Primary biomechanical outcomes	Baseline (week 0)		Follow-up (week 6)	
	Toe-in (n=10)	Toe-out (n=9)	Toe-in (n=7)	Toe-out (n=7)
Early stance peak KAM (Nm/kg*ht)	3.92 (3.20, 4.64)	4.88 (4.12, 5.63)	4.24 (3.38, 5.10)	5.21 (4.35, 6.08)
Late stance peak KAM (Nm/kg*ht)	3.53 (2.95, 4.11)	3.04 (2.42, 3.65)	3.47 (2.78, 4.17)	3.34 (2.64, 4.04)
FPA (°)	10.38 (6.70, 14.06)	7.23 (3.34, 11.12)	4.01 (-0.41, 8.42)	12.28 (7.87, 16.70)

Table 1 Osteoarthritis and Cartilage

Estimated marginal means (95% confidence interval) by groups across time-points.

completeness: proportion of assessments completed, 3) Adverse events: >2-point increase in pain, 4) Adherence: therapist sessions (number attended) and average minutes of daily self-practice, 5) Achievability: achievement of target FPA angle, and 6) Acceptability: rating the likelihood of using the gait retraining strategy on a Numeric Rating Scale (0 being extremely unlikely to 10 being extremely likely). Preliminary comparisons of the intervention effects on knee load over 6-weeks were evaluated using linear mixed modelling.

Results: Recruitment rate was 4 participants/month, with 93% completing the self-reported questionnaires and 80% of participants completing the logbooks. The attrition rate for the follow-up gait assessment was 26%. No adverse events requiring medical attention were reported. Adherence was feasible (average attendance rate = 82%) with mean practice = 30.2 (17.6) minutes/day, standard deviation (SD) = 17.6. Acceptability was positive with 6.1 (3.8) and 5.3 (4.2) reported for toe-in and toe-out respectively. On average, the target FPA (10°) was not achieved at the 6-week 3D gait assessment, with the toe-in group having a mean FPA reduction of 6.37° and the toe-out group an increase of 5.05° from baseline **(Table 1-** *Due to misconduct, one participant was excluded from the trial following randomisation, therefore data are reported for nineteen individuals***).** Although only preliminary analyses can be conducted on the pilot study, there were no differences detected in this sample for the effect of toe-in and toe-out gait retraining on early and late stance peak KAM.

Conclusions: There were no between-group differences for the biomechanical outcomes, but variability in participant responses when evaluated on an individual level. Preliminary findings suggest that a full-scale trial using a participant-specific protocol will be feasible to conduct, but we should aim for larger FPA values to be implemented to ensure the adequate biomechanical effect.

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MOVEMENT STARTEGIES ADOPTED BY INDIVIDUALS WITH MEDIAL KNEE OA IN RESPONSE TO PRESSURE-BASED AUDITORY FEEDBACK GAIT RERAINING

J. He [1,2,3], C. Ferrigno [1], M.A. Wimmer [1]. [1] *Rush Univ., Chicago, IL;* [2] *Stanford Univ., Stanford, CA;* [3] *Palo Alto Veterans Hosp., Palo Alto, CA*

Purpose: Structural progression of medial knee osteoarthritis (OA) is associated with an increased knee adduction moment (KAM), a surrogate measure of the compartmental knee loads. The KAM is thus a target for mechanical intervention. Based on real-time pressure data and individualized training thresholds, the use of plantar pressure-based auditory feedback to shift weight medially was found to reduce the KAM in individuals with medial knee OA. However, its potential mechanisms remain unclear. Thus, this study aimed to elucidate movement strategies adopted by individuals with medial knee OA in response to pressure-based feedback gait retraining and compare movement strategies of substantial and partial responders of the intervention.

Methods: Subjects with radiographic and symptomatic medial knee OA (n = 26; 85% female; 63±9 yr; 30.4±5.5 kg/m2; 11/15 KL-2/3) participated in this IRB-approved study. A wireless insole (Moticon) was used to supply real-time pressure data to a smartphone app for generating auditory feedback. All subjects completed a gait retraining session between the baseline and immediate post-training (IMD) gait test in the lab. After being instructed on subtly modifying gait to stop feedback, subjects self-perceived and adopted movement strategies by following feedback. They continued the training at home for three weeks and returned to the lab for another (W3) gait test. Subjects were categorized as substantial responders if their KAM changes at W3 were ≥6%, which was shown achievable in medial knee OA via medial weight shift. All walking trials were acquired using 3D motion capture (Qualisys & Bertec). Kinematics and kinetics (Visual 3D) were calculated relative to proximal segment. External joint moments were normalized by percent body weight and height (%BW×Ht). Mixed linear models were used to evaluate the Time, Group, and Interaction effect. Walking trials were nested within Subject, and within-subject variability over Time was modeled by an unstructured covariance matrix. Significant results were further analyzed based on the means of least square predictions. Multiple comparisons were adjusted by the Bonferroni's method. Estimated differences [95%CI] and p-values are reported.

