# Variations in normal gait development

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## Abstract

Normal development is not an exact science. Children progress in a variety of ways without falling outside the normal range. This applies to the shape of their legs and feet, as well as the onset and development of their gait pattern. Deviation from parents' expectations may lead to considerable anxiety and medical consultation. It is essential to identify the important pathological diagnoses amongst the array of normal variants to facilitate early intervention and optimise outcomes.

**Keywords** gait development; leg deformity; preschool children; rickets

## Introduction

The attainment of motor milestones such as standing and walking is anticipated and celebrated by parents. Variation from the perceived norm often generates anxiety and medical consultation. Whilst most of these variations fall within the normal physiological range, pathological processes and abnormal progression of development must be identified to facilitate appropriate management.

Normal variants of an average gait pattern may be associated with significant deformity but children often remain remarkably mobile. Toe walking, flatfeet, bow legs and knock knees, in-toeing and out-toeing can ***all*** be part of normal gait development, but the important point is that physiological variants resolve spontaneously. The mainstay of treatment is explanation and reassurance.

Recognising the cases which are outside normal limits or those who progress in an abnormal way over time allows the identification of neuromuscular or musculoskeletal problems that require a full assessment and/or medical treatment in conjunction with orthopaedic management.

## Normal gait

Most children begin to walk independently between 12 and 14 months. They typically walk with straight knees and a wide-based gait. Initial ground contact may vary from heel-toe, whole foot or toe-heel. The adult pattern of heel-to-toe gait develops at around 3 years, whilst changes to velocity and cadence continue up to age 7 (Figure 1).

## Toe walking

In normal variant toe walking, the child may cruise on tip-toe but relax into a flat foot when standing still or on request. Normal adult heel-to-toe gait should prevail by age 3 but a few children continue to tip-toe walk. An underlying pathological cause for toe walking should be considered in children who develop toe walking after a period of walking on their heels and in those in whom toe walking is unilateral.

Idiopathic Toe Walking (ITW) is defined as "persistent toe walking after the age of 2 in healthy children without a neurologic or orthopaedic diagnosis". It is thus a diagnosis of exclusion. It is thought to result from relative shortening of the soleus or gastrocnemius muscles effectively tightening the Achilles tendon. Most cases of ITW will improve spontaneously but for those that do not, a variety of treatments such as stretching techniques, serial casting, night braces and ankle-foot orthoses have been suggested. There is little evidence that outcomes from any intervention is better than the natural history. For cases where there is no major tightness of the muscle, in theory, botulinum toxin injections may be beneficial. A minority of patients

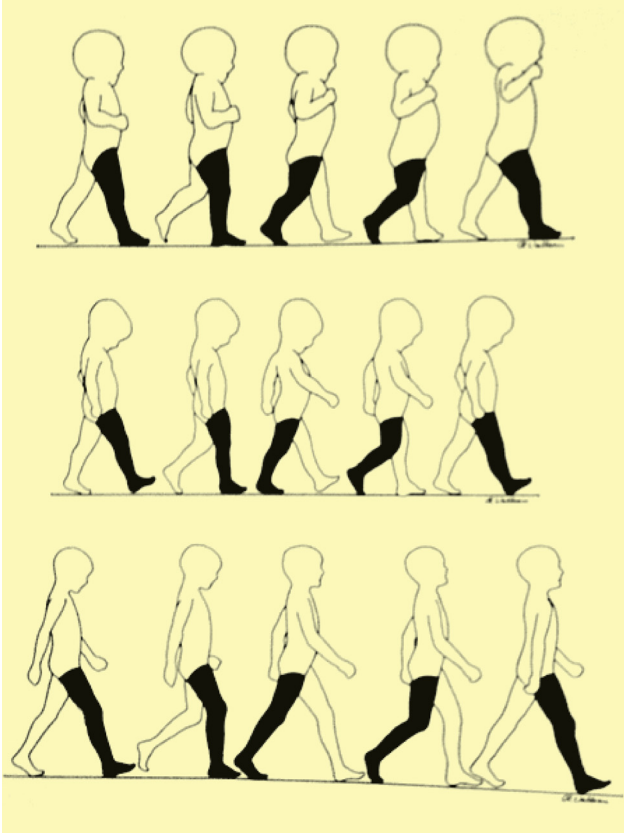

**Figure 1** Development of a mature gait. Top: 1 year old — flexed elbows, no arm swing. Middle: 3 year old — arm swing and heel strike. Bottom: 6 year old — adult-type gait. Figure 2.4 from Benson et al.

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with significant tightness of the gastrocnemius—soleus complex and an inability to stand with their heels down may require operative lengthening of the Achilles tendon. It is essential that the parents understand, that surgical lengthening or indeed stretching of the muscle will only resolve the contracture and allow the heel to touch the ground: the urge/desire to be a tip toe walker often remains as it is centrally driven. The child must relearn their gait pattern to become a heel-to-toe walker.

The most common pathological causes for toe walking are a limb length difference (i.e. a short leg), a dislocated hip or a neuromuscular problem such as Muscular Dystrophy (MD), Cerebral Palsy (CP) or Charcot-Marie-Tooth disease and other Hereditary Sensori-Motor Neuropathies (HSMNs).

