideline

†a = good quality study; b = lesser quality study

Table of Recommendation Strength (see note above)

<i>Strength</i>	<i>Definition</i>
“Strongly recommended”	There is consensus that benefits clearly outweigh risks and burdens (or visa-versa for negative recommendations).
“Recommended”	There is consensus that benefits are closely balanced with risks and burdens.
No recommendation made	There is lack of consensus to direct development of a recommendation.
Dimensions: In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.	
<ol style="list-style-type: none"> 1. Grade of the Body of Evidence (see note above) 2. Safety / Harm 3. Health benefit to patient (<i>direct benefit</i>) 4. Burden to patient of adherence to recommendation (<i>cost, hassle, discomfort, pain, motivation, ability to adhere, time</i>) 5. Cost-effectiveness to healthcare system (<i>balance of cost / savings of resources, staff time, and supplies based on published studies or onsite analysis</i>) 6. Directness (<i>the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome]</i>) 7. Impact on morbidity/mortality or quality of life 	

Tools to assist in the effective dissemination and implementation of the guideline may be available online at <http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm>. Once the guideline has been in place for five years, the development team reconvenes to explore the continued validity of the guideline. This phase can be initiated at any point that evidence indicates a critical change is needed.

critical change is needed.

The guideline was externally appraised by two reviewers² using the AGREE instrument and the results by domain are:

- Scope and Purpose 94%
- Stakeholder Involvement 61%
- Rigor of Development 67%
- Clarity and Presentation 78%
- Applicability 29%
- Editorial Independence 67%

Recommendations have been formulated by a consensus process directed by best evidence, patient and family preference and clinical expertise. During formulation of these recommendations, the team members have remained cognizant of controversies and disagreements over the management of these patients. They have tried to resolve controversial issues by consensus where possible and, when not possible, to offer optional approaches to care in the form of information that includes best supporting evidence of efficacy for alternative choices.

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The guideline has been reviewed and approved by clinical experts not involved in the development process, distributed to senior management, and other parties as appropriate to their intended purposes.

The guideline was developed without external funding. All Team Members and Clinical Effectiveness support staff listed have declared whether they have any conflict of interest and none were identified.

Copies of this Evidence-based Care Guideline (EBCG) and any available implementation tools are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address:

<http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm> Examples of approved uses of the EBCG include the following:

- copies may be provided to anyone involved in the organization's process for developing and implementing evidence-based care guidelines;
- hyperlinks to the CCHMC website may be placed on the organization's website;
- the EBCG may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents; and
- copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at HPCEInfo@cchmc.org for any EBCG, or its companion documents, adopted, adapted, implemented or hyperlinked by the organization is appreciated.

NOTE: These recommendations result from review of literature and practices current at the time of their formulations. This guideline does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this guideline is voluntary. The physician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

For more information about this guideline, its supporting evidences and the guideline development process, contact the Division of Occupational Therapy and Physical Therapy Office at: 513-636-4651.

References

Note: When using the electronic version of this document,  indicates a hyperlink to the PubMed abstract. A hyperlink following this symbol goes to the article PDF when the user is within the CCHMC network.

