Weight-Bearing Passive Dorsiflexion of the Hallux in Standing Is Not Related to Hallux Dorsiflexion During Walking

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Study Design: Case control study.
Objective: To explore the validity of the assumptions underpinning the Hubscher maneuver of hallux dorsiflexion in relaxed standing, by comparing the relationship between static and dynamic first metatarsophalangeal (MTP) joint motions in groups differentiated by normal and abnormal clinical test findings.

Background: Limitation of motion at the first MTP joint during gait may be due to either structural or functional factors. Functional hallux limitus (FHL) has been proposed as a term to describe the situation in which the first MTP joint shows no limitation when non-weight bearing, but shows limited dorsiflexion during gait. One clinical test of first MTP joint limitation during standing (the Hubscher maneuver or Jack’s test) has become widely used in physical therapy, orthopedic, and podiatric assessments, supposedly to assess for the presence of hallux limitations during gait. The utility of the test is based on an assumption that restriction during the static maneuver is predictive of functional limitation at this joint during gait. Despite a lack of evidence for the validity of such an assumption, the outcome of the static test is often used to infer risk of overuse injury or as an outcome for functional therapy. This paper examines the validity of the assumptions supporting this widely used static test.

Methods and Measures: First-MTP-joint motion was assessed using an electromagnetic motion tracking system in cases (n = 15) demonstrating clinically limited passive hallux dorsiflexion in relaxed standing, and in 15 controls matched for age and gender and demonstrating a clinically normal Hubscher maneuver. Maximum hallux dorsiflexion was measured with the subject non-weight bearing (seated), during relaxed standing, and during normal walking.

Results: Hallux dorsiflexion was similar in cases and controls when motions were measured non-weight bearing (cases mean ± SD, 55.0° ± 11.0°; controls mean ± SD, 55.0° ± 10.7°), confirming the absence of structural joint change. In relaxed standing, maximum dorsiflexion was 50% less in cases (mean ± SD, 19.0° ± 8.9°) than in the controls (mean ± SD, 39.4° ± 6.1°; P<.001), supporting the initial test outcome and confirming the visual test observation of static functional limitation in the case group. During gait, however, cases (mean ± SD, 36.4° ± 9.1°), and controls (mean ± SD, 36.9° ± 7.9°) demonstrated comparable maximum dorsiflexion (P = .902). There was no significant relationship between static and dynamic first MTP joint motions (r = 0.186, P = .325).

Conclusion: The clinical test of limited passive hallux dorsiflexion in stance is a valid test only of hallux dorsiflexion available during relaxed standing. There is no association between maximum dorsiflexion observed during a static weight-bearing examination and that occurring at the same joint during walking. J Orthop Sports Ther 2006;36(8):550-556. doi:10.2519/jospt.2006.2136

Key Words: biomechanics, foot, lower extremity, measurement, motion analysis

In the foot, the first metatarsophalangeal (MTP) joint is the site of the highest prevalence of degenerative joint disease, and it is thought that mechanical factors, such as bony malalignment or the loss of timely and appropriate joint motion, contribute to this high rate of pathology.³ Limitation of first MTP joint motion due to joint degeneration or structural change is sometimes known as hallux limitus, or, if the joint is entirely fixed, hallux rigidus. Some authors have noted that functional limitation of the first MTP joint can occur in the absence of frank joint degeneration, describing an entity where the first MTP joint demonstrates a normal range of motion during a non–weight-bearing exam, but apparent restriction during dynamic weight-bearing function such as walking.⁴,⁵,6,17,24 Because it is postulated that this form of limitation may have a functional rather than structural etiology, the term functional hallux limitus (FHL) has been applied to this presentation.⁵

Even in the absence of structural change, FHL has been implicated as a cause of symptoms²⁴
and so it is increasingly common to see a test for FHL included as part of the routine assessment of the foot. Equipment for dynamic assessment of first MTP joint function during walking is often not available to clinicians, and so surrogate static tests of first MTP joint motion have been applied in orthopedic, physical therapy, and pediatric assessments for many years, despite absence of evidence of their validity. The most common static test, first described in 1954 by Jack, and later by Hubscher, involves the examiner manually dorsiflexing the hallux while the patient stands in a relaxed double-limb stance position. A normal test describes a situation where the hallux dorsiflexes freely with minimal resistance, and the hallux movement is associated with a tightening and raising of the medial longitudinal arch. This mechanism is sometimes referred to as the windlass effect. A failed test is recorded where the examiner is unable to dorsiflex the hallux from the foot-wearing bearing surface without the application of excessive force.

