



Topic Exploration Report

Topic explorations are designed to provide a high-level briefing on new topics submitted for consideration by Health Technology Wales. The main objectives of this report are to:

- Determine the quantity of evidence available for a technology of interest.
- Identify any gaps in the evidence.
- Inform decisions on topics that warrant fuller assessment by Health Technology Wales (HTW).

Topic exploration report number:	TER396
Topic:	Remote digital pose estimation for orthopaedic injury or surgery
Summary of findings:	<p>Accurate measurement of the range of motion (RoM) in a joint is critical when making informed decisions about the care of people with orthopaedic injury. Current practice consists of either visual estimation, or the use of a goniometer, a physical measuring device. There is the potential that RoM could be as accurately measured in alternative ways, such as the use of an app or video. Pose estimation technology may also be a significant advancement in the accuracy and reliability of RoM measurement in clinical settings. Health Technology Wales researchers searched for evidence on digital pose estimation tools for assessing RoM in orthopaedic settings.</p> <p>One relevant guideline, one systematic reviews and two individual studies were identified. The literature highlights the need for a greater body of evidence on the topic of pose estimation technology, particularly the effectiveness of pose estimation in practice, compared to standard care.</p>

Introduction and aims

Assessing the range of motion (RoM) in a limb or joint following orthopaedic injury or surgery is a critical process. Accurate RoM measurements inform diagnosis, progression monitoring, surgical planning and decision making and allow clinicians to identify and evaluate any possibility for permanent disability or impairment resulting from said injury or surgery. Measurements are also an important factor in rehabilitation planning, and in many cases serve to include the patient in their own care and rehabilitation through goal setting.

The most commonly used techniques for assessing RoM are visual estimation and goniometry. Of the two, goniometry is generally believed to offer more accurate and reliable measurements, but has some shortcomings when it comes to the measurement of certain limbs or angles.

Given the complexities of orthopaedic injuries and surgery, as well as the lasting effects of COVID-19, it may be more beneficial for RoM assessment to be performed remotely. This may potentially save time for clinicians, and may result in an overall lower cost to the NHS. RoM assessment can be performed remotely through several digital technologies, primarily video recording, still-image photography and most recently through the use of pose estimation technology. MobilityHub was identified as a specific example of pose estimation technology by the topic proposer. Pose estimation uses a camera (from a smartphone, tablet, or webcam) and artificial intelligence to calculate clinically relevant metrics, including joint angles, range of motion, and angular velocity.

Health Technology Wales researchers searched for evidence on digital pose estimation tools for assessing RoM in orthopaedic settings.

Evidence overview

We identified one guideline, one systematic review, and two individual studies.

Guidelines

One guideline that contained potentially relevant recommendations was identified.

Nice Guideline NG211: '*Rehabilitation after traumatic injury*' includes recommendations for arranging telephone or video consultations or rehabilitation rather than in a clinic or hospital setting, particularly where people cannot travel to appointments (1.8.20, 1.8.19) and encourages the use of technology-enabled follow up, support and rehabilitation services, especially where there is limited access to services (1.10.10).

Evidence Reviews

Badiola-Bengoa and Mendez-Zorrilla (2021) undertook a systematic/scoping review summarising the availability and type of evidence on the use of human pose estimation (HPE) in sport and exercise. They identified 20 potential papers, and concluded that there is a significant shortage of data to be able to assess the quality of pose estimation's performance in different contexts. It should be noted that while quality assessment is not undertaken during topic exploration, reporting and methodology of this review appears to be of poor quality and likely not applicable for appraisal. For example, the study designs and outcomes are not clearly reported.

Individual Studies

Adolf et al (2022) assessed the ability of the OpenPose algorithm to detect the key-points required for goniometry on a dataset of videos where patients perform rehabilitation exercise in front of a camera. The study concluded that OpenPose HPE is able to perform RoM measurements in

commonly-performed exercises in a home environment, but noted that there were significant limitations in accuracy where positions varied, such as where the patient was lying down or crouching on their knees.

A second study, from Fan et al (2022), evaluated pose estimation in 30 healthy adults performing 6-motion tasks. Results indicated good reliability of pose estimation technology in measuring RoM in shoulder and elbow angles, compared to visual estimations and still images.

Digital tools for assessing RoM have been determined by Health Technology Wales researchers to be a Tier C Digital Health Technology (DHT) according to the [Evidence Standards Framework for Digital Health Technologies](#). Technologies within this classification will provide information that will be used to aid treatment or diagnosis, to triage or identify early signs of a disease or condition, or will be used to guide next diagnostics or next treatment interventions. For technologies of this classification, it is recommended that satisfactory evidence for effectiveness is produced to demonstrate effectiveness of the technology. This includes studies conducted in a setting similar to the UK health and care system, peer-reviewed studies and prospective studies. Evidence to support the claimed benefits of the DHT should include real-world evaluations of its clinical utility, and include 1 or more high-quality studies that support the claimed benefits of the DHT in a relevant setting, showing improvements in relevant outcomes. Similarly, appropriate assessment of the economics of the DHT should be undertaken

Areas of uncertainty

We did not identify any trials or systematic reviews that explicitly mentioned MobilityHub, and evidence on digital tools for remote pose estimation appears limited. Identified studies focus on the validation or early evaluation of potential pose estimation tools, and there appears to be a lack of evidence evaluating pose estimation in practice (i.e. evaluating pose estimation remotely in orthopaedic settings or, compared to standard practice).

Further clarification is required in the following areas:

- How this intervention would embed in the current NHS structure and practice.
- How much training is required for clinicians and patients to be able to use the software (both for HPA and app-supported RoM measurement).

Literature search results

Health technology assessments and guidance	
NICE. (2022). [NG211] Rehabilitation after traumatic injury. https://www.nice.org.uk/guidance/ng211	
Evidence reviews and economic evaluations	
Badiola-Bengoia A, Mendez-Zorrilla A. (2021). A Systematic Review of the Application of Camera-Based Human Pose Estimation in the Field of Sport and Physical Exercise. <i>Sensors (Basel)</i> . 21(18). doi: 10.3390/s21185996	
Individual studies	
Fan J, Gu F, Lv L, et al. (2022). Reliability of a human pose tracking algorithm for measuring upper limb joints: comparison with photography-based goniometry. <i>BMC Musculoskelet Disord</i> . 23(1): 877. doi: 10.1186/s12891-022-05826-4	
Adolf J, Dolezal J, Kutilek P, et al. (2022). Single Camera-Based Remote Physical Therapy: Verification on a Large Video Dataset. <i>Applied Sciences</i> . 12(2). doi: 10.3390/app12020799	

Date of search:	October 2022
Concepts used:	Pose estimation, digital goniometry, orthopaedic goniometry, goniometry, visual estimation, photography-based goniometry

Proposed research question and evidence selection criteria (if selected)

Proposed research question	What is the clinical and cost-effectiveness of providing digital goniometry in an orthopaedic setting, compared to standard practice?
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	Included	Excluded
Population	Those with orthopaedic injury or receiving orthopaedic surgery	Any other form of injury or surgery, more general physiotherapy needs
Intervention	Remote digital goniometry	Sensor-based goniometry
Comparison/comparators	Standard practice	
Outcomes	Improved recovery, cost saving, time saving	Any other outcomes
Study design	RCTs, observational studies, economic analyses	