# The Ratio of 1st and 2nd Metatarsal Head Plantar Loading in Individuals with MS and Controls

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**Background:** Multiple sclerosis is a progressive neurologic condition. It is the most prevalent inflammatory demyelinating disease in young adults worldwide. As the disease evolves many patients develop unsteady gait and balance.

**Objectives**: Our goal in this cross-sectional study was to determine if the ratio of plantar loading between the 1st and 2nd metatarsal heads differ between individuals with MS and healthy controls. We focused on the medial forefoot because individuals with MS avoid placing increased pressure on the lateral aspect of the foot

**Methods:** Our study included 53 MS patients and 19 healthy controls. Foot Function was assessed by measuring the maximum force and peak pressure during gait using a plantar pressure measuring device. The plantar foot was subdivided into 12 regions using a masking algorithm. The maximum force (N) and peak pressure (N/cm$^2$) were computed for each region.[3] The Max Force M1/M2 Ratio (%) and Peak Pressure M1/M2 Ratio (%) were computed to serve as mechanical biomarkers of medial forefoot function. Statistical analyses were performed by limb using Generalized Estimation Equations (GEE) to account for potential dependence between limbs. The Generalized Chi Square was used as the test statistic for hypothesis testing.

**Results:**

| | Control | | MS | | GEE |
|---|---|---|---|---|---|
| | Mean | Std | Mean | Std | χ2 p value |
| CPEI(H) [%] | 21.17 | 8.01 | 18.61 | 6.95 | 0.184 |
| MaxFmet1 [N] | 130.73 | 58.09 | 137.74 | 61.43 | 0.808 |
| MaxFmet2 [N] | 181.24 | 58.01 | 141.23 | 44.63 | 0.002 |
| PSI (Early-midstance) [%] | 54.7 | 3.16 | 53.01 | 3.77 | 0.016 |
| PSI (midstance) [%] | 54.32 | 4.34 | 51.64 | 4.66 | 0.01 |
| PeakPmet1 [kPA] | 242.53 | 110.11 | 320.8 | 245.14 | 0.079 |
| PeakPmet2 [kPA] | 422.78 | 134.04 | 321.64 | 159.79 | 0.005 |

| M1/M2 Ratio | Controls | | MS Subjects | | |
|---|---|---|---|---|---|
| | Mean | 95% CI | Mean | 95% CI | P |
| Max Force | 0.7366 | 0.6448, 0.8285 | 1.0147 | 0.9025, 1.1268 | 0.001 |
| Peak Pressure | 0.6177 | 0.5084, 0.7271 | 1.0781 | 0.8226, 1.3337 | 0.003 |

**Conclusions:** In the control group the 1st metatarsal appeared to be hypermobile during propulsion leaving the 2nd metatarsal head to do more of the loading (Force and Pressure) during stance phase. The majority of MS subjects had M1/M2 loading ratios equal to or greater than 1. The investigators postulate several potential mechanisms for this reversal in medial forefoot loading strategy: (1) MS subjects may plantarflex the 1st ray to enhance proprioception, (2) MS subjects may have increased stiffness of the 1st metatarsolphalngeal joint, (3) MS subjects may have metatarsus primus elevatus (superior position with reduced mobility of the 1st ray), or (4) that the typical drop foot has resulted in a musculotendinous contracture stiffening the forefoot. Additional research is required to determine this mechanism for reversal of medial forefoot function compared with controls and to determine if treatment provides a more stable gait and posture.