(MRI) performed at two years of age or older. Inclusion criteria required detailed perinatal medical data to be available. We excluded children with postnatally acquired movement disorders and/or evidence of a genetic etiology. Brain MRIs were evaluated uniformly and scored based on the severity and location of brain lesions. The gait pattern was assessed by the gait deviation index (GDI) [1]. Exploratory analyses of the collected data, including medical history, gait pattern analysis, and brain MRI, were conducted. Mixed-effects models were used with GDI as the primary outcome variable, classified as a binary variable: < 90 indicating 'abnormal' and ≥ 90 indicating 'normal.' The models included left and right side as a random effect.

Results

The mean age at gait analysis of overall 67 included patients was 9 years of age, with a minimum age of 4,5 years and a maximum of 18 years (median 8 years). Preliminary data indicate that complications during pregnancy, such as premature rupture of membranes, infections, preeclampsia, vaginal bleeding, or premature contractions, do not significantly affect overall gait pathology (Odds Ratio 0.4). Conversely, a reduction in corpus callosum volume was associated with an 80% increase in the odds of exhibiting more abnormal gait patterns. Unexpectedly, the presence of gliosis did not correlate with overall gait pathology (Odds Ratio 1.0). However, abnormalities in the crus cerebri were associated with a 30% increase in the odds of more abnormal gait patterns.

Conclusions

The finding that a reduction in corpus callosum volume increases the odds of more abnormal gait patterns is consistent with results from similar studies [2]. Overall, our data suggest that there is no straightforward correlation between perinatal medical history, MRI findings, and gait pathology.

References

[1] Michael H.Schwartz, (2008), The gait deviation index: A new comprehensive index of gait pathology, Elsevier, Gait & Posture
[2] Eirini Papageorgiou, Nathalie De Beukelaer et al., (2020), Structural Brain Lesions and Gait Pathology in Children With Spastic Cerebral Palsy, Frontiers in Human Neuroscience

https://doi.org/10.1016/j.gaitpost.2025.01.062

Physiological plausible muscle paths: A MATLAB tool for detecting and resolving muscle path discontinuities in musculoskeletal OpenSim models

Willi Koller [1], Brian Horsak [2], Andreas Kranzl [3], Fabian Unglaube [3], Arnold Baca [1], Hans Kainz [1]

[1] *University of Vienna, Department of Biomechanics, Kinesiology and Computer Science in Sport, Centre for Sport Science and University Sports, Vienna, Austria*
[2] *St. Pölten University of Applied Sciences, Center for Digital Health and Social Innovation, St. Pölten, Austria*
[3] *Orthopaedic Hospital Speising, Laboratory for Gait and Movement Analysis, Vienna, Austria*

Background

Musculoskeletal (MSK) simulations are widely used to quantify forces on internal structures during activities of daily living [1] or sports [2]. In MSK models of OpenSim, the muscle paths are defined by PathPoints and Wrap Objects. During scaling, segments and associated PathPoints and Wrap Objects, are linearly scaled by a factor calculated based on surface markers' locations [3]. If a muscle's PathPoint falls inside a Wrap Object, it is ignored and not used to guide the muscle's path leading to altered muscle moment arms. While this issue is rare in healthy participants and typical gait, it might increasingly happen in individuals with atypical segment length combinations (e.g., large pelvis, short legs), altered bone shapes (e.g., increased femoral anteversion) [4], pathological gait or non-walking movements (e.g., squats). We developed an algorithm to automatically identify and resolve discontinuities of muscle moment arms and used it on a large patient dataset to assess its necessity for more realistic results.

Methods

We used motion capture data from 940 patients with various frontal knee malalignments across 1,536 sessions. Personalized MSK models were created by scaling the widely used Rajagopal model [5] using surface markers and calculated joint centers. OpenSim was used to calculate joint angles from marker trajectories of one selected gait cycle for each session. A MATLAB script was developed to check moment arms of muscles spanning the hip and knee joint during gait. If discontinuities were present, the radius of the corresponding Wrap Object was modified automatically in 1mm steps until smooth muscle moment arm waveforms were achieved. One patient was randomly selected to demonstrate how the script improved muscle moment arms and length.

