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TECHNICAL NOTE

Effect of Tibia Marker Placement on Kinematics in Pathological Gait

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This study aimed to determine the effect of tibia marker placement on walking kinematics in children with pathological gait. Three-dimensional lower extremity gait data were collected using both a traditional tibia wand (protruding laterally from the distal shank) and a tibia crest marker on 25 children with pathological gait. Kinematic variables during walking and quiet standing were calculated using each marker and the "Plug-in Gait" implementation of the conventional gait model. For walking, average differences in kinematics between tibia markers ranged from 0.1° to 1.9° at the knee and ankle, except in the transverse plane where differences were 6.0° to 7.2°. No significant differences were found during quiet standing, indicating that differences in kinematics derive primarily from dynamic sources, which likely affect the tibia wand more than the tibia crest marker. These results suggest that the tibia crest marker can be used in place of the traditional tibia wand in clinical gait analysis.

Keywords: gait analysis, marker placement, kinematics, motion analysis

Gait analysis is often used to better understand the effect of injuries and pathologies on movement and is a helpful tool in orthopedic treatment and surgical decision-making.[1–3] It is, therefore, crucial to ensure the best possible kinematic data are collected while still maintaining a test that is efficient and feasible for the patient. One of the initial aspects of gait analysis includes selection of a marker set to define segments and an appropriate biomechanical model.[4,5] Markers are often surface mounted and attached directly over the skin representing the underlying anatomical landmarks of interest.[6] Modifications to marker locations are frequently made to address specific issues that may arise such as intermarker movement from soft tissue artifacts or high-impact movements.[7] For example, moving the thigh marker from the lateral thigh to the patella has been shown to improve the accuracy of hip rotation measurements.[8]

The conventional gait model is commonly employed in pediatric gait laboratories and involves a minimal configuration approach; this model traditionally includes tibia and thigh wands to define the shank and thigh segments, respectively.[6] Wands are retro-reflective markers mounted to a small (several centimeters long) stick and attached to the segment of interest. Markers and joint centers are used to define body segments, which are modeled as rigid.[4] Markers moving relative to each other and to the underlying bone may create noise and error in calculated body segment orientations and therefore decrease accuracy of the kinematic results.

The tibia wand marker may be prone to movement during certain activities that increase the probability of soft tissue artifact and wand "wobble" such as change in direction drills, high-impact sport maneuvers, and hard foot contacts. Pathological gait, such as scissoring and jump knee gait in cerebral palsy, often involves forceful motions that can generate movement artifact from the wand marker.[9] In addition, assistive devices used to stabilize walking during testing can easily displace the wand because it laterally protrudes from the shank. Peters et al have suggested using a tibia crest marker instead of a lateral wand to define the tibia segment because of the minimal soft tissue artifact on the tibia crest.[7] Wren et al found more accurate tracking of dynamic hip range of motion when using a patella marker in place of the traditional thigh wand.[8] To our knowledge, no studies have investigated the difference in kinematic output between the tibia crest and wand markers.

The purpose of this study was to examine the effect of tibia marker placement on walking kinematics in children with pathological gait. Specifically, we sought to compare the tibia wand and crest markers using (1) quiet standing kinematics, (2) average kinematics over the gait cycle, (3) average kinematics over loading response, (4) root mean square differences over the gait cycle, and (5) maximum differences over the gait cycle. We hypothesized that a marker placed over the tibia crest would yield similar lower body kinematics compared with the traditional tibia wand.

Methods

Participants

Three-dimensional gait data from 25 children (mean ± standard deviation [SD] age: 10.1 ± 3.8 years, height: 135.0 ± 29.9 cm, weight: 44.4 ± 31.2 kg) with gait abnormalities including cerebral palsy (13), spina bifida (3), clubfoot (2), and other movement-related conditions (7) was examined. Eighteen participants had bilateral lower extremity involvement, and 7 had unilateral lower extremity involvement. All study procedures were approved by our institutional review board. Written assent and consent were obtained from participants and their guardians; some retrospective

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