Pediatric orthopedic mythbusters: the truth about flexible flatfeet, tibial and femoral torsion, W-sitting, and idiopathic toe-walking

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Purpose of review
Myths, widely held but false or unproven beliefs, exist in pediatric orthopedics, with the most common examples related to flexible flatfeet, in-toeing/out-toeing, W-sitting, and toe-walking. Concerns regarding these findings and suggested treatments, unfounded in science, may be passed along verbally or published through various media, without citation. The current review investigates these myths and provides up to date recommendations on diagnosis and treatment (or lack of necessary treatment) for these common pediatric orthopedic findings.

Recent findings
Orthotics used in childhood do not alter foot development for flexible flatfeet. W-sitting is not associated with developmental dysplasia of the hip, and there is no scientific evidence to support that it leads to contractures, hip dislocations, or functional deficits.

Summary
Misinformation about normal variants of growth in childhood and suggested treatments are rampant and can be found published through various media without citation, as supportive scientific studies do not exist or existing studies refute the claims. Flexible flatfeet, in-toeing/out-toeing, W-sitting, and toe-walking typically improve throughout childhood without intervention. Physical therapy, orthotics and bracing have not been proven effective. Treatment is required in rare scenarios and should be directed by the orthopedic surgeon.

Keywords
flexible flatfeet, idiopathic toe-walking, orthotics/bracing, tibial/femoral torsion, W-sitting

INTRODUCTION

Myths, widely held yet false or unproven beliefs, are rampant in pediatric orthopedics, mainly pertaining to normal variants of growth that are perceived as abnormal and requiring some form of treatment. Myths may be propagated through word of mouth, or publication in various media, including online [1–6], yet lack citation of original scientific studies documenting causation and/or treatment efficacy. There are, of course, publications that provide balanced and scientifically based advice, but it can be difficult for caregivers to differentiate the quality of the information source. Some of the greatest myths in pediatric orthopedics involve flatfeet, in-toeing and out-toeing, W-sitting, and toe-walking, all of which are common and can be normal variants of growth and development in young children. These orthopedic myths may be particularly difficult to break when they continue to be propagated by trusted yet suboptimally informed therapists, teachers, or medical practitioners. Caregivers may also recall these treatments being used for other family members or children in previous generations. Resolution of 'abnormal' childhood alignment or function may anecdotally be attributed to bracing/physical therapy or other interventions. However, as the natural history includes resolution over time, this attribution is frequently misappropriated. We present a critical evaluation of the evidence (or lack thereof) behind these myths, and practical recommendations on how to approach the evaluation, treatment, and counselling of these patients.

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KEY POINTS

- Flexible flatfeet, tibial and femoral torsion, W-sitting, and toe-walking are typically normal variations of growth and development and resolve over the first decade of life. Referral to pediatric orthopedics is warranted for definitive diagnosis and management, and in particular if there is moderate to severe deformity, lack of resolution or worsening with time, pain, functional issues, and/or need for additional parental reassurance.
- Pediatric flexible flatfeet usually resolve by age 10, yet additional improvement can occur until skeletal maturity. Arch supporting shoes/orthotics do not modify the natural course of foot development, and are not routinely recommended for asymptomatic flexible flatfeet.
- Femoral and tibial torsion typically improve in the first 10–14 years of life. Bracing has shown no benefit over the natural course, and is not recommended.
- W-sitting is a comfortable seating position for children with femoral anteversion and increased internal hip rotation. W-sitting does not cause hip dysplasia, nor is there evidence to support the concern that it may cause future functional deficits.
- Toe-walking requires a careful physical exam to rule out potential underlying causes. Idiopathic toe walking typically resolves by age 5.5, but when it does not, serial casting or gastroc/soleus/Achilles lengthening is frequently successful.