Results: There were 13 substantial and 13 partial responders, and their baseline characteristics and gait were not different. Ten out of the 13 substantial responders achieved ≥6% KAM1 reduction at both IMD and W3. Five out of the 13 partial responders achieved ≥6% KAM1 reduction at IMD but not W3. Their speed-adjusted KAM1 reduction were 0.32 [0.11, 0.52], 0.49 [0.27, 0.70] and 0.49 [0.28, 0.71] %BW×Ht (all $p < 0.001$), equivalent to 10 and 16% at IMD and W3, respectively. Four subjects discontinued after the first visit; although one subject reduced KAM1 by 7% at IMD, they were considered partial responders for this analysis. The speed-adjusted KAM1 reduction of the partial responders was 0.20 [0.07, 0.34] %BW×Ht ($p < 0.001$; 6%) at IMD. They showed an increased KFM by 0.31 [0.03, 0.58] %BW×Ht ($p = 0.018$), making their KFM at IMD 0.46 [0.00, 0.92] %BW×Ht ($p = 0.048$) higher than that of the substantial responders.

Substantial responders reduced speed via reducing strides at IMD and W3, whereas the partial responders reduced speed via reducing both stride and cadence at IMD. The groups employed different mechanisms to medialize their COP that shortened the lever arm to reduce KAM. For example, at IMD, the substantial responders medialized COP, which translated proximally to less rearfoot inversion, ankle inversion, and shank lateral tilt (Fig. 1). Decreased hip adduction, which suggests trunk lean, cannot be verified due to the lack of a difference in pelvis lateral tilt. This series of kinematic changes moved the knee joint center closer to the frontal-plane GRF that translated medially regardless. At W3, the substantial responders maintained the described kinematic changes, except decreased hip adduction. Meanwhile, partial responders widened their step, showed less shank lateral tilt, knee adduction, and thigh lateral tilt and an increased mediolateral GRF. These findings suggested that COP medialization was likely a consequence of wider step, and the lever arm was shortened by the altered GRF vector orientation. In the sagittal plane, the partial responders shifted their COP more posteriorly and reduced the anteroposterior GRF less than the substantial responders. Consequently, their sagittal-plane GRF acted further away from the knee joint center, resulting in an increased KFM.

Conclusions: Substantial and partial responders adopted different movement strategies in response to pressure-based auditory feedback to reduce the KAM. These findings will aid researchers to suggest strategies to subjects to effectively reduce the KAM and avoid increasing KFM that may offset the reduced KAM, improving this intervention to benefit more individuals.

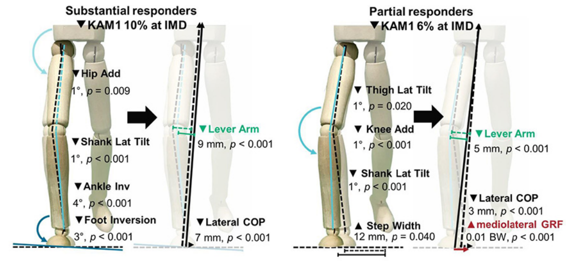

Figure 1. In response to pressure-based feedback gait retraining, substantial responders adopted a series of kinematic changes and partial responders widened steps to alter their KAM1. Estimated differences and *p*-values between baseline (dashed line) and immediately (IMD) post-retraining (solid line) are shown.

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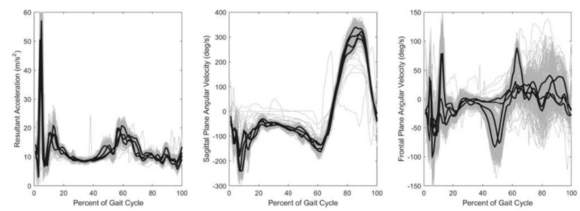
BETWEEN DAY WAVEFORM RELIABILITY OF WEARABLE INERTIAL MEASUREMENT UNITS IN A CLINICAL POPULATION

