Idiopathic Toe Walking: A Gait Laboratory Review

Abstract:

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Abstract

Idiopathic toe walking (ITW) is defined as one who is neurologically normal but demonstrates a preference for walking on the toes. It is a diagnosis of exclusion so differential diagnoses such as cerebral palsy, neuropathy or myopathy must be ruled out. A review of 102 patients attending a gait laboratory with a presumptive diagnosis of ITW found that gait analysis data agreed with this diagnosis in 81 (79.4%) of cases while the remaining 21 (20.6%) were not typical of this diagnosis. The features found to be significantly different between the groups were Babinski response, fast stretch of the gastrocnemius, knee flexion at initial contact and asymmetry at the ankles during gait. This study highlights that clinical gait analysis can be a useful, non-invasive means of diagnosing idiopathic toe walking and recommending appropriate intervention based on clinical and dynamic assessment of calf tightness.

Introduction

Toe-walking is the inability to heel strike during the initial contact of gait and the absence of full foot contact during stance phase[1]. Toe-walking is regarded as a normal variation in children up to 3 years of age[2]. Beyond this a diagnosis of idiopathic toe-walking (ITW) must be considered. Hall et al[3] first described a group of 20 neurologically normal patients who presented with tightness of the tendo-achilles and a tendency to walk on their toes. Subsequent reports documented many cases of ITW without static contracture and so the classic presentation of ITW is now described as one who is otherwise neurologically normal, possesses normal muscle strength and selective control, and demonstrates a preference for walking on the balls of the feet[4]. ITW is estimated to occur in 7% to 24% of the childhood population[5]. A review of eighty children with ITW found that 32% had a family history of ITW, 28% were born prematurely and 16% had psychomotor delay[6].

ITW is a diagnosis of exclusion so other known causes of toe-walking such as mild cerebral-palsy (CP), neuropathy, spinal dysraphism and myopathy must be ruled out before this diagnosis can be assigned[7]. Walking history can be important as generally children with CP begin walking at a later age whereas those with ITW walk at appropriate times[8]. Importantly, toe-walking that begins after a mature heel-toe pattern has been established is not typical of ITW. While walking history can be informative, definitively ruling out the range of differential diagnoses can be difficult and might involve significant investigation. Some investigations such as brain and spine MRI require the child to remain motionless for a significant period of time which may prove difficult. Others such as nerve conduction studies and fine-wire electromyography can be distressing and uncomfortable. Gait analysis (GA) has been shown to be helpful in diagnosing ITW and kinematic, kinetic and EMG features associated with this condition have been described. Kelly et al[2] report normal sagittal plane knee kinematics in ITW but significant disruption in those with mild spastic diplegia. The ITW ankle pattern was characterised by initial dorsiflexion in swing phase followed by sudden plantarflexion to preposition the foot for toe-contact[2]. Westberry et al[4] confirmed a normal knee kinematic and found that while there were abnormalities in ankle kinematics and kinetics a diagnosis of ITW can be confirmed by the ability to normalise these deviations. Surface EMG can assist in differentiating ITW from mild CP[9]. On resisted knee extension those with CP demonstrate co-contraction in the gastrocnemius which is absent in ITW. This information complements a complete assessment of the presenting toe-walker. Those not fitting the typical presentation are referred for further investigation and GA serves as a baseline against which deterioration or changes can be monitored.

For those who match the features associated with ITW, gait analysis can help guide intervention based on the degree of calf contracture measured both clinically and dynamically with GA. While it is thought that ITW eventually resolves spontaneously in the majority of children[10] it appears that there may be a relationship between persistent toe-walking and the development of ankle equinus[11] and excessive external tibial rotation[7] and so interventions should be considered to inhibit these progressions. The original GA acts as a baseline against which treatment outcomes can be measured. In this study we reviewed all patients presenting to the gait laboratory with a presumed or queried diagnosis of idiopathic toe walking over a ten year period. We looked at the characteristics of those felt to be typical of ITW versus those with an atypical presentation.

Methods

A retrospective study of all patients who had attended the Gait Laboratory between 2003 and 2013 was conducted. Criteria for inclusion were a proposed or queried diagnosis of ITW, no previous surgical history and a full barefoot 3-dimensional GA using the CODA mpx-30 system. Application of these criteria produced a study sample of 102. Based on GA, clinical exam and patient history the original gait laboratory report concluded whether the patient was typical of ITW or not. The study sample was subdivided into two groups on this basis. Clinical and dynamic gait variables were retrospectively examined in each group. The variables selected were those relevant to ITW. The clinical variables examined were gastrocnemius length on fast and slow stretch, hamstring length and Babinski reflex. Based on these measurements the presence of spasticity in the gastrocnemius was defined as a difference between a slow and fast stretch of e10[0]. The dynamic gait variables examined were- ankle ground-contact position, knee ground-contact position, maximum ankle dorsi-flexion in stance and maximum knee extension in stance. In addition the degree of asymmetry in maximum ankle dorsiflexion between left and right legs was assessed. Significant differences were examined using a two-tailed t-test with significance level set at $p<0.05$. Prevalence was tested for significance using a chi-square test with significance level also set at $p<0.05$.