ASYMPTOMATIC FLEXIBLE FLATFEET

Definition: Flexible flatfeet (which may also be described as pes planus, pes planovalgus, pronation, or over-pronation depending on the provider) have well-defined arches when nonweight-bearing and diminished arches upon weight-bearing. Asymptomatic means there is no pain or difficulty with physical activities. Almost all infants and toddlers have flatfeet attributed to their inherent ligamentous laxity. By age 10, without treatment, 85–96% have developed arches [7,8], as ligamentous laxity decreases with age [7].

The myth: Children with flatfeet need orthotics. Children with flatfeet that persist at age 6 need orthotics [9]. Children who are athletic in particular need custom-made orthotics as this improves gait and running performance [9]. Children who are obese need orthotics [1,9,10].

Presentation: Parents/caregivers will often present with concerns for pronation/over-pronation, collapsed arches, prominent inner ankles, and out-toeing. Typically, flexible flatfeet are not painful and there are no functional issues; the child is keeping up with their peers. Sometimes a therapist, teacher, medical provider or family member has suggested orthotics, or the family is seeking them because another family member or friend was previously treated with orthotics.

Physical exam: With the patient barefoot, nonweight bearing, assess for presence of an arch (Fig. 1a). The feet should then be examined weight-bearing, noting the presence or absence of the arch (Fig. 1b). Heel valgus typically increases with weight bearing, assessed by observing the angle between the calcaneus and the lower leg (Fig. 1c). When the patient stands on their toes, the arch should be accentuated and the calcaneus should swing into varus (Fig. 1d). If the child is too young to stand on their toes, the great toe can be dorsiflexed, and the arch should be observed to increase. If the arch fails to accentuate with toe rise or toe dorsiflexion, or if the foot is constantly flat, this may be more consistent with a rigid flatfoot and additional investigations or treatment may be required.

Scientific findings: Publications demonstrating the natural history and treatment outcomes of flat feet are listed (Table 1). Although flatfeet are ubiquitous in infants and toddlers, by the age of 10 the incidence, without treatment, is only 4–15% [7,8]. Arch improvements may continue until skeletal maturity [11▪]. When the foot is flexible and pain-free, orthotics are not indicated, as they not proven more effective than the natural course [12▪,13,14].

Recommendations:

(1) Do not prescribe custom orthotics for children with asymptomatic flexible flatfeet.
(2) Supportive shoes with a built-in arch support or over-the-counter cushioning yet supportive orthotics/insoles can be considered for families who are concerned about the cosmetic appearance of the feet. Orthotics may improve the appearance by raising the arch while the shoes/orthotics are worn, but should not be expected to help with arch development or improve physical function such as running speed.
(3) Refer to pediatric orthopedics for a definitive diagnosis and guidance on management, and in particular if feet are painful, stiff, other atypical physical features are present, or if there are functional deficits.

IN-TOEING AND OUT-TOEING

Definition: In-toeing refers to internal foot progression angle, meaning the foot is pointed inwards with respect to the direction the body is moving

FIGURE 1. Pediatric patient with asymptomatic flexible flatfeet. (a) When nonweight bearing, the arch is visible. (b) When weight-bearing, the arch is decreased. (c) During weight bearing, the medial arch is decreased and hindfoot valgus is accentuated. (d) When instructed to go up on the toes, the medial arch is accentuated and the hindfoot appropriately swings into varus. Permission from Dare DM, Dodwell ER. Pediatric flatfoot: cause, epidemiology, assessment, and treatment, *Curr Opin Pediatr* 2014;26:93–100. doi: 10.1097/MOP.0000000000000039.

