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Conference Abstract

Impact of Different Biomechanical Models on Knee Kinematics and Bicycle Fit Recommendations

Erin McCallister [1,] * and Nicholas Russell [2]

[1] Assistant Professor of Physical Therapy. Louisiana State University Health Sciences Center at Shreveport, 1501 Kings Highway, Shreveport, LA, USA, 71103. erin.mccallister@lsuhs.edu
[2] Instructor of Physical Therapy, Clinical. Louisiana State University Health Sciences Center at Shreveport, 1501 Kings Highway, Shreveport, LA, USA, 71103. nicholas.russell@lsuhs.edu

* Correspondence: (EMC) erin.mccallister@lsuhs.edu

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Abstract

Introduction: Three-dimensional motion capture is the gold standard for measuring kinematic angles, and Vicon's Plug-in-Gait (PiG) biomechanical model is often used to process kinematic data.[1-4] The Conventional Gait Model 2 (CGM2) was recently developed to update PiG with improved knee and hip joint axes.[5,6] Aim one of this study was to compare the kinematics outputs of PiG and CGM2 at the knee joint during cycling. Aim two was to compare the dynamic knee extension angle of each model to a visual assessment performed by a physical therapist trained in bicycle fit and assess if differences in saddle height classification exist between these methods of kinematic assessment.

Methods: Thirty-seven healthy, adult, recreational cyclists were recruited for this observational study. The participant's bike was mounted on a Road Machine Smart2 trainer (Kinetic, Minnesota, USA). After a standard warm up, data was collected during a two-minute trial cycling at 80-90 cadence using a Vicon motion capture system (Vicon Motion Systems, Oxford, UK). Ten pedal cycles were processed using the two biomechanical models. For aim one, knee extension, total frontal plane knee motion, and total transverse plane knee motion were compared between models using repeated-measures t-tests ($p < .05$). For aim two, saddle height classifications were compared using Cohen's kappa. Four classifications schemes were used: knee extension angle in CMG2, knee extension angle in PiG, visual assessment of knee angle, and visual assessment of lower body biomechanics. One author compared the kinematic output of each model to the normal dynamic value of knee extension (33-43).[2] If the angle was less than 33 , the saddle height was labeled "high". If the angle was greater than 43 , the saddle height was labeled "low." Values between 33 and 43 were labeled "acceptable". The other author visually assessed each participant's video camera data and decided if the saddle height was high, low, or acceptable using two methods: first, based on only knee extension angle, and second, based on clinical judgement of lower body biomechanics.

Results: 35 recreational cyclists (12 female, age 48.5 (SD 12.6) years, BMI 24.3 (SD 3.2) kg/m^2) were included. There were two drop-outs due to data collection error. For aim one, CGM2 reported a larger sagittal angle than PiG by 1.82 (95% CI .39, 3.25), $p = .014$, $d = 0.438$. CGM2 reported 10.8 (95% CI 7.5, 14.1) less frontal plane motion than PiG, $p < .001$, $d = 1.123$. There was no significant effect on transverse plane knee motion ($p = .280$). For aim two, there was moderate agreement on saddle height between both models and visual assessment using knee angle (CGM2 $\kappa = 0.493$, PiG $\kappa = 0.539$). There was fair agreement on saddle height between both models and visual assessment of lower body biomechanics (CGM2 $\kappa = 0.302$, PiG $\kappa = 0.325$). Agreement between PiG and CGM2 on saddle height was moderate ($\kappa = 0.461$). Visual assessment of knee angle and PiG had the highest number of cases with the same classification ($n = 27$).

Discussion: For aim one, CGM2 modeled the knee as more flexed than PiG, therefore decisions to adjust saddle height based on knee angle may differ depending on the model used to process data. CGM2 also modeled less frontal plane motion at the knee but since no normal values for frontal plane knee motion have been established the clinical utility of this data is not certain. Differences in the two models exist likely due to the different methods used to calculate the knee and hip joint axes.[5,6] For aim two, neither CGM2 nor PiG had better Cohen's kappa agreement with the clinician's visual assessment of saddle height, though clinician assessment agreed with PiG in the most cases so PiG may be more clinically relevant. Correlation with the biomechanical models was better when the visual assessment included knee angle only rather than the whole limb biomechanics. Bicycle fitters should be aware that reliance on only knee joint angle to determine saddle height will provide different fit decisions compared to examining the whole lower body biomechanics.

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Key Words: Cycling, Motion Analysis, Saddle Height, Vicon

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