Results

Discontinuities in muscle moment arm waveforms were found for glmax1 (713x), iliacus (346x), psoas (325x), glmax2 (268x) and glmax3 (1x). Overall, discontinuities were detected in 529 sessions (34%). The developed script successfully resolved these in all but 17 sessions (1%). Analysis of one patient showed that the Wrap Object of glmax1 was modified which ensured smooth muscle length and moment arms around the hip joint (Fig 1).

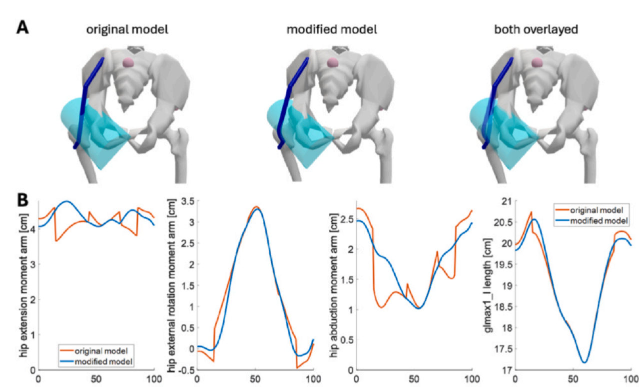

Figure 1: A) Visualization of left glmax1 muscle path in the original and automatically modified model at approximately 20% of the gait cycle. B) Visualization of moment arm of glmax1 around all rotational degrees of freedom of the hip joint as well as muscle length during the gait cycle.

Conclusions

The high prevalence of muscle moment arm discontinuities in patients underscores the need for validation checks even on generally validated MSK models. This is essential to prevent errors in subsequent simulations, such as estimation of muscle activations and forces. The developed script is a valuable tool for ensuring smooth and physiological plausible muscle paths and is freely available on https://github.com/WilliKoller/OpenSim_MuscleMomentArmsChecker.

References

[1] W. Koller, A. Baca, H. Kainz, (2023), The gait pattern and not the femoral morphology is the main contributor to asymmetric hip joint loading, PLoS ONE, Vol 18, https://doi.org/10.1371/journal.pone.0291789

[2] C. Buehler, W. Koller, F. De Comtes, H. Kainz, (2021), Quantifying Muscle Forces and Joint Loading During Hip Exercises Performed With and Without an Elastic Resistance Band, Frontiers in Sports and Active Living, 3, https://doi.org/10.3389/fspor.2021.695383

[3] H. Kainz, H.X. Hoang, C. Stockton, R.R. Boyd, D.G. Lloyd, C.P. Carty, (2017), Accuracy and Reliability of Marker-Based Approaches to Scale the Pelvis, Thigh, and Shank Segments in Musculoskeletal Models, Journal of Applied Biomechanics, 33, https://doi.org/10.1123/jab.2016-0282

[4] H. Kainz, W. Koller, E. Wallnöfer, T.R. Bader, G.T. Mindler, A. Kranzl, (2024), A framework based on subject-specific musculoskeletal models and Monte Carlo simulations to personalize muscle coordination retraining, Scientific Reports, 14, https://doi.org/10.1038/s41598-024-53857-9

[5] A. Rajagopal, C.L. Dembia, M.S. DeMers, D.D. Delp, J.L. Hicks, S.L. Delp, (2016), Full-Body Musculoskeletal Model for Muscle-Driven Simulation of Human Gait, IEEE Transactions on Biomedical Engineering, 63, https://doi.org/10.1109/TBME.2016.2586891

https://doi.org/10.1016/j.gaitpost.2025.01.063

Is the pressure load and kinematics of the unaffected foot normal in persons with unilateral clubfoot?