Results

A total sample of 102 patients was reviewed. The average age of those referred was 7.6–3.2 (range 4-16 years). The majority were male (74 male, 28 female). Gait analysis agreed with a diagnosis of ITW in 81 cases (79.4%) while 21 (20.6%) were felt to be not typical of the diagnosis. Referrals to the gait laboratory were from consultant orthopaedic surgeons, consultant neurologists, consultant paediatricians, general practitioners or physiotherapists. The breakdown of ITW referrals by profession along with how often the gait laboratory assessment agreed with the diagnosis of ITW is summarised in Figure 1. The clinical and dynamic differences between those felt to be typical of ITW versus those who had an atypical presentation are summarised in tables one and two. Clinically, those who were not a typical ITW presentation were more likely to have a positive Babinski response and had a tighter range of movement on a fast stretch of the gastrocnemius. However, neither group was more likely than the other to present with defined gastrocnemius spasticity. Dynamically the non typical-ITW group had a more flexed knee at ground contact and increased asymmetry at the ankles during gait. The recommended treatment for typical ITW is summarised in Figure 2. Conservative management through stretching and/or physiotherapy was the most common recommendation.

Discussion

The average age and the dominance of males in the study population are consistent with previous studies[12,13]. The breakdown of those referring potential ITW to the laboratory is probably reflective of the condition and population involved. Treatment of these children often involves stretching or lengthening of the calf muscles so it is not surprising that orthopaedic and paediatric consultants were the most common source of referrals. The general practitioner is often the first point of contact for parents concerned about their childâ s walking pattern so referrals from this profession would be expected. There are a number of differential diagnoses which must be ruled out before a diagnosis of ITW can be assigned including neuropathies and cerebral palsy and so neurologists will sometimes be involved in a small number of cases where there are persisting concerns. This is reflected in the lowest over-all referral numbers from neurologists. Gait analysis findings were consistent with a diagnosis of ITW in the majority of

those referred (81/102). In this group planning appropriate treatment and monitoring the outcome is the priority. Parents can also be assured that the child presents as a typical ITW and baseline gait data is recorded against which any persisting concerns can be measured.

The treatment recommended following GA is consistent with published protocols. Treatment typically begins conservatively with stretching of the plantar flexors, casting and/or botulinum toxin and for those who do not respond surgical lengthening of the gastro-soleus complex is often performed[7]. The advantage of treatment recommendations post gait analysis is that intervention can be individualised to the degree of ankle tightness assessed both clinically and dynamically during gait. This avoids unnecessary surgery for those without a significant contracture and conversely identifies those unlikely to respond to conservative management and appropriate intervention can be expedited. It also provides a baseline to assess outcomes of intervention particularly in the case of a return to toe-walking. This is important as outcomes following treatment are variable in the literature and it is reported that, while short-term results may be positive, relapse may occur following conservative treatment[14-16]. Identifying those with a typical ITW presentation and those with suggestions of a more sinister differential diagnosis can be difficult in light of the range of potential differential diagnoses and particularly in a busy clinical setting. Diagnosis based on GA is made after careful consideration of clinical exam in conjunction with kinematic, kinetic and surface electromyography. Our clinical data highlights the difficulty of assigning a diagnosis on this basis alone. Both groups were equally tight on a stretch of the gastrocnemius and there was no difference between the groups in hamstring range. The presence of abnormal neurological signs is often assessed using the Babinski response and assessing for spasticity in a muscle (increased tightness on a fast stretch versus slow). While those with non typical-ITW presentations were more likely to have a positive Babinski response, the majority had a normal response suggesting that on its own this sign is not sensitive enough. The non typical-ITW group were 9^0 significantly tighter on a fast stretch of the gastrocnemius. However, while statistically significant the 3.9^0 difference is unlikely to be clinical meaningful and the non typical-ITW group were no more likely to present with spasticity.

There were significant differences in the kinematics between the groups. Interestingly there was no difference between the groups in terms of the degree of toe-walking (ankle ground contact, maximal ankle dorsiflexion in stance) though the symmetry of toe-walking was a significant feature. Those with a typical-ITW presentation did so more symmetrically than the non-typical group. The 6.2^0 of asymmetry would be difficult to appreciate on visual inspection of gait but is readily assessed and apparent on kinematic graphs. The non typical-ITW group had more flexed knees at ground contact compared to typical-ITW. This is consistent with previous work which found that ITW typically demonstrate normal knee patterns whereas those with a differential diagnosis of spastic diplegia were more likely to demonstrate knee flexion[2]. Again the difference between the groups (6.6^0 versus 13.1^0) would most likely be difficult to appreciate on visual inspection. EMG and kinetic features[4,9] associated with ITW have also been described and these are also considered as part of a clinical gait analysis but are not described in this study. The diagnosis of ITW in this study was established based on GA and clinical data only. A Follow-up study of those thought to be typical ITW is recommended both to examine long-term outcomes post treatment but also to examine the sensitivity of the initial GA in diagnosing ITW and establish if any subsequent differential diagnoses were made.

This study highlights the contribution clinical GA can make in confirming a typical ITW presentation and recommending treatment based on the degree of ankle tightness on both clinical and dynamic gait assessment. The gait analysis also serves as a baseline against which any future concerns can be measured.

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