(Fig. 2a). Out-toeing refers to external foot progression, meaning the foot points outwards with respect to the direction the body is moving (Fig. 2b). In-toeing can be because of increased laxity of the hip joint, femoral anteversion (an internal twist in the femur/thigh bone), internal tibial torsion (an internal twist in the tibia/shin bone) or adductus in the foot (inward curving of the foot itself). Out-toeing can be caused by increased laxity of the hip joint, femoral retroversion (an external twist in the femur/thigh bone), external tibial torsion (an external twist in the tibia/shin bone) or foot deformities that include abduction/valgus/pronation (such as with flatfeet). Neonates are born with about 40° of femoral anteversion and this naturally decreases over time until about 10–14 years of age when femoral anteversion is typically 10–20° (Fig. 2c) [15–17]. Neonates are frequently born with internal tibial torsion (measured by thigh-foot angle) of about 5° internal, and this derotates throughout childhood such that by the age of 8–14, tibial torsion is typically 10–15° external (Fig. 2c and d) [16,18].

The myth: Bracing will correct in-toeing and out-toeing. Bracing will correct femoral/tibial torsion [19–23].

Presentation: With in-toeing, parents/caregivers will often present with concerns that their child is walking 'pigeon-toed', tripping, and/or running like an 'eggbeater.' They may also note a preference for standing with the feet turned in, and/or a preference for sitting in the 'W' position (Fig. 3a). With out-toeing, parents/caregivers may describe walking 'like a duck' or preferring to sit criss-cross. With both in-toeing and out-toeing, there is typically no pain, and young children are typically not concerned about their appearance, gait, or seating position. The parents/caregiver may recall someone they knew being treated with braces for torsional issues and may present requesting braces.

Physical exam: With the patient standing, assess whether the knees are pointing towards each other, and if the feet are pointing neutral, in or out. Observe the patient walking and running, barefoot and in shoes. Assess the foot progression angle while

Table 1. Review of the literature: asymptomatic flexible flatfeet, in-toeing and out-toeing, W-sitting, toe-walking

Asymptomatic flexible flatfeet

- In children 2 and younger, the prevalence of flatfeet, defined by heel to arch width ratio, was 97% [7].
  Flatfeet were present in 54% of 3 years old and 26% of 6 years old [25].
- At age 10, only 4–15% had flatfeet [7,8].
  Flatfeet are associated with obesity [41], ligamentous laxity [42], younger age [43], and family history [43].
- A randomized controlled trial of patients 7–11 years old with flexible flatfeet comparing custom or prefabricated orthoses versus no treatment found no significant difference in motor skills, exercise efficacy, self-perception, or reported pain [44].
- In children aged 1–6 years with flexible flatfeet, a prospective study found no difference between corrective orthopedic shoes, heel cups, custom orthotics versus no treatment [13].
- A prospective cohort study of patients with flexible flatfeet, aged 10–11 years followed until skeletal maturity, comparing medial arch support insoles versus observation for flexible flatfeet, demonstrated mild improvement in both groups over the course of the study, although no difference between the groups [11▪].
- In a study of preschool aged children with flatfeet, 10% of children were treated with orthotics, yet only 1% were pathologic (rigid/painful or from underlying neuromuscular or other condition); the authors concluded that over 90% of orthotic treatments were unnecessary [14].
- Dependence on orthotics may have negative psychosocial sequelae in children such as a reduction in self-image and restriction of activities of daily living [45,46].
- A recent systematic review concluded there was no strong evidence to support that long-term use of orthoses improves flexible flatfeet in children [12▪].

In-toeing and out-toeing

- Historically, bracing was used for torsional issues [22,23].
- Femoral anteversion and tibial torsion naturally improve throughout development (Fig. 2c) [15,25,26].
- In children with neuromuscular conditions, femoral and tibial torsion may persist or worsen with age [27,28].
- In a longitudinal observational study, femoral anteversion and gait improved without treatment over time and the authors concluded treatment was not necessary [29].
- In a prospective cohort study comparing Dennis-Browne Splints (an abduction bar) to no intervention, the bar had no effect on the natural history of in-toeing [30].