The Hubscher maneuver or Jack’s test, as a supposed surrogate indicator for FHL during gait, has become one of the more widely used tests of foot posture/function. The test has been reported in the literature as an outcome measure for foot surgery, a risk factor for diabetic ulceration, an indicator of plantar fascia dysfunction associated with Charcot’s neuroarthropathy, a risk factor for plantar fasciitis, and an outcome measure in 3 in vivo exploratory orthotic studies.

Where facilities are not available to confirm the actual first MTP joint ranges of motion occurring during gait, clinicians often extend the interpretation of a failed Hubscher maneuver (in a patient who has good first MTP joint range of motion when non-weight bearing), to infer the likely presence of FHL during walking. This inference is based on 2 assumptions: firstly, that the motion available in the first MTP joint both affects and is affected by the mechanical function of the medial longitudinal arch, and, secondly, that the outcome of static test is predictive of maximum first MTP joint dorsiflexion during walking. Despite the widespread use of the Hubscher maneuver, the validity of these assumptions and their relevance to the test has not been established.

Regarding the first assumption of the test, the interrelated function of the medial longitudinal arch and hallux dorsiflexion (the “windlass effect”) has been examined previously in 3 reports. Carlson et al in a static, in vitro study described a linear relationship between increments of increased passive hallux dorsiflexion (0°-45°) and increased tensile strength of the plantar fascia. Kappel-Bargass et al found a similar relationship in a small (n = 20) in vivo study that measured passive hallux dorsiflexion and arch movement during relaxed standing using video analysis.

One study examined the second assumption, the relationship between static, passive hallux dorsiflexion measurement and motion of the first MTP joint during gait. Nawoczenski et al investigated static, passive hallux dorsiflexion and hallux dorsiflexion during gait and found they were well correlated ($r = 0.61$), but only in normal control subjects. More recently, in a report that included patients with foot impairment, Halstead et al questioned this link in a patient population.

The aim of the current study was to explore the validity of the assumptions underpinning the Hubscher maneuver by investigating the relationship between static and dynamic first MTP motions in 2 groups: those demonstrating a normal Hubscher maneuver and those with an abnormal clinical test finding.

**METHODS**

Fifteen patients attending a hospital outpatient’s foot health department for lower limb musculoskeletal assessment were recruited, along with 15 age- and gender-matched controls. Candidates with less than 50° available first MTP joint dorsiflexion during a visual non–weight-bearing assessment of first MTP joint function were excluded, ensuring that the sample included no patients with true structural hallux limitus. This visual observation was confirmed objectively following enrollment by repeating the non–weight-bearing test, while measuring first MTP joint dorsiflexion with an electromagnetic motion tracking (EMT) system. Other exclusion criteria were a history of any major lower limb or foot trauma, significant ankle or foot surgery in the last 18 months, or the presence of significant musculoskeletal or joint disease in the lower limb. On the day of assessment, patients were excluded if musculoskeletal lower limb pain was reported when walking for less than 10 minutes. Enrollment into the case group was based on the observation of functionally limited hallux dorsiflexion (estimated to be less than 40° maximum passive hallux dorsiflexion) during the Hubscher maneuver in relaxed standing, despite the presence of 50° or greater dorsiflexion while non-weight bearing (cut points based on data...
of Nawoczenski et al. The 15 controls all demonstrated normal (visually estimated at greater than or equal to 40°) passive hallux dorsiflexion when tested in relaxed standing and greater than or equal to 50° dorsiflexion tested while non-weight bearing.

Ethical approval for this study was granted by the Leeds Teaching Hospitals Trust Local Research Ethics Committee and all participants gave informed consent.

