

Feasibility of Implementing OpenCap Smartphone-Based Motion Capture Technology to Remotely Assess Musculoskeletal Movement in Patients with Various Orthopedic Disorders

Holly D. Aitken, Joshua B. Holt, Robert W. Westermann, Jacob M. Elkins, Dallas A. Vanorny, Justin T. Crawmer, Eli S. Gregory, Silvana Velasquez-Marin, Cole M. Rich, Jessica E. Goetz
 Department of Orthopedics & Rehabilitation, University of Iowa Health Care, North Liberty, IA
 holly-aitken@uiowa.edu

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Introduction: Diagnosing, treating, and evaluating recovery from orthopedic conditions involves assessing a patient’s limb or joint movement.^{1,2} In predominantly rural regions, it can be particularly challenging for patients, especially those with mobility issues, to travel for repeat assessments, physical therapy, or research studies. Recently, rapidly evolving methods for automatic video analysis have enabled development of novel, open-source tools that can provide objectively quantified movement data extending well beyond that acquired during traditional telehealth visits. OpenCap,³ a new, smartphone-based technology to assess musculoskeletal movement, requires two iOS devices (iPhone, iPad, iPod) and the ability to upload videos to a web-based motion capture application. While smartphones are widely available, it is not clear if the specific resources for remotely assessing musculoskeletal movement are available in specific orthopedic patient populations or in more remote locations where they may provide the greatest benefit. Therefore, the objective of this work was to use questionnaires to determine patient access to these technological resources and the comfort level with the OpenCap data collection process among (1) pediatric orthopedic patients and their parents, (2) sports medicine patients (adults), and (3) total joint arthroplasty patients (older adults).

Methods: Under Institutional Review Board approval, three patient cohorts representing the general orthopedic patient community were prospectively enrolled in this study: (1) 118 pediatric patients (64 females/54 males, ages 10-17 years) being treated and/or monitored for a pediatric orthopedic condition/injury, (2) 188 sports medicine patients (118 females/70 males, ages 18-50 years) being treated and/or monitored for a sports-related orthopedic condition/injury, and (3) 119 total joint arthroplasty patients (64 females/55 males, ages 51-99 years) being treated with and/or monitored as a candidate for a total hip or knee arthroplasty. Upon study enrollment, patients were administered a set of 5 questions regarding their home, orthopedic condition, and their simultaneous access to two iOS devices. If participants indicated that they have access to two iOS devices, they were then asked about their ability to set up the iOS devices in a stationary manner, their comfort level installing an app on the iOS devices, and their simultaneous access to the two iOS devices and a computer with internet connection. If participants indicated that they were able and comfortable doing these tasks, they were then asked a set of 6 questions regarding their comfort level with performing an OpenCap data capture remotely. For questions with yes/no responses, *t*-tests with Bonferroni corrections were used to assess differences between the three patient cohorts. For questions with categorical responses, one-way ANOVA with Tukey’s post-hoc tests were used to assess differences between the three patient cohorts.

Results: Significantly fewer total joint arthroplasty patients (63.0%) indicated they were able to have access to two iOS devices simultaneously than both pediatric (83.1%, $p = 0.002$) and sports medicine (77.1%, $p = 0.015$) patients. Comfort level with recording themselves walking, squatting, and performing a sit-to-stand task using the OpenCap technology was not significantly different between pediatric, sports medicine, and total joint arthroplasty patients ($p = 0.746$). Pediatric, sports medicine, and total joint arthroplasty patients did not have significantly different comfort levels with securely sharing the videos recorded of themselves with Stanford University for OpenCap’s automated analysis ($p = 0.832$). Differences in the potential reduction on the burden to travel to clinic for evaluation between pediatric, sports medicine, and total joint arthroplasty patients were not quite significant ($p = 0.0565$).

Discussion: While OpenCap has been shown to be a valid musculoskeletal movement assessment tool in able-bodied young adults,³ these individuals are not representative of most mobility-challenged patients with orthopedic deformities and/or movement abnormalities who would derive maximum benefit from such technologies. Overall, 63.0-83.1% of orthopedic patients had access to the necessary technological resources to use OpenCap, including those in rural regions. As expected, significantly fewer total joint arthroplasty patients indicated an ability to have two iOS devices simultaneously than both pediatric and sports medicine patients, suggesting a reduced potential for OpenCap to be widely deployed as a remote assessment tool in this population. The addition of iOS devices to mobile evaluation units may improve technological access for the approximate 37% of total joint arthroplasty patients for whom it is not currently available. In orthopedic patients in which the technology was available, there were no significant differences in comfort level recording themselves using OpenCap, comfort level securely sharing these video recordings for automated analysis, or potential reduction on the burden to travel to clinic for evaluation between pediatric, sports medicine, and total joint arthroplasty patients. This suggests that the broader orthopedic patient population, including those in rural regions, would be comfortable using the OpenCap technology and may potentially benefit from remote musculoskeletal movement evaluation.

Significance: OpenCap is a potentially feasible and beneficial tool for remote musculoskeletal movement assessment in most of the broader orthopedic patient population. Further work is required to determine the accuracy of the kinematic calculations produced by OpenCap for patients with various orthopedic deformities and/or movement abnormalities prior to implementing the technology for widespread orthopedic use.

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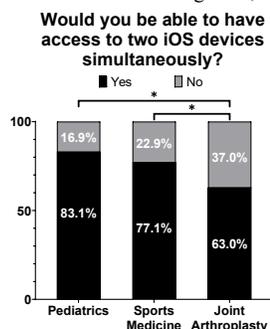


Figure 1: Percentage of patients being treated by pediatric (left), sports medicine (middle), and joint arthroplasty (right) orthopedic providers that would (black) and would not (gray) be able to have access to two iOS devices simultaneously as needed for using the OpenCap motion capture technology. * $p < 0.05$

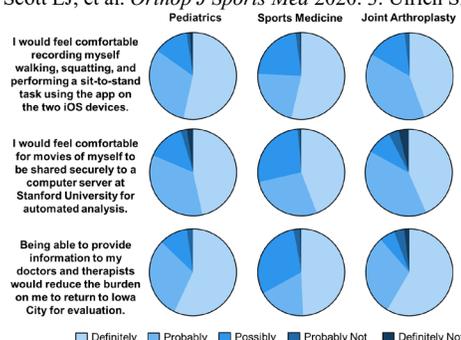


Figure 2: Proportion of pediatric (left column), sports medicine (middle column), and joint arthroplasty (right column) patients that would feel comfortable recording themselves (top row), feel comfortable sharing recordings of themselves (middle row), and feel that remote assessment would reduce the burden on them to travel to clinic for evaluation (bottom row).