



Influence of a Metatarsus Adductus Foot Type on Plantar Pressures During Walking in Adults Using a Pedobarograph



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ABSTRACT

Metatarsus adductus is a relatively common congenital foot deformity that is often unrecognized at birth. Thus, the adult foot with metatarsus adductus is prone to pathologic entities that have been theorized to result from lateral column overload. We present a descriptive study comparing plantar foot pressure distribution during gait in subjects with and without metatarsus adductus. A total of 65 subjects were recruited for the study: 28 subjects with and 37 subjects without metatarsus adductus. An EMED® pedobarograph was used to collect the data. The analysis of the peak pressure and pressure-time integral in each of the 8 regions of the plantar surface of the foot showed significant ($p < .05$) differences between each of the regions and a significant ($p < .05$) interaction effect between the 8 regions and the 2 groups. A series of independent Student's t tests were therefore performed to determine which of the plantar regions showed a significant difference between the 2 groups. The result of those t tests showed that the peak pressure and pressure-time integral were significantly different ($p < .05$) between the 2 groups for the "heel," "lateral midfoot," and "lateral forefoot." The results of the present study support the concept that during gait, the adult foot with metatarsus adductus has increased peak plantar pressures on the lateral side of the foot.

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The current definition of metatarsus adductus (MA) is a uniplanar transverse plane deformity in which the metatarsals are angulated at the Lisfranc joint causing adduction of the forefoot in relation to the midfoot and hindfoot (1,2). Other terms in the medical data have included metatarsus varus (3), metatarsus adductovarus (4), pes adductus, metatarsus supinatus, forefoot adductus, and hooked forefoot (5), less precise terms that include frontal plane deviation (6).

The occurrence of MA in live births has been reported on consensus to be 1 to 2 cases per 1000 (7,3) and sometimes as high as 3 per 1000 (1). It is the most common congenital foot deformity in newborns (7), with a male predilection as great as 80% (3). The prevalence is believed to be greater than reported, because recognition is clinician dependent and sensitive to the assessment method (8).

Fetal constraint has often been cited as etiologic factor, because of compression of the forefoot with the legs crossed across the body in late gestation, as evidenced by its sparse incidence in premature

infants delivered before 30 weeks of gestation (3). Other etiologic hypotheses include abnormal tendon insertions or osseous deformity.

MA can occur independently or with associated other deformities. Also, 1% to 5% of patients with MA will have developmental dysplasia of the hip or acetabular dysplasia (2), and 5% to 10% will have congenital hip dislocation (3,9). Neurologic associations have included spina bifida occulta and spinal muscular atrophy (10). It is a common cause of in-toeing in children and a component of talipes equinovarus; residual MA can persist after conservative or surgical treatment of clubfoot (2). Insufficient appreciation can also lead to greater recurrence of hallux abductovalgus owing to underestimation of the intermetatarsal angle (11).

Bleck's clinical classification of MA focused on severity and flexibility. Extension of the plantar longitudinal heel bisection can define the relationship of the heel to the forefoot. Severity is dictated by the point at which the heel bisector crossed the digits. The grade is considered normal, mild, moderate, or severe if the line bisects the second interdigital space, the third digit, the third interdigital space, or the fourth interdigital space, respectively (12).

The clinical examination must also differentiate between rigid and dynamic, with the former an indication of fixed positioning and the latter suggesting an imbalance of the anterior tibial tendon during

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Fig. 1. Jones fracture commonly seen with metatarsus adductus.

gait (2). The amount of flexibility of the forefoot is a high prognostic indicator (13). Mild cases often go unnoticed unless symptomatic in later years. One of the most common causes for seeking medical attention is when the child begins to walk with an in-toeing gait (14).

Reliable radiographic identification is necessary for the initial diagnosis and classification, monitoring progression, preoperative planning, and evaluation of the outcome. The Sgarlato technique, a modified Sgarlato technique, Engle's angle, a modified Engle's angle, the talar-first metatarsal angle, calcaneus-fifth metatarsal angle, Lepow's angle, and Kilmartin's angle have all been proposed in published studies for radiographic calculation of the MA angle (8).