Test for Inclusion

All participants underwent a clinical examination of passive hallux dorsiflexion (including the Hubscher maneuver) to compare available dorsiflexion weight bearing and non-weight bearing and to discern case and control groups. Weight-bearing examinations were conducted with the patients standing in relaxed double-limb support, with knees fully extended, and with the foot in its relaxed position. Non–weight-bearing examinations were undertaken with the patient sitting in a chair, knee and ankle flexed to 90°, and the calcaneus aligned to the long axis of the shank with the feet on the floor. In both the weight-bearing and non–weight-bearing examinations a single researcher (J.H.) passively dorsiflexed the hallux by pushing up on the proximal phalanx until the position of maximum dorsiflexion was reached. The 2 clinical tests, weight bearing and non-weight bearing, were conducted according to a generally accepted clinical protocol and employed a visual estimation of maximum first MTP joint dorsiflexion, based on clinical judgment in preference to instrumented goniometry.7,21 In the 15 cases, the limb with the greatest limitation of first MTP joint dorsiflexion during gait was defined relative to the metatarsal as described previously.7,21,25 The limb used for the EMT studies. In the control group, the dominant limb (determined by the limb used to initiate walking) was instrumented for the kinematic studies.

Instrumentation

First-MTP-joint motion data were captured using 2 channels of a Fastrak EMT system (Polhemus Inc, Colchester, VT), configured with the long-range transmitter at a rate of 30 Hz, and filtered using a 6-Hz low-pass Butterworth filter. A proximal sensor was mounted upon the supero-medial aspect of the long axis of the shank with the feet on the floor. In both the weight-bearing and non–weight-bearing examinations a single researcher (J.H.) passively dorsiflexed the hallux by pushing up on the proximal phalanx until the position of maximum dorsiflexion was reached. The 2 clinical tests, weight bearing and non-weight bearing, were conducted according to a generally accepted clinical protocol and employed a visual estimation of maximum first MTP joint dorsiflexion, based on clinical judgment in preference to instrumented goniometry.7,21 In the 15 cases, the limb with the greatest limitation of first MTP joint dorsiflexion during gait was defined relative to the metatarsal as described previously.7,21,25 The limb used for the EMT studies. In the control group, the dominant limb (determined by the limb used to initiate walking) was instrumented for the kinematic studies.

Analyses

Analyses were carried out using Microsoft Excel and SPSS Version 12. The data were compared for clinical test positive (cases) and test negative (control) groups. Coefficients of multiple correlation (CMC) were derived according to the method of Kadaba for each group.

The participants’ maximum weight-bearing static dorsiflexion (1MTPα static), maximum non–weight-bearing static dorsiflexion (1MTPα non-sh), and maximum first MTP joint dorsiflexion during gait (1MTPα dynamic) were compared descriptively using means, standard deviations, and 95% confidence intervals for differences. A Student independent t test
Table: Participant characteristics and mean maximum dorsiflexion at the first metatarsophalangeal joint.

<table>
<thead>
<tr>
<th></th>
<th>Case Mean ± SD</th>
<th>Control Mean ± SD</th>
<th>Difference Between Groups Mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Gender (female/male)</td>
<td>8/7</td>
<td>10/5</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>35.5 ± 8.1</td>
<td>35.5 ± 8.9</td>
<td>0.07 (–6.3 to 6.5)</td>
</tr>
<tr>
<td>Mean 1MTPJ(\alpha_{\text{non-wb}})(^\circ)</td>
<td>55.0 ± 11.0</td>
<td>55.0 ± 10.7</td>
<td>0.0 (–8.1 to 8.0)</td>
</tr>
<tr>
<td>Mean 1MTPJ(\alpha_{\text{static}})(^\circ)</td>
<td>19.0 ± 8.9</td>
<td>39.4 ± 6.1</td>
<td>20.4 (14.6 to 26.0)*</td>
</tr>
<tr>
<td>Mean 1MTPJ(\alpha_{\text{dynamic}})(^\circ)</td>
<td>36.4 ± 9.1</td>
<td>36.9 ± 7.9</td>
<td>0.5 (–6.9 to 6.1)</td>
</tr>
</tbody>
</table>

Abbreviation: 1MTPJ, alpha rotations of first metatarsophalangeal joint.

*P<.001.

was used to calculate the significance of differences between groups and significance was set at P<.05.
The level of association between 1MTPJ\(\alpha_{\text{static}}\) and 1MTPJ\(\alpha_{\text{dynamic}}\) was calculated using the Pearson product moment correlation coefficient, with significance set at P<.05.