1. **Accardo, M., Heaney, Whitman, Tomazic:** Toe Walking and Language Developmental. *Clinical Pediatrics*, (March): 158-160, 1992, [4b] .
2. **Alvarez:** Classification of Idiopathic Toe Walking Based on Gait Analysis. *Gait & Posture*, 26: 428-435, 2007, [3a] .
3. **AmericanPhysicalTherapyAssociation:** Impaired Muscle Performance, Practice Pattern 4C. In *Interactive Guide to Physical Therapist Practice*. Edited by APTA, American Physical Therapy Association, 2003, [5] .
4. **Bailes, A.:** Development of Guidelines for Determining Frequency of Therapy Services in a Pediatric Medical Setting. *Pediatric Physical Therapy*, 2008, [5a] .
5. **Breniere:** Development of postural control of gravity forces in children during the first 5 years of walking. *Exp Brain Res*, 121: 255-262, 1998, [4a] .
6. **Brouwer, B.; Davidson, L. K.; and Olney, S. J.:** Serial casting in idiopathic toe-walkers and children with spastic cerebral palsy. *J Pediatr Orthop*, 20(2): 221-5, 2000, [4a] .
7. **Brunt, D.; Woo, R.; Kim, H. D.; Ko, M. S.; Senesac, C.; and Li, S.:** Effect of botulinum toxin type A on gait of children who are idiopathic toe-walkers. *J Surg Orthop Adv*, 13(3): 149-55, 2004, [4b] .
8. **Burnett, C. N., and Johnson, E. W.:** Development of gait in childhood. II. *Dev Med Child Neurol*, 13(2): 207-15, 1971, [4b] .
9. **Caselli, M. A.; Rzonca, E. C.; and Lue, B. Y.:** Habitual toe-walking: evaluation and approach to treatment. *Clin Podiatr Med Surg*, 5(3): 547-59, 1988, [5] .
10. **Clark, E.:** Effects of Motor Control Intervention for Children with Idiopathic Toe Walking: A 5-case series. *Pediatric Physical Therapy*, 2010(22): 417-426, 2010, [5a] .
11. **Conrad, L., and Bleck, E. E.:** Augmented auditory feed back in the treatment of equinus gait in children. *Dev Med Child Neurol*, 22(6): 713-8, 1980, [4b] .
12. **Cottalorda, J.; Gautheron, V.; Metton, G.; Charmet, E.; and Chavier, Y.:** Toe-walking in children younger than six years with cerebral palsy: the contribution of serial corrective casts. *Journal of Bone & Joint Surgery, British Volume*, 82B(4): 541-544, 2000, [4b] .
13. **Crenna, P.; Fedrizzi, E.; Andreucci, E.; Frigo, C.; and Bono, R.:** The heel-contact gait pattern of habitual toe walkers. *Gait & Posture*, 21(3): 311-317, 2004, [4a] .
14. **DiGiovanni, C. W.; Kuo, R.; Tejwani, N.; Price, R.; Hansen Jr, S. T.; Cziernecki, J.; and Sangeorzan, B. J.:** ISOLATED GASTROCNEMIUS TIGHTNESS. *Journal of Bone & Joint Surgery, American Volume*, 84(6): 962-970, 2002, [4a] .
15. **Eastwood, D. M.; Dennett, X.; Shield, L. K.; and Dickens, D. R.:** Muscle abnormalities in idiopathic toe-walkers. *J Pediatr Orthop B*, 6(3): 215-8, 1997, [4a] .
16. **Engstrom, P.:** Does botulinum toxin A improve the walking pattern in children with ITW? *Journal of Child Orthop*, 4: 301-308, 2010, [4a] .
17. **Fox:** Serial casting in the treatment of Idiopathic toe-walkers and review of the literature. *Acta Orthopaeadica Belgica*, 72: 722-730, 2006, [4a] .
18. **Furrer, F., and Deonna, T.:** Persistent toe-walking in children. A comprehensive clinical study of 28 cases. *Helv Paediatr Acta*, 37(4): 301-16, 1982, [4b] .
19. **Gormley:** The use of botulinum toxin in children: a retrospective study of adverse reactions and treatment of idiopathic toe-walking. *European Journal of Neurology*, 4: 27-30, 1997, [4b] .
20. **Gourdine-Shaw:** Equinus Deformity in Pediatric Patient: Causes, Evaluation and Management. *Clinical Podiatric Med Surg*, 27(2010): 25-42, 2010, [5a] .
21. **Griffin, P. P.; Wheelhouse, W. W.; Shiavi, R.; and Bass, W.:** Habitual toe-walkers. A clinical and electromyographic gait analysis. *J Bone Joint Surg Am*, 59(1): 97-101, 1977, [4b] .
22. **Hall, J. E.; Salter, R. B.; and Bhalla, S. K.:** Congenital short tendo calcaneus. *J Bone Joint Surg Br*, 49(4): 695-7, 1967, [5] .
23. **Harris, E.:** An Approach to Toe Walking: Appropriate Decision Making. In *Pediatric Foot and Ankle Surgery*, pp. 285-303. Edited by Richard Jay, D., 1999, [5] .
24. **Hemo, Y.; Macdessi, S. J.; Pierce, R. A.; Aiona, M. D.; and Sussman, M. D.:** Outcome of patients after Achilles tendon lengthening for treatment of idiopathic toe walking. *J Pediatr Orthop*, 26(3): 336-40, 2006, [4a] .
25. **Hicks, R.; Durinick, N.; and Gage, J. R.:** Differentiation of idiopathic toe-walking and cerebral palsy. *J Pediatr Orthop*, 8(2): 160-3, 1988, [4b] .
26. **Hill, R. S.:** Ankle equinus. Prevalence and linkage to common foot pathology. *J Am Podiatr Med Assoc*, 85(6): 295-300, 1995, [4b] .
27. **Jacks, L. K.; Michels, D. M.; Smith, B. P.; Koman, L. A.; and Shilt, J.:** Clinical usefulness of botulinum toxin in the lower extremity. *Foot and Ankle Clinics of North America*, 9(2): 339-348, 2004, [4b] .
28. **Kalen, V.; Adler, N.; and Bleck, E. E.:** Electromyography of idiopathic toe walking. *J Pediatr Orthop*, 6(1): 31-3, 1986, [4a] .