Andreas Kranzl [1,2], Fabian Unglaube [1], Bernhard Attwenger [1], Nils Wagner [1], Gabriel Mindler [2,3], Christof Radler [3]

[1] *Orthopaedic Hospital Speising, Laboratory for Gait and Movement Analysis, Vienna, Austria*
[2] *Vienna Bone and Growth Center, Vienna, Austria*
[3] *Orthopaedic Hospital Speising, Department of Pediatric Orthopaedics, Vienna, Austria*

Background

In longitudinal studies, the unaffected foot (UF) is often employed as a reference. Aronson et al. [1] demonstrated that there is no statistically significant difference between the UF and a reference group in strength testing, radiography and motion [2] [3]. Studies utilising pressure measurements by three research groups [4] [5] revealed that there are significant differences between the UF and a normal foot. With regard to foot kinematics, no definitive conclusion can be drawn at this time.

The objective of this study is to determine whether there are significant differences in pressure distribution, joint kinematics, and particularly in foot kinematics, between the unaffected foot in unilateral clubfoot and a healthy foot.

Methods

Individuals with unilateral idiopathic clubfoot were identified from our motion analysis database and included in the study if they had undergone a 3-dimensional gait analysis with a foot model (Oxford) and a pressure distribution measurement. The reference data set included age-matched data from 38 individuals with a mean age of 10.5 years. A further subgroup analysis was conducted on data from individuals aged above 7 years and under. The data were analysed for differences.

Results

The database comprised 39 individuals aged between 4 and 18 years. No significant differences were observed in time-distance parameters and ankle joint when compared to the control group. The maximum value for plantar flexion exhibited a significantly lower range for the UF group in comparison to the control group. Maximum dorsiflexion was not found to be significantly increased. The mean supination position of the forefoot in relation to the hindfoot exhibited a significantly higher value in the UF. In addition to the significantly supinated position of the forefoot in relation to the hindfoot in the stance phase, there is a slight increase in eversion of the heel. In the swing phase, there is a tendency for the forefoot to be supinated. The contact area, maximum pressure and normalised maximum force values are increased in the midfoot. A differentiation into individuals below and above the age of seven revealed analogous significant discrepancies in joint kinematics and pressure values. Nevertheless, the number of significant pressure measurement parameters in comparison to the norm for the group above the age of seven is markedly higher.

Conclusions

The pressure measurement findings align with the existing literature. The UF exhibits notable kinematic discrepancies in the foot model when compared to the norm. Specifically, the forefoot demonstrates an elevated supination position, while the hindfoot displays an increased valgus heel position. Consequently, the UF may not be an optimal choice for kinematic comparative studies.

References

[1] J. Aronson, C.L. Puskarich, (1990), Deformity and disability from treated clubfoot, J. Pediatr. Orthop., 109–119

[2] B. Maton, P. Wicart, (2005), Centrally adaptations in unilateral idiopathic clubfoot children following conservative treatment, J. Electromyogr. Kinesiol, 72–82

[3] T.C. Davies, G. Kiefer, R.F. Zernicke, (2001), J. Pediatr. Orthop., 366–371

[4] A. Cooper, H. Chhina, A. Howren, C. Alvarez, The contralateral foot in children with unilateral clubfoot, is the unaffected side normal?, Gait Posture, 375-380

[5] P. Favre, G.U. Exner, B. Drerup, D. Schmid, H.H. Wetz, H.A.C. Jacob, The contralateral foot in children with unilateral clubfoot: a study of pressures and forces involved in gait, J. Pediatr. Orthop, 54-59

https://doi.org/10.1016/j.gaitpost.2025.01.064

What are the kinematic and kinetic effects of using different methods to determine gait events?

Andreas Kranzl [1,2], Fabian Unglaube [1], Brian Horsak [3,4], Djordje Slijepčević [5], Bernhard Dumphart [3,4]

[1] *Orthopaedic Hospital Speising, Laboratory for Gait and Movement Analysis, Vienna, Austria*
[2] *Vienna Bone and Growth Center, Vienna, Austria*