Many children are afflicted by foot and ankle pathologies which affect the ankle, midfoot, and metatarsophalangeal joints. However, a clinically feasible foot model capable of assessing multi-segment kinetics throughout the gait cycle does not exist. Similarly, a musculoskeletal foot model utilizing multiple ground reaction forces (GRF) and Milwaukee Foot Model (MFM) kinematics has not been created. The purpose of this study was to develop a clinically feasible method of modeling multi-segment foot properties without increased clinician and/or patient burden or expense. To this end, a force distribution algorithm (FDA) was created, allowing for calculation of multi-segment foot kinetics, musculoskeletal modeling, and foot invertor/evertor muscle tendon length (MTL) analyses. Pediatric participants with and without foot pathology underwent motion capture gait analysis with the MFM marker set and a pedobaragraphic plate overlaying a force plate. The novel FDA divided force plate GRF into hindfoot, forefoot, and hallux vectors. The FDA segmented GRFs were compared to pedobaragraphic plate segment mappings. Ankle, midfoot, and metatarsophalangeal kinetics were calculated with an inverse dynamic approach. Further, a musculoskeletal model accounting for MFM kinematics and segmented GRFs was adapted in OpenSim. The musculoskeletal model was used to determine foot invertor and evertor MTLs, establishing normal MTL bands. In groups with and without pathology, no statistical differences were found between FDA and pedobaragraphic plate results during 2nd rocker for hindfoot and forefoot GRFs, and ankle and midfoot moments. Differences were found in both groups for hallux GRFs and metatarsophalangeal moments. Force and moment residuals of the musculoskeletal model were within acceptable limits for both groups. Static optimization muscle activations of anterior tibialis and medial gastrocnemius muscles were strongly correlated to EMG for those without pathology and weakly correlated for those with pathology. Within the pathology group, MTLs correlated with hindfoot coronal plane kinematics. This study was successful in creating an FDA for hindfoot and forefoot GRF vectors, leading to valid ankle and midfoot kinetics. OpenSim invertor and evertor MTL bands were appropriate and deviations correlated with coronal plane kinematics. Clinicians can use these new tools to illuminate effects of pathologies and interventions on foot function.