W-sitting

- In a prospective cohort study, 17% of subjects' families were warned by medical professionals (either physicians or occupational/physical therapists) that W-sitting negatively affects their child's hip development [31▪].
- W-sitting was not associated with DDH, and the authors concluded it is unnecessary to discourage W-sitting [31▪].
- In a study of 3–6 year olds, 63% preferred W-sitting (otherwise known as the'television' position in this article) [47].
- W-sitting is associated with increased internal rotation of the hip and increased femoral anteversion [25,47,48].
- Femoral anteversion is typically present at birth, typically 30–40°, and decreases to the normal adult value of 10–20° by 10–14 years (Fig. 2c) [15–17].
- As femoral anteversion is present at birth [15], before W-sitting starts, and W-sitting resolves as femoral anteversion decreases, it is reasonable to conclude that W sitting does not cause femoral anteversion, rather it is a position of comfort due to the natural rotation in the bone.
- High-quality prospective studies linking W-sitting to various functional abnormalities do not exist [31▪].

Toe-walking

- Toe-walking can be idiopathic (meaning for no apparent cause) or because of an underlying orthopedic condition such as clubfoot, leg length discrepancy or hip dislocation, neuromuscular condition such as cerebral palsy, muscular dystrophy or tethered cord, or neuropsychiatric cause such as autism spectrum disorder or sensory diagnoses [36].
- Toe-walking is a normal variant of gait development. The age at which toe-walking should resolve is controversial, typically felt to be between 3 and 7 years [49,50].
- Idiopathic toe-walkers typically first walk at a normal age, and can stand plantigrade. Spontaneous heel strike occurs from 15–92% of the time and sometimes is under voluntary control. Conversely, in most nonidiopathic cases the child cannot voluntarily produce heel strike [51].
- Most children grow out of toe-walking by age 5.5 years. A population study of children aged 5.5 years found toe-walking in only 2% of normally developing children versus 41% of children with neuropsychiatric disorders or developmental delays [35].
- In a prospective series of normally developing toe-walkers, children aged 2–14 years, treated with below knee walking casts, 66% demonstrated improved gait and ankle dorsiflexion. However, there were no controls included in this study [52].
- In a prospective cohort study of idiopathic toe walkers, 72% of patients treated with Achilles tendon lengthening had normal or improved gait at follow-up, compared to 51% of controls [40].
- In a randomized controlled trial comparing ankle foot orthoses (AFO) versus rigid footplate orthoses in idiopathic toe-walking pediatric patients, both treatments significant improved toe-walking while worn; AFOs had a greater effect on preventing initial toe contact. All patients reverted to toe-walking to some degree at 6-week follow-up, with the AFO group completely regressing to baseline. This study included no long-term follow-up beyond the 6 week study period [37].
- AFOs substitute toe-walking for another abnormal gait pattern by encouraging heel strike but limiting push off [37].
- In a case series of idiopathic toe-walkers treated with physical therapy, 80% demonstrated no or only slight improvement in gait [38].
- In a retrospective study comparing idiopathic toe-walking treated with physical therapy, casting or orthotics, and Achilles lengthening or gastrocnemius recession, patients who underwent surgical lengthening had improved range of motion compared to patients treated with physical therapy, casting, or orthotics [39].