RESULTS

Consistency of Motion Data

The CMC indicates a high degree of within-subject consistency for measurement of first MTP joint motions during gait (CMC cases, 0.966; CMC controls, 0.856).

Comparison of Case and Control Groups

The age profile for the case and control groups (Table) was not significantly different (P = .983). The results of the non–weight-bearing assessments showed no difference of mean 1MTPJ\(\alpha_{\text{non-wb}}\) between the case and control groups (Table).
The static assessment of hallux dorsiflexion in weight bearing showed statistically significant differences (P<.001) in EMT-measured 1MTPJ\(\alpha_{\text{static}}\) between case and control groups, with the mean for the case group 20.4° (50%) lower than the mean of the controls, confirming that the clinical test was appropriately differentiating the groups according to their static clinical presentation (Table). In contrast, mean 1MTPJ\(\alpha_{\text{dynamic}}\) during gait differed by only 0.5° between cases and controls, a difference that in this sample was too small to reach statistical significance (P = .902) (Table).

Relationship Between Static and Dynamic First MTP Joint Function Measured by EMT

No relationship existed between the maximum hallux dorsiflexion measured during the static test and maximum hallux dorsiflexion during gait (r = 0.186, P = .325) (Figure).

DISCUSSION

Static Analyses

Both cases and controls demonstrated similar amounts of passive hallux dorsiflexion when measured in a non–weight-bearing, seated position. The mean (±SD) passive dorsiflexion in both the case (55.0° ± 11.0°) and control group (55.0° ± 10.7°), compared well to a previous study reporting a mean of 57° using similar methodology and instrumentation. This finding supports the study requirement for absence of structural first MTP joint pathology in both case and control groups.

Those 15 participants who were judged to have failed the Hubscher maneuver (cases) demonstrated significantly reduced passive maximum hallux dorsiflexion angles as compared to the control group, but only in relaxed standing. This finding is consistent with a static, passively induced manifestation of the windlass effect described by Hicks and by Carlson et al; although, as noted below, our dynamic data do not support the extrapolation of this effect to walking.

Gait Analyses

The mean (±SD) maximal hallux dorsiflexion values recorded with the EMT system during the stance phase of gait (case, 36.4° ± 9.1°; control, 36.9° ± 7.9°) were comparable to a study by Nawoczenski et al using similar methodology (42°). Both cases and controls demonstrated a similar range of motion during normal walking, and the difference (0.5°) did not approach statistical or clinical significance. The windlass/FHL theories would predict that reduced static passive hallux dorsiflexion values in the case group would also be associated with reduced ranges of motion at this joint during walking (ie, a significant correlation). There was no such relationship demonstrated in this study (r = 0.186, P = .325). A stronger relationship between these variables (r = 0.61) has been described in normal control subjects previously, but our data are the first to describe the
relationship in people who have demonstrated an abnormal Hubscher maneuver. The discrepancy between the static test and dynamic function may reflect the fact that the mechanics of the first MTP joint and neighboring structures is likely to differ substantially between a passive test of hallux dorsiflexion and the dynamic passage of the foot over the hallux during gait. In the static test, windlass activation is brought about by external manipulation of hallux dorsiflexion relative to a static foot, which is weight bearing over its entire plantar surface. Any tightening of the plantar fascia will occur as the moving distal component, the hallux, moves relative to the metatarsal. Conversely, the dynamic mechanism in gait involves raising the heel over the fixed forefoot during the late midstance/heel-off period, using a combination of structural mechanics and coordinated muscle activity. In the dynamic model, any increase in tension in the plantar structures would be generated by the movement of the proximal foot over the fixed hallux. Other factors, such as independent motion of the first MTP joint during the static test, compared with combined flexion of all MTP joints during walking, are likely to differentially influence the soft tissue tension and may contribute to the lack of association. When the complex spatial and temporal interrelationships between functional units within the foot are considered, it is perhaps unsurprising that the simple static test is not reflective of walking mechanics. The lack of relationship between the static and dynamic EMT data clearly shows that first MTP joint dorsiflexion during gait is not predicted by the amount of first MTP joint dorsiflexion measured during relaxed stance.

