Analysis of Serial Foot Radiographs to Determine Foot Height Multipliers

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INTRODUCTION: The Multiplier Method is a simple arithmetic calculation that can estimate the amount of growth remaining until skeletal maturity. When predicting lower limb length discrepancy (LLD), differences in foot height are typically added to the femur and tibia discrepancy. Foot height Multipliers have not yet been calculated using radiographic measurements, so it is unclear whether foot height develops at the same pace as the femur and tibia. This study used serial images to calculate foot height Multipliers and compared them to published lower limb and foot length Multipliers.

METHODS:

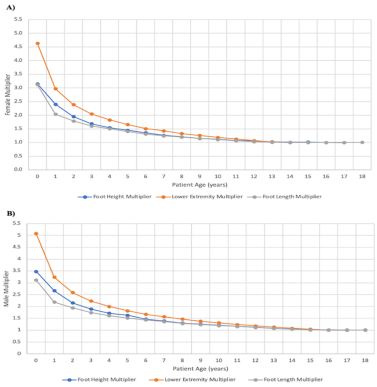
The Bolton Brush radiograph collection was used to measure foot height on the lateral foot view. Radiographs were excluded if the image quality was poor or if important bony landmarks for foot height measurement, such as the head of the first metatarsal, inferior calcaneus, or superior talus, could not be easily visualized. Foot height was determined by drawing a straight line between the inferior head of the first metatarsal and the inferior calcaneus, and then measuring a line heading perpendicular from the first line to the superior aspect of the talus (Figure 1). Multipliers were calculated for ages where there were at least 10 serial study visits. 212 patients with 2195 radiographs were included in the study, with 102 female patients (1131 radiographs) and 110 male patients (1064 radiographs). Foot height Multipliers were calculated for ages 0 to 17 years (females) and 0 to 18 years (males).

RESULTS:

The Multipliers decreased with age in males and females, but qualitatively seem to plateau at age 13 in females and age 15 in males (Table 1). For females and males, lower extremity Multipliers have a more dramatic growth curve, indicating comparatively greater lower extremity growth after birth (Figure 2). However, when comparing a limb length discrepancy calculation using the lower extremity Multiplier versus the foot height Multiplier in a child with congenital femoral deficiency and fibula hemimelia with a total predicted LLD of 145 mm, the difference was 4.5 mm when using the foot height Multiplier.

DISCUSSION AND CONCLUSION:

This paper provides a database of foot height Multipliers. Foot height does seem to grow on a different trajectory than other lower limb components, confirming that one should consider separate Multiplier values. Given the negligible difference created by the foot height Multiplier versus lower extremity Multiplier, separate use of the foot height Multiplier is likely only necessary in young children with large foot height discrepancies.



Patient Age (years)	Female Foot Height Multiplier	Male Foot Height Multiplier
0	3.150	3.484
1	2.403	2.669
2	1.951	2.151
3	1.687	1.893
4	1.543	1.716
5	1.450	1.634
6	1.357	1.468
7	1.265	1.388
8	1.208	1.302
9	1.149	1.254
10	1.122	1.210
11	1.075	1.161
12	1.060	1.128
13	1.028	1.078
14	1.016	1.053
15	1.019	1.020
16	1.003	1.013
17	1.000	1.011
18	-	1.007