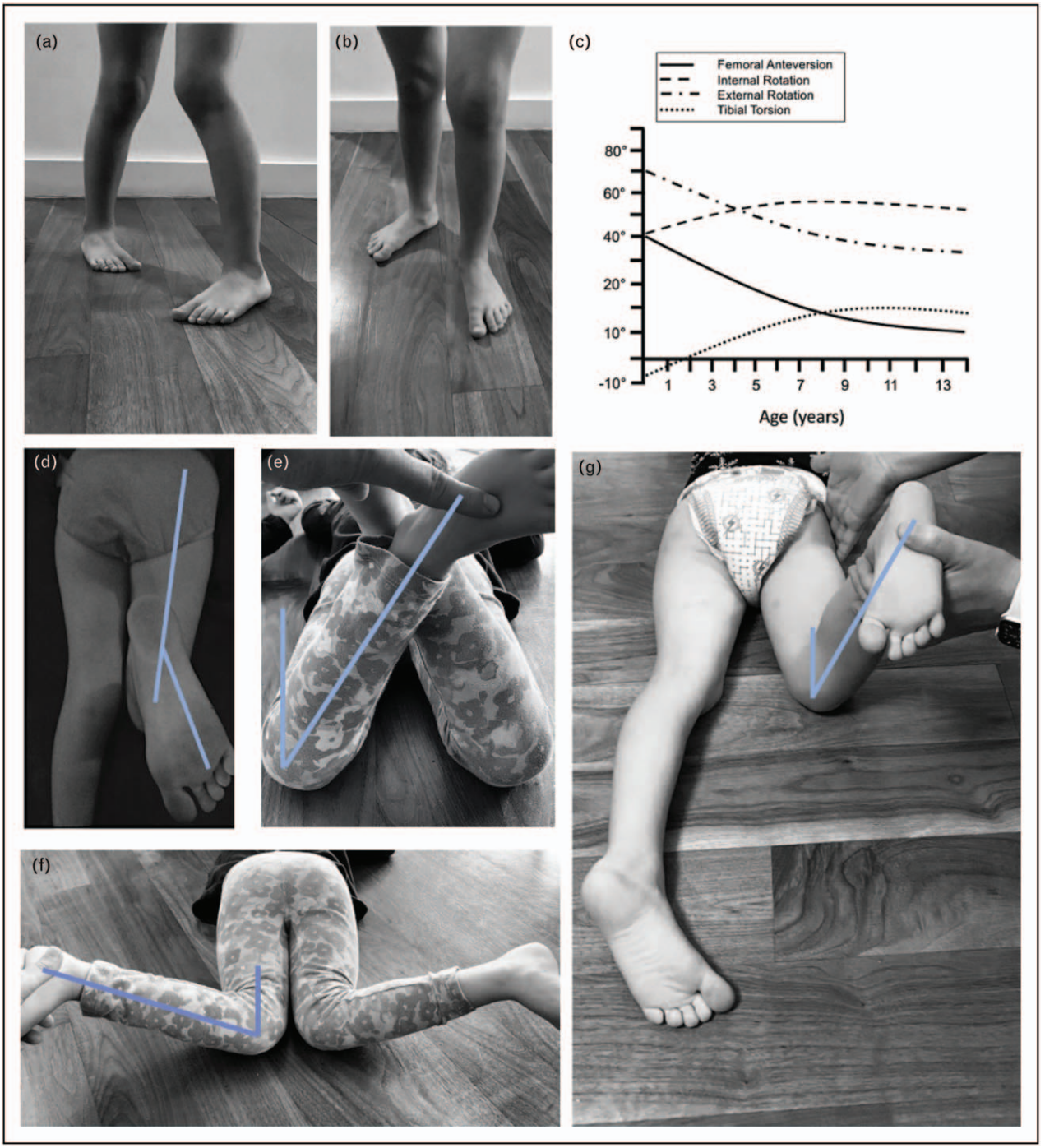

FIGURE 2. Pediatric patient demonstrating (a) in-toeing and (b) out-toeing. (c) Mean tibial torsion (measured by thigh-foot angle), femoral anteversion, internal, and external rotation (in degrees) over the course of development (in years).[26,28] Measurement of torsional profiles: (d) Thigh-foot angle is the angle between the foot and thigh axes when patient is prone. (e) Hip external rotation is measured by the angle between the vertical axis and the tibia (feet cross each-other while measuring external rotation). (f) Hip internal rotation is measured by the angle between the vertical axis and the tibia (feet are distant from each other while measuring internal rotation). (g) Craig's test assesses femoral anteversion.[24] The examiner internally and externally rotates the hip while palpating the greater trochanter. At the point that the greater trochanter is maximally prominent, the angle between the tibia and the vertical axis indicates the degree of femoral anteversion (in this case the hip is internally rotated when the greater trochanter is most prominent; femoral anteversion is about 20°). Permission from Dare DM, Dodwell ER. Pediatric flatfoot: cause, epidemiology, assessment, and treatment, *Curr Opin Pediatr* 2014;26:93–100. doi: 10.1097/MOP.0000000000000039.