29. **Katz, M. M., and Mubarak, S. J.:** Hereditary tendo Achillis contractures. *J Pediatr Orthop*, 4(6): 711-4, 1984, [4b] _____
30. **Local Consensus:** during the guideline development timeframe. ed., [5] _____.
31. **Mackey, A. H.; Lobb, G. L.; Walt, S. E.; and Stott, N. S.:** Reliability and validity of the Observational Gait Scale in children with spastic diplegia. *Dev Med Child Neurol*, 45(1): 4-11, 2003, [4a] _____.
32. **McMulkin, M. L.; Baird, G. O.; Caskey, P. M.; and Ferguson, R. L.:** Comprehensive outcomes of surgically treated idiopathic toe walkers. *J Pediatr Orthop*, 26(5): 606-11, 2006, [4a] _____.
33. **Montgomery:** Sensory Dysfunction in children who toe walk. *Physical Therapy*, 58: 1195-1204, 1978, [4b] _____.
34. **Papariello, S. G., and Skinner, S. R.:** Dynamic electromyography analysis of habitual toe-walkers. *J Pediatr Orthop*, 5(2): 171-5, 1985, [4b] _____.
35. **Reimers, J.; Pedersen, B.; and Brodersen, A.:** Foot deformity and the length of the triceps surae in Danish children between 3 and 17 years old. *J Pediatr Orthop B*, 4(1): 71-3, 1995, [4b] _____.
36. **Rose, J.; Martin, J. G.; Torburn, L.; Rinsky, L. A.; and Gamble, J. G.:** Electromyographic differentiation of diplegic cerebral palsy from idiopathic toe walking: involuntary coactivation of the quadriceps and gastrocnemius. *J Pediatr Orthop*, 19(5): 677-82, 1999, [4a] _____.
37. **Sala, D. A.; Shulman, L. H.; Kennedy, R. F.; Grant, A. D.; and Chu, M. L. Y.:** Idiopathic toe-walking: a review. *Developmental Medicine & Child Neurology*, 41(12): 846-848, 1999, [5a] _____.
38. **Shulman, L. H.; Sala, D. A.; Chu, M. L.; McCaul, P. R.; and Sandler, B. J.:** Developmental implications of idiopathic toe walking. *J Pediatr*, 130(4): 541-6, 1997, [4b] _____.
39. **Sobel, E.; Caselli, M. A.; and Velez, Z.:** Effect of persistent toe walking on ankle equinus. Analysis of 60 idiopathic toe walkers. *J Am Podiatr Med Assoc*, 87(1): 17-22, 1997, [4b] _____.
40. **Stott, S.:** Treatment for idiopathic toe walking: results at skeletal maturity *Journal of Pediatric Orthopedics*, 24: 63-69, 2004, [4a] _____.
41. **Stricker, S. J., and Angulo, J. C.:** Idiopathic toe walking: a comparison of treatment methods. *J Pediatr Orthop*, 18(3): 289-93, 1998, [4b] _____.
42. **Sutherland, D. H.; Olshen, R.; Cooper, L.; and Woo, S. L.:** The development of mature gait. *J Bone Joint Surg Am*, 62(3): 336-53, 1980, [5] _____.
43. **Tabrizi, P.:** Limited dorsiflexion predisposes to injuries of the ankle in children. *Journal of Bone & Joint Surgery, British Volume*, 82 - B(8): 1103-1106, 2000, [4a] _____.
44. **Taussig, G., and Delouee, E.:** [Idiopathic toe walker child. Diagnosis and spontaneous evolution]. *Ann Readapt Med Phys*, 44(6): 333-9, 2001, [4b] _____.
45. **Tidwell, M.:** The child with tip-toe gait. *International Pediatrics*, 14: 235-238, 1999, [5a] _____.
46. **Westberry, D. E.; Davids, J. R.; Davis, R. B.; and de Moraes Filho, M. C.:** Idiopathic toe walking: a kinematic and kinetic profile. *J Pediatr Orthop*, 28(3): 352-8, 2008, [4a] _____.
47. **Williams, C.:** Idiopathic toe walking and sensory processing dysfunction. *Journal of Foot and Ankle Research*, 3(16): 1-6, 2010, [5] _____.
48. **Williams, C.:** The Toe Walking Tool: A novel method for assessing idiopathic toe walking children. *Gait and Posture*, 32 (4): 508-511, 2010, [4a] _____.
49. **Woosley, M.; Anderton, R.; Blackburn, H.; Burch, C.; Mays, M.; Parsons, R.; and Reder, R.:** Serial Casting of the Lower Extremity. (35): 12, 2007, [5] _____.