assess more samples and determine whether such a stiffening response is compromised with osteoarthritis.

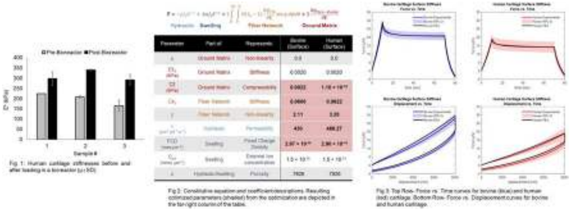

Fig 1: Human cartilage stiffnesses before and after loading in a bioreactor (μ ± SD)

Fig 2: Constitutive equation and coefficient descriptions. Resulting optimized parameters (shaded) from the optimization are depicted in the far-right column of the table.

Fig 3: Top Row- Force vs. Time curves for bovine (blue) and human (red) cartilage. Bottom Row- Force vs. Displacement curves for bovine and human cartilage.

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SQUATTING BIOMECHANICS FOLLOWING TREATMENT FOR FEMOROACETABULAR IMPINGEMENT SYNDROME: HIP ARTHROSCOPY VS CONSERVATIVE CARE

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Purpose: Femoroacetabular impingement syndrome (FAIS) is a hip disorder where femoral head/neck asphericity and/or acetabulum overcoverage lead to hip pain, which is exacerbated by repetitive/sustained hip flexion (e.g. squatting). FAIS is associated with hip osteoarthritis onset, and is commonly treated with hip arthroscopy (addresses osseous deformities), and physiotherapist care (targets neuromuscular deficits and activity modification). The purpose of this study was to compare changes in kinematics and moments following hip arthroscopy and physiotherapist care during a deep squat task.

Methods: The Australian FASHIoN trial recruited 140 participants with FAIS from waiting lists for hip arthroscopy, and a subset (n=36) underwent biomechanical analysis. Participants were randomly assigned to hip arthroscopy (n=18) or 12 weeks of PHT (n=18). Three-dimensional body motion and ground reaction forces were measured before randomization (baseline) and at 12-months (follow-up) during four deep squat trials. Inverse kinematics and dynamics were performed in OpenSim to calculate joint angles and moments. Changes in trunk, pelvis, and lower limb angles (°), and external lower limb moments (Nm·kg/bodyweight·height[%]) were compared across the squat cycle between groups using independent t-tests, and within groups using paired t-tests via statistical parametric mapping ($p<.05$). Spatiotemporal variables (i.e., squat depth, descent and ascent velocity, and descent and ascent speed) were compared between- and within-groups using independent and paired t-tests, respectively, in SPSS.

Results: Hip sagittal, frontal, and transverse plane kinematics are displayed (Figure 1). We detected no between-group differences in 12-month changes in kinematics or moments. Compared to baseline, both groups at follow-up squatted with increased hip external rotation angles and to a greater depth (arthroscopy: mean difference -27.3% limb length [95% confidence interval -35.2, -19.5], $p<0.001$; PHT: mean difference -24.5% limb length [95% confidence interval -33.4, -15.6], $p<0.001$). Compared to baseline, the PHT group at follow-up had increased hip abduction during squat descent.

Conclusions: Changes in kinematics and moments during squatting following arthroscopy and PHT did not differ. Participants in both groups squatted with increased external rotation and to a greater depth. Chondrolabral damage is often located anterosuperiorly in FAIS patients, and increased external rotation during squatting may reduce anterior hip loading, potentially altering local hip cartilage stresses.

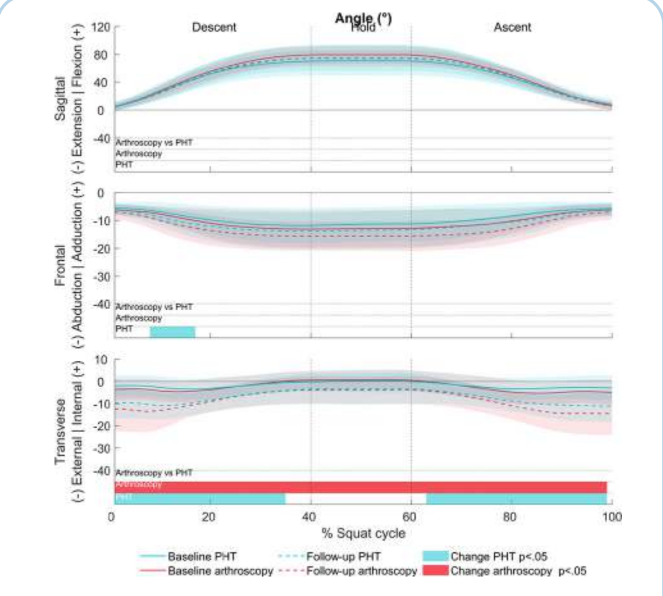

Figure 1 Osteoarthritis and Cartilage

Hip sagittal (top), frontal (middle), and transverse (bottom) plane kinematics for Personalised Hip Therapy (PHT, blue) and arthroscopy (red) groups at baseline (solid line) and follow-up (dashed line). Solid bars indicate statistical significance via SPM ($p<.05$) for between-group (arthroscopy vs PHT) and within-group (arthroscopy, PHT) differences.