FIGURE 3. A pediatric patient in various common seating positions (a) W-sitting, (b) side-sitting, (c) criss-cross, and (d) straight sitting.

walking and running. Perform a supine exam, assessing hip flexion, abduction, adduction, extension, knee flexion and extension. Perform a prone exam. Assess thigh foot angle by measuring the axis of the thigh compared to the axis of the foot (Fig. 2d). Assess hip external and internal rotation (Fig. 2e and f, respectively). Using Craig's test to further assess femoral anteversion, internally rotate the hip until the greater trochanter is maximally prominent; the angle between the tibia and vertical is the femoral anteversion (Fig. 2g) [24]. Assess for foot deformity. Assess for tone, power, sensation, clonus, and reflexes.

Scientific findings: Publications demonstrating the natural history and treatment outcomes of tibial and femoral torsion are listed (Table 1).

Femoral anteversion and internal tibial torsion typically improve with time, by the age of 10–14 [15,25,26], although neuromuscular conditions and decreased ambulatory status are associated with persistent or worsening torsion [27,28]. Femoral retroversion and external tibial torsion are less common in young children but can also improve with time. External tibial torsion in older children is less likely to resolve and in some cases may naturally worsen with growth. Bracing was used historically, but was abandoned when recognized that it worked no better than observation [22,23]. Bracing, physical therapy, massage, orthotics, and shoe wedges have not been shown to alter torsion/rotation within the bone [29,30].

Recommendations:

(1) Bracing/shoes/therapy are not recommended for treatment of torsional variations in childhood.
(2) Families typically can be reassured that these variations will improve with time, usually by age 10–14.
(3) Refer to pediatric orthopedics for a definitive diagnosis and guidance on management, and in particular if the deformity is moderate to severe, worsening with time or has not improved, if there are functional deficits, or if there are any developmental delays or concerns for an underlying neuromuscular condition.

W-SITTING

Definition: W-sitting involves sitting on the floor with hips and knees flexed, hips abducted, and internally rotated, forming a 'W' appearance (Fig. 3a).

The myth: W-sitting causes hip dysplasia and dislocations, weakens the core/trunk muscles, and limits ability to use both arms. W-sitting can lead to deficiencies in table top activities like writing, hinders hand preference, and leads to problems with coordination and gross motor skills such as running and jumping [2,5,6].

Presentation: Parents/caregivers may present with concerns that the child is sitting in the W-position. They may have concerns that this may harm the hips, or result in in-toeing or other problems. They may have been told by a therapist/teacher/provider/family member that this position should be discouraged.

Physical exam: As above for In-toeing/Out-toeing.

Scientific findings: Publications related to W-sitting are listed (see Table 1). W-sitting is a common seating position for children during the first decade of life, when femoral anteversion is at its greatest, making this a position of comfort [15]. As femoral anteversion decreases to adult levels by 10–14 years of age [15–17], W-sitting naturally resolves. There are no high-quality studies linking W-sitting to any functional deficits, and high-quality studies do exist demonstrating that W-sitting is not associated with hip dysplasia [31▪].

Recommendations:

(1) There is no need to correct W-sitting as it should resolve with time.
(2) As 'moderation in all things' is a reasonable approach, W-sitting could be permitted, while encouraging alternative seating positions including side-sitting, criss-cross, straight sitting, and kneeling (Fig. 3b–d) at other times.
(3) Refer to pediatric orthopedics for a definitive diagnosis and guidance on management, and in particular if there are functional deficits, or if there are any developmental delays or concerns for an underlying neuromuscular condition.

TOE-WALKING

Definition: Toe-walking involves walking on the toes/forefoot, without heel strike. Idiopathic toe-walking is the term used when there is no identified neuromuscular or other cause; it is a diagnosis of exclusion.