Muscular Dystrophy describes a group of inherited genetic disorders resulting in progressive muscle weakness and increasing disability, the most common of which is Duchenne muscular dystrophy (DMD); an X-linked recessive disorder affecting 1 in 4000 boys. Classically, in these children, toe walking starts after a period of normal heel-to-toe walking. The exact clinical presentation depends on the type of muscular dystrophy but may include a delay in independent walking. A suspected diagnosis is supported by markedly elevated Creatinine Kinase (CK) levels and confirmed by DNA testing.

Cerebral Palsy is a fixed, non-progressive brain lesion that occurs before, at or soon after birth. It is estimated to affect 1 in 400 children. Cerebral palsy may present in many ways, dependent on the extent of the brain lesion. Mild, hemiplegic CP may present as unilateral toe walking or a spastic diplegia with bilateral toe walking. Examination will reveal a child with permanent equinus during gait and perhaps whilst standing. Spasticity will often be present in the lower limb but it is important to look at the arms too as posture changes are sometimes more obvious in the upper limb than the lower limb. A careful clinical examination will distinguish between CP and ITW. Dynamic electromyography (EMG) may facilitate differentiation between CP and Idiopathic Toe-Walking.

## Flatfeet

The term 'flatfeet' is used to label feet with a depressed medial longitudinal arch. Flatfeet occur as part of normal development: babies have no detectable medial arch as it is obscured by a fat pad until the onset of walking. The medial arch typically appears between 2 and 3 years of age. In a proportion of children failure to develop this arch occurs as part of a pathological process. Flatfeet can be divided into three subgroups: physiological flexible flatfeet, pathological flexible flatfeet often with a short Achilles and rigid flatfeet.

Flexible flatfeet are part of normal development. They are present from birth, run in families and are more frequent in both obese children and certain races. They are associated with familial joint laxity. Examination reveals a foot with good mobility of the subtalar joint. The arch is seen when the child is non-weight bearing and is reproducible in standing using the Jack's Test, where the great toe is extended by the examiner or visible when the child stands on tip-toe. See Figure 2.

Flexible flatfeet may be associated with activity related pain and nocturnal ache. Traditionally these patients have been managed with exercises and orthoses. There is no evidence this improves outcomes, but it may relieve some symptoms and increase longevity of footwear by altering the wear pattern of shoes.

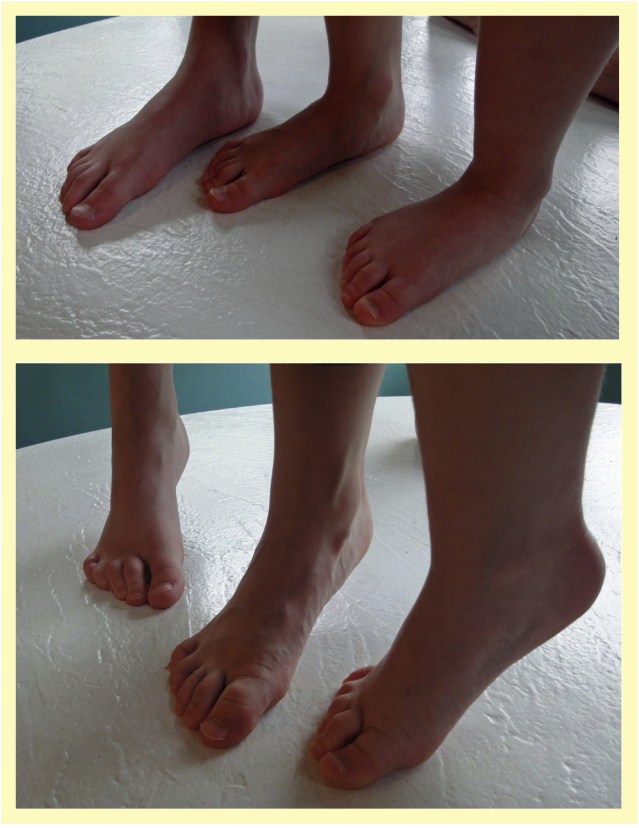

**Figure 2** Jack's Test showing flexible flatfeet in a 2 year-old (on the right) and 4 year-old (middle) and a 6 year-old child.

Flexible flatfeet with a short Achilles tendon occur in older children and may account for 25% of flatfeet in adults. Diagnosis is confirmed when less than 10 degrees of dorsiflexion can be achieved with the knee fully extended and the hindfoot valgus corrected. The majority of patients improve with simple stretching exercises, although a few symptomatic patients may require surgical lengthening procedures or osteotomies. Flexible flatfeet associated with soft tissue laxity conditions can be very difficult to treat.

Rigid flatfeet are pathological and a cause should be identified. Examination reveals a stiff subtalar joint and persistence of flatfeet despite great toe extension. Most result from tarsal conditions, such as calcaneonavicular or talocalcaneal coalition. These patients present with pain at the time that the cartilaginous coalition begins to ossify; between 8 and 12 years in calcaneonavicular coalition or between 12 and 16 years in talocalcaneal coalition. The coalitions may be imaged with CT or MR scans. The pain may be relieved by application of a below-knee walking cast, which should be applied for 4—6 weeks. Orthotic supports can be tried but are often unsuccessful as they can not correct the alignment of a rigid hindfoot. If symptoms persist despite initial treatment, surgical options include resection of the coalition, osteotomy or, in older patients with advanced arthritis, triple arthrodesis.