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VALIDITY AND RELIABILITY OF A BODY-WORN BIOMECHANICAL SENSOR PLATFORM FOR GAIT ANALYSIS

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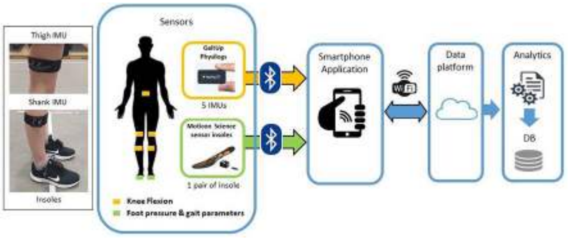
Purpose: Knee osteoarthritis (OA) is currently evaluated clinically using structural imaging. Meaningful change in biomechanical gait variables has been strongly associated with disease progression in knee OA, which can help to advance the understanding of this disease progression. Measurement of gait biomechanics is often performed in laboratories using optical motion capture systems and floor mounted force plates. However, these systems are expensive, not conveniently portable and require skilled staff to operate. Here we describe the development and testing of an alternative approach, a portable biomechanical sensor platform (BSP). The BSP consists of wireless body-worn inertial monitoring units (IMUs) and foot pressure insole units (ISUs), suitable for the measurement of lower extremity gait biomechanics. Appropriate verification and validation is a prerequisite when considering deployment of the BSP for the measurement of gait biomechanics for use as clinical trial endpoints.

Methods: The BSP consists of both IMUs (GaitUp, Switzerland) and foot pressure ISUs with integrated IMUs (Moticon, Germany), Figure 1. The BSP is thus capable of measuring spatio-temporal gait parameters, body-segment kinetics and kinematics.



Data from the two sensor systems are communicated wirelessly, via Bluetooth TM, where they are integrated and transferred securely to a central database using a custom designed mobile application. To examine the reliability and accuracy of the BSP, two separate studies were conducted. Study 1 involved fifteen healthy participants (mean age 42.9±14.5, 7 female / 8 male) who performed multiple 2-minute (2mWT) and 6 meter (6MWT) walking tests in a laboratory while wearing the BSP. Each subject completed a study routine involving two separate visits to the lab. The reliability of each gait parameters across walking trials was considered within a session (intra-session reliability) and between visits (inter-session reliability). Study 2 evaluated the concurrent validity and reliability of the knee angle measurements and involved fourteen healthy participants (mean age 58.3±4.2, 7 female / 7 male) who completed a study routine involving two separate visits to the lab. Participants performed multiple 6MWT while data were captured simultaneously from the BSP and an optical motion capture system (CODA, Charnwood Dynamics, UK) with integrated floor mounted force plate (Bertec Corp, USA). The IMU-derived measurements were compared to knee angles recorded from the CODA system during the 6MWT.

Results: In study 1. Inter-session test-retest reliability for kinetic parameters (Moticon/Insoles only) ranged from good to excellent (ICC>0.75) for parameters such as mean-Local minimum between peaks, to excellent (ICC>0.9) for parameters such as max and mean total force during stance phase. Inter-session test-retest reliability for spatio-temporal (GaitUp/IMU) ranged from moderate to excellent (ICC>0.5) for parameters such as mean stride velocity and stride length, to excellent (ICC>0.9) for parameters such as mean stance, swing time and cadence. Intra-session test-retest reliability for mean kinetic parameters (Moticon/Insoles only) were excellent (ICC>0.9). Intra-session test-retest reliability for spatio-temporal (GaitUp/IMU) ranged from excellent (ICC>0.9) for parameters such as mean stance, swing time and cadence, to moderate to excellent (ICC>0.5) for parameters such as mean stride velocity and stride length. In study 2, moderate (0.5<ICC<0.75) repeatability was observed for knee kinematics with variability estimates in the 5-8 degree range, measured using the shank and thigh IMUs during the 6MWT, Table 1. In study 2, validity statistics, including root-mean-square-error (RMSE) and mean-absolute-error (MAE) for knee angles measured during initial contact and at maximum during gait cycles. Results ranged from 3.83 to 5.37 degrees for the initial contact angle and from 4.49 to 8.85 degrees for the maximum angle.