The myth: Toe-walking should be treated with physical therapy and stretching from an early age. Cueing the child to walk heel-toe will help [32,33]. Rigid insoles or high-top shoes should be used [33].

Presentation: Parents/caregivers may present with a concern that the child is tip-toeing, not getting their heels down. The child may be able to walk with a good heel strike some of the time, particularly when reminded. They may report poor balance, frequent falls, pain, fatigue and/or muscle pain, or it may be purely a cosmetic concern without pain or functional problems. The child may walk on their toes more on a cold floor, when barefoot, or when they are excited. The child may have an underlying condition such as sensory abnormalities or autism spectrum disorder, or an underlying neuromuscular condition such as tethered cord or cerebral palsy.

Physical exam: The child should be observed toe-walking, and then attempting heel strike both barefoot and in shoes. The child should be asked to stand with the feet flat on the ground. Assess spine, hip, knee and ankle range of motion. At the ankle, it is critical to assess ankle dorsiflexion with the knees extended and also with the knees flexed to diagnose contracture of the gastroc/soleus/achilles. Children 2–8 years have on average 24° of dorsiflexion while children 9–19 have 17° [34]. Dorsiflexion less

than 10° is uncommon in children and indicates contracture [34]. Perform a neurologic exam assessing tone, power, sensation, clonus, and reflexes.

Scientific findings: Publications demonstrating the natural history and treatment outcomes of toe-walking are listed (see Table 1). Idiopathic toe-walking is a natural gait variant that typically resolves by 5.5 years of age [35]. As toe-walking can be a manifestation of many neurologic and/or orthopedic conditions [36], orthopedic and neurologic referral may be required to confirm the diagnosis of idiopathic toe-walking, as this is a diagnosis of exclusion. For idiopathic toe-walking, neither physical therapy nor orthotics are effective treatments [37–39]. Serial casting and surgical tendon lengthening are effective treatment options [39,40].

Recommendations:

1. In the first few years of life, bilateral toe-walking, in the setting of normal development and a normal physical exam, including normal ankle range of motion, does not typically require immediate investigation or treatment as it should resolve with time.
2. Unilateral toe-walking should always raise concern for an underlying cause such as clubfoot, hip dislocation, leg length discrepancy, cerebral palsy, tethered cord, or other neuromuscular disease; it requires prompt referral.
3. Rapid onset toe-walking, severe contractures, abnormal neurologic exam, or onset of toe walking after the first few years of life may be more likely to be associated with an underlying diagnosis and requires prompt referral.
4. Idiopathic toe-walking at ages 5–7, or in younger children with contracture, should be treated with serial casting ×6 weeks (progressive casting in short leg walking casts in maximum dorsiflexion, casts changed every 2 weeks). This stretches the gastroc/soleus/Achilles and also helps to break any 'habit' component of the toe walking, as the child has no choice but to walk on their flat feet for 24/7 ×6 weeks.
5. For toe-walking with severe contracture (no dorsiflexion beyond neutral) or in children 7–9 years or older, surgical lengthening of the gastroc, gastroc and soleus, or achilles can be considered as initial treatment.

CONCLUSION

Myths exist regarding flatfeet, in-toeing/out-toeing, W-sitting, and toe-walking. Careful evaluation of the literature reveals that there is minimal or no scientific basis for much of the advice that families receive. Even medical providers have historically contributed to orthopedic myth propagation.

Pediatricians and other pediatric providers can play a vital role in promoting evidence-based approaches to these common variations of growth and development. With an understanding of these conditions and the scientific basis for their treatment (or lack of need for treatment), we can provide appropriate recommendations, normalize parental expectations, decrease parental concern, minimize unnecessary primary care, specialist and physical therapy visits, and limit unwarranted bracing and shoe modifications.

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Conflicts of interest

There are no conflicts of interest.

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