

Gait in Mid- to Low-Lumbar Myelomeningocele: Self-Optimization?

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Introduction: Myelomeningocele (MMC), a congenital birth defect which affects sensory and motor function, often results in muscle paresis proportional to ascending spinal lesion level. Gait with sacral level lesions have been characterized by reduced ankle movement and increased knee flexion during stance. Only a few studies have investigated the effect of hip abductor weakness, in which a gait pattern with large trunk frontal movements, increased knee flexion and no increase in center of mass motion has been described. In previous studies, we show a large increase in center of mass movement with large frontal and transverse trunk movements but an extended knee at initial contact and mid-stance. We have furthermore presented independent walking kinematics of a group for which very little documented is in the literature, an MMC group with total paresis of the hip abductors and hip extensors, in addition to weakness around the ankles and some reduce strength in knee flexion.

Statement of Clinical Significance: Individuals with similar muscle strengths have been little documented in the literature as self-ambulatory. We show that this does not need to be the case, and when all efforts are given to preserve the required compensatory movements, an altered pattern of 'normal' gait can be achieved in mid- to low lumbar MMC.

Methodology: Of 33 recruited children with MMC, 11 displayed weakness in the ankle dorsiflexors, plantarflexors and hip abductors (weakness is defined as Manual Muscle Test grade ≤ 2). Of these 11 children, 4 have no strength of the hip extensors. Whole-body gait analysis was performed (Vicon Motion Systems, Kistler force platforms) on all MMC subjects and 21 control children. All subjects with MMC used orthoses and none used a walking aid: 8 used KAFOs with a free knee joint and 3 AFOs.

Kinematics of the trunk, pelvis and knee as well as kinetics at the knee and pelvis were examined for the subjects. For each subject, an ensembled kinematic average was generated from 5 left and 5 right gait cycles. An ensembled kinetic average was likewise generated from 3 left and 3 right gait cycles. The following parameters were collected from each person's average gait cycle:

- Average trunk tilt, trunk rotation range, trunk sway range
- Average pelvic tilt, pelvic rotation range, pelvic obliquity range
- Hip flexion/extension and ab/adduction
- Knee flexion in loading response and extension in midstance
- Hip ab/abduction moment, flexion/extension moment, internal rotation moment
- Knee flexion/extension moment, valgus/varus moment
- Center of mass motion in global lateral and vertical directions

The parameters were gathered according to subject group and statistics were performed.

Results: A different strategy was used in gait in the No Abductors MMC Group. Significant differences in all kinematic parameters were observed between the No Abductors and the Control group. Significant differences were observed in all kinetic parameters except knee flexion/extension moment. Much larger trunk and pelvic frontal and transverse motion is observed with a straight knee at initial contact and mid-stance. Hip adductor moment, slight knee valgus moment, and a reduction of internal hip moment were observed in the No Abductor MMC Group. The center of mass was observed to have more than double the lateral excursion (8% vs.3% leg length) with similar vertical excursion (4% for both).

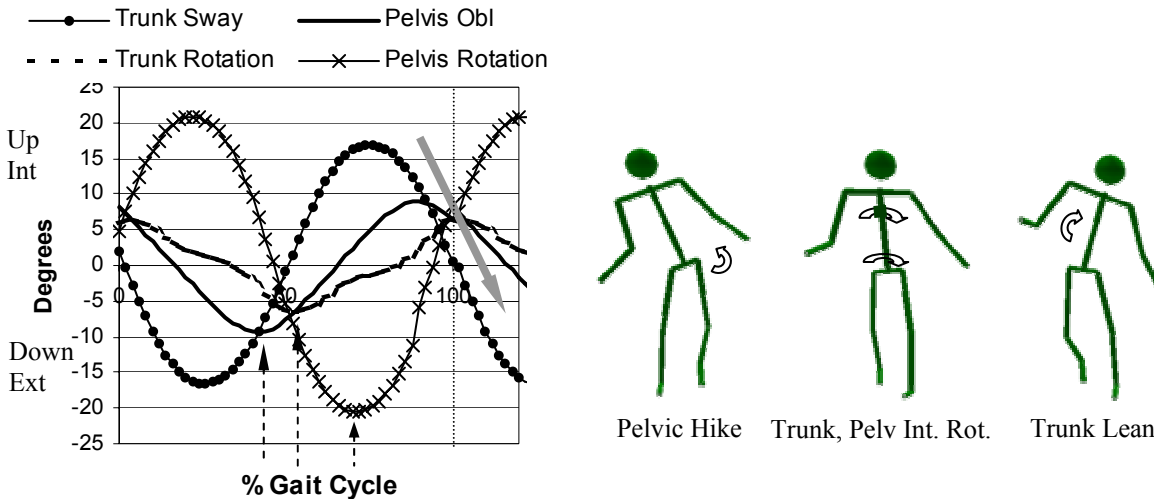


Figure 1: Kinematics of 120% gait cycle for mid-low lumbar MMC with illustration.

Table 1: Kinematic parameters of No Abductor MMC and Control

	Trunk Sway Range (°)	Trunk Rotation Range (°)	Pelvic Obliquity Range (°)	Pelvic Rotation Range (°)	Knee Flexion in Mid-Stance (°)
Control	4	5	8	13	5
MMC	34	15	20	45	0

Discussion: Due to the completely different strengths in mid- to low lumbar MMC, an altered gait pattern is acquired from a very early age and becomes the new normal gait pattern. A characteristic sequence was identified beginning at pre-swing and is depicted in Figure 1: Pelvic hike, followed by first trunk, then pelvic internal rotation, and finally a lateral trunk tip to the new stance leg. This is achieved with a larger lateral center of mass excursion but a straight knee and therefore no increased vertical center of mass excursion. This strategy efficiently utilizes the remaining muscle strengths to progress forward. All efforts to stabilize the lower extremities with orthoses and accommodate large upper body motion to allow this method of progression should be preserved to maintain ambulatory function even in children with this described high paresis level.

References: Stark and Baker (1967) Dev Med Child Neurol 9: 732-44, Bartonek et al. (2002) Gait Posture 15:120-29, Gutierrez et al. (2002) Gait Posture 16(1):136-7, Duffy et al. (1996) J Ped Orthop 16:786-91.