Conclusions: We have evaluated the application of a portable biomechanical sensor platform suitable for the measurement of gait outside of a laboratory setting. Evaluation of the BSP against optical motion capture has demonstrated its validity and reliability in the measurement of several spatio-temporal, kinetic and knee kinematic gait parameters. The reliability of the GaitUp and Moticon sensor systems was examined both within walking trials and between visits for both 6 meter and 2-minute walking tests. For the Moticon insoles, excellent intra-session and inter-session reliability was observed for several gait parameters. Measures based on force (e.g. mean and max total force during stance phase) and spatio-temporal gait parameters (e.g. gait cycle time and stride length) demonstrates reliability when examined across walking trials both within and between visits. For the kinematic measures from the GaitUp sensors, excellent intra-session and inter-session reliability was observed for the gait parameters for each walking trial with slightly weaker reliability observed for the 6MWTs compared to the 2mWTs.

Knee angle reliability

Knee	Feature	Mean	Rater Difference	Between Subject SD	Between Visit SD	Pure error SD	ICC %	Total all source SD
Left Knee	Max Angle	59.65 (1.57) (p<0.001)	0.792 (0.43) (p=0.068)	5.52	3.27	4.04	53	7.58
	Min Angle	-6.77 (0.99) (p<0.001)	0.63 (0.46) (p=0.173)	3.54	1.03	4.32	38.8	5.68
	RoM	66.42 (1.25) (p<0.001)	0.186 (0.33) (p=0.572)	4.39	2.65	3.06	54	5.97
Right Knee	Max Angle	59.84 (1.6) (p<0.001)	1.304 (0.26) (p<0.001)	5.88	2.57	2.41	73.6	6.86
	Min Angle	-6.7 (1.07) (p<0.001)	1.674 (0.33) (p<0.001)	3.94	1.34	3.1	57.6	5.19
	Rom	66.54 (1.16) (p<0.001)	-0.35 (0.26) (p=0.176)	4.12	2.3	2.43	60.4	5.31

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MUSCLE CAPACITY UTILIZATION DURING GAIT WAS IMPROVED BY STRENGTHENING EXERCISE IN WOMEN WITH SYMPTOMATIC KNEE OSTEOARTHRITIS

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Purpose: The quadriceps muscle is a primary contributor to functional knee joint stability. Deficits in quadriceps muscle strength (i.e., deficits in peak knee extensor torque) alter the distribution of contact stresses across the articular surface of the knee, thereby increasing the risk of knee damage. It is not surprising, then, that a deficit in peak knee extensor torque is likely a risk factor for the initiation (and perhaps progression) of knee OA, particularly among women. Among those with knee OA, women demonstrate lower absolute peak knee extensor torque compared to men. Thus, it is very likely that women use a greater proportion of their total muscle capacity (absolute peak knee extensor torque) to complete daily activities. This potential greater relative utilization of their maximal muscle capacity may be a key mechanism by which women experience knee OA disease and illness more frequently than men. The purpose of this study was to determine whether knee extensor muscle capacity utilization during level walking was reduced after a 12-week strengthening exercise program in women with symptomatic knee OA. Here, muscle capacity utilization refers to the percentage of the maximal knee extensor torque required, or relative effort, to complete an activity. We hypothesized that muscle capacity utilization during level walking would be reduced, reflecting a reduced relative demand on quadriceps.

Methods: This study is a secondary analysis of pre-existing data. Data included were collected from women 50 years of age and older who met the American College of Rheumatology (ACR) criteria for clinical knee OA. All participants completed a 12-week strengthening exercise intervention of three one-hour supervised group classes per week. All outcome measures were measured at baseline (Week 1) and at follow-up (Week 13) on the most symptomatic knee by one blinded assessor.Muscle capacity utilization was represented as the peak external knee flexor moment (KFM) value determined from the stance phase of gait relative to the maximum voluntary isometric contraction (MVIC) of the knee extensors measured on a dynamometer. This ratio reflects the proportion of knee extensor MVIC required to complete level walking.To determine the peak external KFM, three-dimensional gait analyses were conducted while participants walked barefoot, at a self-selected speed. Three-dimensional kinematics were recorded with a four-camera bank (12 cameras) active-marker motion capture system (Optotrak Certus, Northern Digital Inc.) synchronized with ground reaction forces and moments collected with a floor-embedded force plate (OR6-7, AMTI). Commercial software (Visual 3D, C-Motion Inc) was used to filter these data and calculate the peak external KFM. The mean of 5 peak values was used.To determine MVIC of the knee extensors, a dynamometer (Biodex System 3, Shirley, MA, USA) was