Comparison of 3-Dimensional Kinematics and Kinetics in Symptomatic and Asymptomatic Knee Joints of Children with Myelomeningocele

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Introduction: Almost 90% of children with lumbosacral myelomeningocele (MM) achieve functional ambulation by their teen and adult years. Children with MM ambulate using kinematic patterns that allow them to compensate for muscle weakness and skeletal malalignment[1]. These compensatory patterns have been postulated to result in abnormal loading at the knee joint[2]. Three-dimensional gait analysis techniques have identified increased stance phase knee flexion and decreased or reversed frontal plane moments as contributors to abnormal knee joint loading[1,2,3]. However, the role of abnormal loading in predisposing an individual to knee problems is not well understood. The purpose of our study was to examine joint kinematics and loading in symptomatic and asymptomatic knees of children with MM, in order to develop a better understanding of the combination of factors that predispose an individual to knee problems. We hypothesize that a combination of kinematics and kinetics would define abnormal loading at the knee and that individuals with MM differentially load the symptomatic and the asymptomatic limbs.
Statement of Clinical Significance: Knee pain, instability and early degenerative changes have been documented in approximately one-quarter of the adult lumbo-sacral level MM population[4]. The associated pathological changes are a major factor in precluding independent ambulation in this population. Identification of abnormal kinematic and/or kinetic patterns involved in abnormal loading may lead to the development of early and effective intervention strategies to prevent functional limitation.

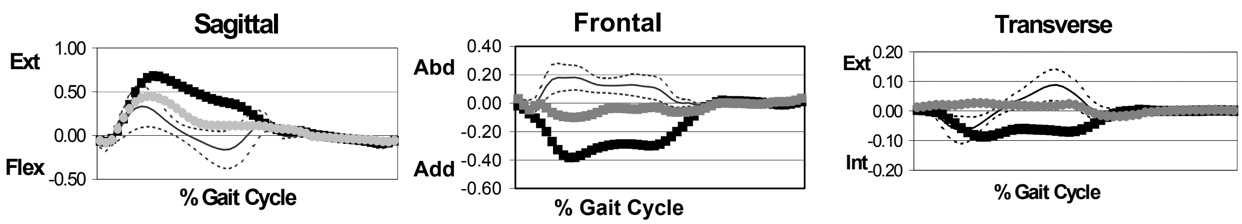
Methodology: Six children (5 females, mean age 15.31±1.61 yrs, mean weight 48.71±5.72 kg, mean height 1.42±0.13m) with L4 MM and five age-matched controls (3 females, mean age 13.71±3.61 yrs, mean weight 50.22±2.92 kg, mean height 1.57±0.32m) participated in this study. Kinematic data were collected bilaterally using 3 markers placed on the foot, leg, thigh, pelvis and trunk segments as the subjects walked at their self-selected walking velocity, along a 10 m walkway wearing their AFOs and shoes. Markers were tracked at 60 Hz using the Optotrak motion analysis system. Kinematic data were filtered at 6 Hz and combined with forceplate data (filtered at 8 Hz) and anthropometric measurements to calculate joint kinematics and kinetics using Euler angles and Newtonian mechanics respectively. **Analysis:** The limbs in the MM group were divided into 2 sub-groups: symptomatic (6 limbs) and asymptomatic (6 limbs) based on history of pain and/or instability at the knee joint in the last 6 months. Data from 2 limbs in the asymptomatic group had to be discarded due to missing markers. A one-way ANOVA was used to compare temporospatial, kinematic and kinetic variables ($\alpha = 0.05$)

Results: Subjects with MM walked at slower velocity compared to the control group: 0.65m/s and 0.93m/s respectively ($p<0.001$). Subjects with MM had shorter stride lengths compared to controls (0.785m and 0.987m respectively on the symptomatic and asymptomatic limbs, 1.21m on the control limbs, $p<0.005$). Comparison of knee kinematics follows in Table 1.

Table 1: Comparison of kinematics at the knee over the gait cycle. Significance between: 1.symptomatic and asymptomatic, 2.asymptomatic and control, and 3.symptomatic and control limbs; is indicated ($p<0.05$)

	Symptomatic	*Asymptomatic*	*Control*
Peak knee flexion in loading response (deg)	31.17[1,3]	17.79[1]	14.05[3]
Peak knee extension in stance (deg)	19.84[1,3]	1.565[1]	2.503[3]
Total frontal plane ROM in stance (deg)	5.104	6.113	5.787
Total transverse plane ROM in stance (deg)	6.259	6.408	5.205

Figure 1: Sagittal, frontal and transverse moments at the knee joint (N.m/kg)



Legend: Symptomatic Knee = ▬ Asymptomatic Knee = ▬ Control = —

Table 2: Comparison of kinetics at the knee during the stance phase of the gait cycle. Significance between: 1.symptomatic and asymptomatic, 2.asymptomatic and control, and 3.symptomatic and control limbs; is indicated ($p<0.05$)

	Symptomatic	*Asymptomatic*	*Control*
Peak extensor moment (N.m/kg)	0.658[1,3]	0.481[1,]	0.319[3]
Peak frontal plane moment (N.m/kg; + Abd)	-0.361[1,3]	-0.115[1,2]	0.1713[3,2]
Peak knee transverse plane moment (N.m/kg)	-0.098[1]	0.027[1]	-0.0295

Discussion: These results indicate that there are significant differences in loading of the symptomatic and the asymptomatic knee joints of children with MM, compared to age-matched controls. These differences may be defined effectively using knee sagittal, frontal, and transverse plane moments. Our findings for knee joint kinematics and sagittal and frontal moments and are in agreement with those published in the literature[3,5]. Contrasting kinematic and kinetic factors that are acting at the knee in symptomatic versus asymptomatic individuals provides valuable insights into factors predisposing to potentially debilitating knee pathology. These results must be confirmed in larger groups of subjects and over time to facilitate the interpretation of biomechanical factors in a clinically meaningful context.

References:

1. Vankoski SJ, et al. Gait Posture 3(1):51-57. 2. Lim R, et al. J Ped Orth. 18(4):428-33. 3. Ounpuu S, et al.J Ped Orth. 20(5):629-35. 4. Williams JJ, et al. J Ped Orth. 13(6):701-3. 5. Thomson JD, et al. J Ped Orth. 19(1):27-33.

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