

Title: Associations of the mechanical, anthropometric and gait contributors to the knee adduction moment during paediatric gait.

Research Question: What are the relationships with the mechanical, anthropometric and gait contributors to the knee adduction moment during paediatric gait?

Introduction: The knee adduction moment (KAM) during gait has been proposed as an indirect measure of dynamic knee joint loading and has been reported to be higher in obese children [1, 2]. The KAM is primarily calculated from the resultant ground reaction force (GRF) and the lever arm length, both of which can be manipulated through weight-loss or medical interventions [1]. However, there is little data on the relationships between the mechanical, anthropometric and gait contributors to the KAM during paediatric gait. The objectives of the study were to examine the associations with the first (1st) and second (2nd) peak KAM (pKAM) and: (1) centre of pressure (CoP), KAM lever arm length, vertical and mediolateral ground reaction forces (GRF) and, (2) fat mass, height, step width, foot rotation, knee rotation and walking velocity.

Materials and Methods: Fat mass was measured in fifty-five boys (9.60 ± 1.13 years old) using air displacement plethysmography. Mechanical and gait parameters were captured using three-dimensional gait analysis to model the lower limbs by plug-in gait. To control for the effects of body height (h) and weight (w) on forces, both raw and normalised associations were included. To assess the association between 1st and 2nd peak KAM and the contributing factors, step-wise forced entry multivariate regression analysis was conducted on variables significantly correlated with the KAM peaks. A priori alpha level of $p < .05$ was set for significant main effects. Sample mean (x) \pm standard deviations are presented.

Results: Greater vertical GRF (x at 1st pKAM $412.9 \pm 126.9\text{N}$, x at 2nd pKAM $328.9 \pm 128.6\text{N}$) and fat mass (x $24.42 \pm 9.07\%$) predicted higher absolute 1st and 2nd pKAM (x $13.08 \pm 7.93\text{Nm}$, x $5.66 \pm 4.27\text{Nm}$, respectively). Normalised vertical GRF (x at 1st pKAM $1.14 \pm 0.24\text{N}\cdot\text{w}$, x at 2nd pKAM $1.14 \pm 0.24\text{N}\cdot\text{w}$) was a significant predictor of normalised 1st and 2nd pKAM (x $0.24 \pm 0.27\text{Nm}\cdot\text{w}^*\text{h}$, x $0.09 \pm 0.12\text{Nm}\cdot\text{w}^*\text{h}$, respectively). Greater external foot rotation (x at 1st pKAM -11.06 ± 15.02) predicted higher raw and normalised 1st pKAM.

Discussion: The contribution of greater fat mass to the KAM confirms previous findings on the effect of obesity on frontal plane knee loading during gait [2]. Greater external foot rotation may indicate reduced stability and has been reported in obese individuals and patients with osteoarthritis [3, 4]. These findings have implications for conservative interventions such as weight loss or in-toe walking to alter dynamic knee joint loading. Further research into the long term effects of obesity and gait parameters on knee joint loading is warranted.

References:

1. Hunt MA, Birmingham TB, Giffin JR, Jenkyn TR. Associations among knee adduction moment, frontal plane ground reaction force, and lever arm during walking in patients with knee osteoarthritis. *Journal of biomechanics* 2006; 39(12):2213-20.
2. Gushue DL, Houck J, Lerner AL. Effects of childhood obesity on three-dimensional knee joint biomechanics during walking. *Journal of pediatric orthopedics* 2005;25(6):763-8

3. Simic M, Wrigley TV, Hinman RS, Hunt MA, Bennell KL. Altering foot progression angle in people with medial knee osteoarthritis: the effects of varying toe-in and toe-out angles are mediated by pain and malalignment. *Osteoarthritis Cartilage* 2013; 21(9):1272-80.
4. Hills AP, Parker AW. Gait characteristics of obese children. *Arch Phys Med Rehabil* 1991; 72(6): 403-7