Analysis of the Center of Mass and Center of Pressure in Typically Developing Children During Heel-Toe Gait and Toe Walking

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Background: Idiopathic Toe Walking is a diagnosis of exclusion, given after all diagnoses that could explain a child's persistent atypical toe walking gait pattern have been ruled out[1]. Researchers defined toe walkers as a parent report of persistent use of toe walking. It is estimated that the prevalence of toe walking is up to 7 to 24% in children[1]. Toe walking is commonly seen in children in varying degrees during early development, but it is widely accepted that this gait pattern normalizes by three years of age[2]. After this point, or in the presence of other symptoms, a child who toe walks may be referred to a medical professional. If toe walking persists after age 3, a diagnosis of Idiopathic Toe Walking (ITW) is made[2]. While literature from researchers such as Kelly et al[3] and Hicks et al[4], have noted significant changes in ankle kinematics for children with ITW, there is no evidence on how the Center of Mass and Center of Pressure position change in toe walking. By changing the Center of Mass position in relation to the Center of Pressure during toe walking, children could be effectively using or not using certain musculature. This research works to fill the gap on differences in Center of Mass and Center of Pressure positioning during heel-toe gait and toe walking.

Methods: Children ages 3 to 6 were assessed kinematically using Nexus 2.52 8-camera motion capture system (VICON ®) and kinetically with 4 Kistler force plates. Markers were placed on various bony prominences following an adaptation of the Plug-in-Gait model. Children were instructed to walk in a heel-toe and toe walking pattern across force plates. A total of three successful trials of each pattern were collected. A "successful" trial was defined by the child striking at least one of the force plates with one foot only. The data collected was filtered into the Visual 3D software for analysis. Whole body Center of Mass (COM) was calculated based on predicted COM measurements of pediatric body segments previously obtained from the literature[5] and anthropometric data measured on each participant. Center of Pressure (COP) was determined at initial contact and pre-swing for each gait pattern. The angle between the COM and COP (COM-COP angle) in the sagittal plane at the two phases of gait was calculated using trigonometric functions and the process used by Yamaguchi et al[6]. Independent t-testing was used to analyze the differences in the COM-COP angle between the heel-toe gait and toe walking groups.

Results: The authors hypothesized that the data collected will show that there is a significant decrease in displacement of COM over COP during toe-walking. The researchers predicted that as the COM approaches the COP, the angle decreases between the two in the sagittal plane at initial contact and pre-swing during toe-walking. This decreased angle and displacement explains the decreased anterior and posterior weight shift during toe-walking. Thus, concluding that the children are maintaining their COM over their COP in order to stay upright during toe-walking.

Discussion: This information is important to a clinician's diagnostic and prognostic evaluations as well as in the selection process of appropriate interventions for a child with ITW. If the authors' hypotheses hold true, identifying this pattern of a decreased angle between COM over COP could be important for diagnosing ITW and separating it from other differential diagnoses. The accurate diagnosis of ITW

affects the clinician's expectations of the child's prognosis, as early recognition and appropriate treatment play a large role. Lastly, without this information, clinicians may misunderstand a toe-walker's biomechanics, which in turn may lead to inappropriate interventions, poorer outcomes and decreased overall function.

References:

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