M. Ruder, Z. Masood, D. Kobsar. *McMaster Univ., Hamilton, ON, Canada*

Purpose: Gait analysis can provide valuable information on the etiology and progression of knee osteoarthritis (OA). While traditionally a lab-based assessment, gait analyses are beginning to shift to more accessible locations through the use of wearable inertial measurement units (IMU). These small, affordable sensors offer not only more ecologically valid data, but also collect orders of magnitude more data over longer collection periods. Unfortunately, much of the data on their reliability is still based on conventional, lab-based collections. Therefore, there is a need to assess reliability in the data collected with these sensors in clinical populations with altered biomechanics assessed 1) over several days and 2) outside of a controlled lab setting. The purpose of this study was to assess the reliability of waveforms obtained from wearable IMUs between four out-of-lab collections in a clinical population of older adults with advanced OA. It was hypothesized that vertical (V) and resultant (R) accelerations would demonstrate excellent reliability, with potentially reduced reliability in the other axis-specific waveforms due to their alignment.
Methods: As part of a larger study related to intra-articular knee injections, six older adults (62.5 $\pm$ 6.2) with moderate-to-severe knee OA were recruited from an orthopedic clinic four weeks prior to their injection. Participants were required to be able to walk for 6 minutes without assistive devices, have >3/10 knee pain on a visual analog scale, and have no other physical or cognitive impairments. In the four weeks prior to their knee injection, participants completed a total of four data collections at least five days apart. Data collections consisted of two wearable inertial sensors (IMeasureU, 250Hz, Vicon Ltd., Oxford, UK) being placed on each leg at the anterior-medial aspect of the proximal tibia using semi-elastic straps before they completed an outdoor 6-minute walk at their self-selected pace. Data were processed using a custom MATLAB script that applied an alignment correction to the data and parsed data into individual steps for the left and right sides. For each side, reliability of the waveforms was assessed via correlation of multiple correlation (CMC). The CMC was calculated for the first 100 steps between each sequential trial and then averaged. Reliability between CMC for a given waveform was defined as <0.5, 0.50-0.75, 0.75-0.90, and 0.90+ defined as poor, fair, good, and excellent, respectively.
Results: Contrary to our hypotheses, only sagittal plane angular velocity demonstrated excellent reliability (CMC: 0.98-0.99), while V, anteroposterior, and R accelerations, as well as transverse plane angular velocity demonstrated good reliability (CMC: 0.76-0.86). Mediolateral (ML) acceleration and frontal plane angular velocity demonstrated fair reliability (CMC: 0.64-0.74). See Table 1 and Figure 1.
Conclusions: While ML acceleration and frontal plane angular velocity only demonstrated fair reliability, the good to excellent reliability for all other axes show the reliability of IMU sensors across multiple out-of-lab data collections in a clinical population of patients. Additional research is needed to determine if this degree of reliability can be obtained in out-of-lab data collected when patients are self-placing the sensors, as well as if the reliability translates to peak acceleration metrics used in assessing disease state. Improvement of between day reliability in frontal plane measures is also critical as these are often used as an estimate of varus thrust.



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PROGRESSIVE CARTILAGE BREAKDOWN ASSOCIATED WITH UNDER-LOADING AND LACK OF DYNAMIC CONTROL ONE YEAR AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

A. Stone [1], K.A. Reeves [1], M.K. Owen [1], C. Conley [1], N. Heebner [1], D. Johnson [1], C. Lattermann [2], C. Jacobs [1], B. Noehren [1]. [1] *Univ. of Kentucky, Lexington, KY;* [2] *Brigham & Women's Hosp., Harvard Med. Sch., Boston, MA*

Purpose: After an anterior cruciate ligament (ACL) injury, up to 50% to 80% of patients will develop radiographic evidence of posttraumatic osteoarthritis (PTOA). The injury and reconstructive surgery initiates a complex mechanobiologic disease process with subsequent alterations knee joint biomechanics that is believed to result in joint degeneration. This relationship is poorly understood and the effects of strenuous conditions, such as those experienced during running and landing, on cartilage breakdown are unknown. The purpose of this study was to determine the association between progressive cartilage breakdown and knee joint biomechanics during more demanding tasks (running and single leg hop) in the first year after ACL reconstruction. We hypothesized that under-loading (reduced knee joint power, joint moment and angle) would be associated with increased type II collagen breakdown at one year after ACL reconstruction.

Mean CMC values for accelerations and angular velocities across four testing days

	Mediolateral Acceleration	Vertical Acceleration	Anteroposterior Acceleration	Resultant Acceleration	Sagittal Plane Angular Velocity	Transverse Plane Angular Velocity	Frontal Plane Angular Velocity
Right	0.71 $\pm$ 0.12	0.85 $\pm$ 0.08	0.86 $\pm$ 0.08	0.85 $\pm$ 0.07	0.99 $\pm$ 0.01	0.76 $\pm$ 0.09	0.65 $\pm$ 0.13
Left	0.74 $\pm$ 0.11	0.86 $\pm$ 0.09	0.88 $\pm$ 0.07	0.86 $\pm$ 0.06	0.98 $\pm$ 0.02	0.77 $\pm$ 0.11	0.64 $\pm$ 0.14