Most of the published data on the topic of MA has been related to the pediatric condition. However, a paucity of data is available on the clinical manifestations of MA in the adult population. Because the incidence of MA is relatively common, and only the most severe cases are treated at birth, many adults with the unrecognized condition will seek medical care for foot pain. The Jones fracture has often been associated with MA (Fig. 1). It has been postulated that the Jones fracture is ultimately a stress fracture, leading to a frank fracture occurring with overuse or injury (15,16). Studies have also described varus influence of the hindfoot leading to the Jones fracture and MA as a common finding in lateral metatarsal stress fractures (17). An association of increased lateral column overloading of the foot is the principle theory. Simoneau (18) described the center of pressure moving laterally in gait in subjects with MA. No reports describing the plantar pressure distribution during gait in the MA foot type (MAFT) have been published, which was confirmed by searching PubMed and MEDLINE using the key words "metatarsus adductus," "metatarsus varus," "plantar pressures," and "pedobarograph."

Clinical observations and features of the adult MAFT can include a prominent fifth metatarsal base, hallux valgus, and a C-shaped foot print. The senior author (W.D.F.) has observed that the adult MAFT has



Fig. 2. Nontraumatic arthrosis often seen with metatarsus adductus.

the propensity to experience lateral column pain in the region of the fourth and fifth metatarsocuboid joint region and generalized dorsal foot pain in the region of the central metatarsals. Commonly, when the foot is examined, pain to palpation of the dorsal central metatarsals will be present; however, no clinical evidence of a stress fracture, such as a patch of dorsal erythema or edema, or radiographic findings of a fracture will be found. We consider this condition a stress syndrome of the foot. Another clinical manifestation of MA in the adult foot includes nontraumatic arthrosis of the second and third tarsometatarsal joints (Fig. 2).

The main goal of the present study was to describe the plantar foot pressure distribution during gait in adults with the MAFT. This information could help explain why the MAFT is predisposed to certain pathologic conditions.

Patients and Methods

A total of 65 subjects (21 [32.3%] males, 44 [67.7%] females) were included in the present study. The subjects were evaluated clinically by a licensed podiatrist (W.D.F.) to determine whether the subject had MA using plain film radiographic measurements. Of the 65 subjects, 28 (11 males, 17 females) were classified as having the MAFT and 37 (10 males, 27 females) were classified as not having the MAFT (control group). The demographic features of the 2 groups are listed in Table 1. The subjects were excluded from the study if they had had previous foot or ankle surgery, had compound deformities such as tibial vacuum or valgum, skew foot, pes cavus deformity, or if they had pain or dysfunction in their feet or lower extremities that would alter their ability to ambulate normally. The subjects were examined during gait to assess for obvious signs of an antalgic gait or limping. Moreover, the subjects were asked whether they would be able to walk on the test runway without out pain or favoritism to an extremity. Patients with a diagnosis of inflammatory conditions such as a sprain, strain, plantar fasciitis, tendinitis, capsulitis, periostitis, and fracture were excluded. During recruitment, 61 patients were identified as having the MAFT and 33 were excluded. The institutional review board at Northern Arizona University approved the present study.

Table 1
Demographic information (N = 65)

Variable	Metatarsus Adductus Group	Control Group
Age (y)	43.3 ± 16.7	43.0 ± 17.3
Height (cm)	168.1 ± 10.9	168.5 ± 9.9
Weight (kg)	78.7 ± 19.9	74.2 ± 16.6
BMI (kg/m ²)	27.74 ± 6.0	26.05 ± 4.9
Metatarsus adductus angle (°)	21.9 ± 4.0	11.5 ± 5.2

Abbreviation: BMI, body mass index.

Data presented as mean ± standard deviation.

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