

# Markerless Motion Capture Distinguishes Gait Waveform Patterns by Radiographic Severity in Osteoarthritic Knees

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**INTRODUCTION:** Markerless motion capture using computer vision and machine learning approaches for obtaining biomechanical data offer significant potential for clinical implementation. Understanding the sensitivity of the markerless motion capture to identify joint kinematic differences that distinguish severity based on existing clinical measures is an important step in validating the use of markerless motion capture for the development of clinical assessment tools. The objective of our study was to investigate the ability of joint kinematics determined by markerless motion capture to distinguish radiographic knee OA severity quantified by Kellgren-Lawrence score.

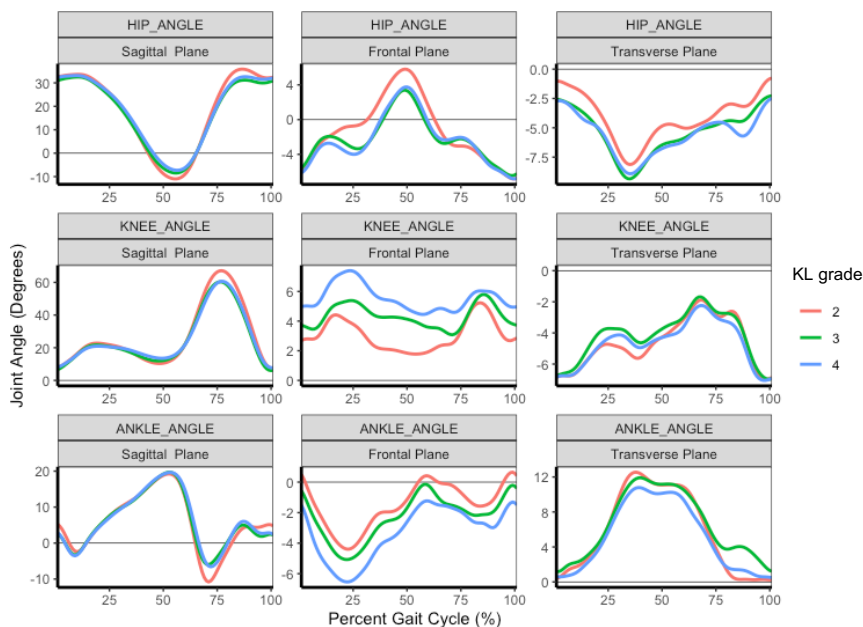
**METHODS:** Ethics approvals were in place and participants provided informed consent. Participants were recruited directly from an orthopaedic assessment clinic where they had been referred for evaluation of knee OA by advanced practice physiotherapists. Gait was assessed during over-ground walking at a self-selected speed (6 lengths of a 10 m walkway). Participants wore the clothes and shoes they had worn that day. Markerless motion capture was recorded using 8 commercially available synchronized video cameras (Sony RX0-II) recorded at 60 Hz with 1/125 shutter speed and processed using Theia3D (Theia Markerless Inc., version 2023.1.0.3161). Existing short film radiographs were reviewed by a single fellowship-trained orthopaedic surgeon for Kellgren-Lawrence (KL) global rating score (scale: grade 0 = no evidence of OA to grade 4 = severe OA) [1]. Analysis was limited to cases with predominantly medial knee OA as determined by the orthopaedic surgeon from radiographs, with or without the presence of patellofemoral OA.

**RESULTS SECTION:** A total of 133 knees in 96 patients were analyzed. Patients were 63% female, 36% male with a mean age of 65 years (SD 8 years). Radiographic knee OA severity levels were KL grade 2 in 34 cases, KL grade 3 in 66 cases and KL grade 4 in 33 cases. Mean self-selected walking speed was 1.03 m/s. Joint angle waveform data captured with the markerless system show separation between KL grades in the knee frontal plane angle, with average waveforms for higher KL grades associated with greater varus alignment during stance (Figure 1). In the sagittal plane, knee flexion angles showed lower peak flexion angles for the KL grades 3 and 4 groups compared to KL grade 2 group (Figure 1).

**DISCUSSION:** This study demonstrated the sensitivity of markerless motion capture data to distinguish radiographic knee OA severity levels. Joint kinematics showed patients with more severe radiographic knee OA (KL scores 3 and 4) had reduced range of motion during stance phase and reduced peak knee flexion during swing, typical of stiff knee gait and consistent with the literature [2-5]. Greater varus alignment during stance with greater KL severity classification was evident and this is also consistent with previous biomechanical studies using traditional marker-based motion capture technology [2, 6-8].

**SIGNIFICANCE/CLINICAL RELEVANCE:** The markerless motion capture system demonstrated sensitivity to radiographic severity levels of knee OA, particularly in the frontal plane. The incorporation of biomechanical assessments in to clinical care pathways has the potential to add increased resolution to assessment tools and future development of functional severity-based scoring that may offer enhanced resolution above radiographic assessments alone.

**REFERENCES:** [1] Kellgren JH, et al., Ann Rheum Dis, 1957 16(4) 494-502. [2] Outerleys JB, et al., J Appl Biomech, 2021 37(2) 130-138. [3] Levinger P, et al., J Arthroplasty, 2013 28(6) 994-9. [4] Naili JE, et al., BMC Musculoskelet Disord, 2017 18(1) 122 [5] Biggs PR, et al., PLoS One, 2019 14(1) e0203417. [6] Debbi EM, et al., Clin Biomech (Bristol, Avon), 2015 30(9) 889-94. [7] Mandeville D, et al., Clinical Biomechanics, 2008 23(8) 1053-1058. [8] Orishimo KF, et al., Clin Orthop Relat Res, 2012 470(4) 1171-6.



**Figure 1:** Joint kinematics from markerless motion capture (Theia3D) for knees with medial osteoarthritis (n = 133 knee in 96 patients) by KL grade. The knee angle in the frontal plane demonstrates higher varus alignment during stance (0-60% of gait cycle) with higher KL (more severe) grades. In the sagittal plane, there is a decreased range of motion for KL grades 3 and 4 compared to KL grade 2.