Clinical Test

The dichotomization of the groups based on first MTP joint dorsiflexion during relaxed stance was reflected strongly by the EMT measurements. This supports the assertion that the subjective clinical test was adequate for only the most superficial working premise of the clinical test (ie, for the purposes of differentiating according to static limitation). Success or failure of the clinical test of passive hallux dorsiflexion was, however, poorly related to first MTP

![FIGURE](image-url) The relationship between static and dynamic maximum hallux dorsiflexion.
joint limitation during gait. Previous studies have shown that alternative static tests, such as a standing heel raise, have a stronger relationship to maximum hallux dorsiflexion during gait than the common hallux dorsiflexion test tested in this study.\textsuperscript{14,21} Indeed, the simple observation of pinch callus (a callus found on the plantar medial surface of the interphalangeal joint of the big toe) has been noted to be as predictive of gait alteration as static first MTP joint dorsiflexion.\textsuperscript{25} This area warrants further investigation, but either of these tests/observations would appear preferable to the Hubscher maneuver.

We consider the underlying assumptions required for inferring dynamic function from the Hubscher maneuver to be invalid, and we suggest that the term FHL can only be applied using an instrumented dynamic gait assessment to confirm first MTP joint limitation during walking. The data indicate that the Hubscher maneuver is an inappropriate basis for treatment decisions and cannot be considered valid as an outcome measure for other functional therapy.

**Limitations**

Our findings are to be interpreted with consideration of certain limitations. The study employed a relatively small sample and it is recognized that the diagnostic accuracy of the test may differ in a larger sample or in specific patient groups. Three protocol issues also warrant discussion: the standardization of the conduct of the clinical test, the absence of a randomization protocol, and the choice of motion-tracking system. The clinical test of passive dorsiflexion was conducted by the same observer in each case, but was not performed with any artificial constraint to the applied force. This approach was used because it best reflects real-world practice and thus provides data with broader application than does an artificially constrained protocol. The order of testing of the hallux dorsiflexion tests in the clinical setting and using the EMT system were not randomized, however, and the consistent sequencing may have introduced some potential for learning or fatigue effects.

EMT is objective and adequately accurate for this type of study but there are technical limitations including sensor size (~1 cm\(^3\)), the need for tethering of the subject by data cables, and potential interference with the electromagnetic field. In the case of our study, the use of 5-m cables allowed for complete passage along the length of the walkway and the field was carefully calibrated to compensate for distortion. The accuracy of the EMT system in measuring angular rotation (RMS error, \(<0.1^\circ\)) justifies its use in this context.\textsuperscript{18,25-26} In this study, the mean maximum hallux dorsiflexion measured during walking in controls (36.9\(^\circ\)) was less than the 42\(^\circ\) reported previously using similar methodology and instrumentation.\textsuperscript{21} Other studies using EMT have also reported lower first MTP joint excursions than studies employing video protocols, although reported values vary widely for all techniques.\textsuperscript{14,21} It is possible that the EMT protocol used by ourselves and Nawoczenski et al\textsuperscript{21} has underestimated absolute dorsiflexion because the reference position from which the system is calibrated does not take into account the incident angle of the metatarsal to the supporting surface.\textsuperscript{21} Nonetheless, the relative motions in case and control groups are directly comparable and indicate a lack of relationship between static and dynamic data.

Finally, it must also be noted that walking speed can influence joint kinematics. Our subjects acclimatized to a preferred walking speed; but this was not controlled during data capture and it is a limitation that walking speed between the 2 groups may have differed and may be different from the walking speeds used in other studies.

**CONCLUSION**

The capacity of the static weight-bearing clinical test to correctly identify patients with limited static hallux dorsiflexion was confirmed by the subsequent weight-bearing static EMT measures. The maximum dorsiflexion measured during the standing evaluation did not, however, show any relationship with the maximum hallux dorsiflexion occurring during normal walking. The inference of dynamic function from the clinical Hubscher maneuver is, therefore, not valid. We recommend that the static Hubscher maneuver should not form the basis for clinical decisions relating to dynamic foot function, nor be used as an indicator or outcome measure for functional therapy.

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**REFERENCES**


