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## Using Upper Limb Kinematics to Refine Clinical Assessment in Neuromuscular Disorders

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### Introduction

Duchenne muscular dystrophy (DMD) and spinal muscular atrophy (SMA) are rare genetic disorders characterized by progressive muscle degeneration and weakness. Recent therapeutic advancements for DMD and SMA underscore the importance of precise clinical outcome metrics. Traditionally, the Performance of Upper Limb (PUL) scale for DMD and Revised Upper Limb Module (RULM) scale for SMA are used to evaluate clinical outcomes [1][2][3].

Aforementioned scales rely solely on the physiotherapist's interpretation and lack refinement. Therefore, instrumented analysis, particularly with Inertial Measurement Units (IMUs), has gained popularity, providing objective data to complement specialist assessments [4].

### Research Question

This study aims to assess an IMU-based system's effectiveness in enhancing standard clinical evaluation by acquiring quantitative kinematic metrics to evaluate the motor status of children with DMD and SMA.

### Methods

Ten children with DMD (12-17 years, 1- 4 Brooke score), ten with SMA (6-13 years, 1-3 Brooke score) and six with typical development (6-16 years, 1 Brooke score) completed the appropriate clinical scale while equipped with IMU sensors. The study received approval from the Ethical Committee of the Hospital Sant Joan de Déu, Barcelona (PS-28-22). Quaternion data of 7 IMUs (Xsens Dot, Xsens Technologies) on the hand (2), forearm (2), upper arm (2), and torso, were recorded. A sensor-to-segment calibration was conducted integrating the upper limb angular position derived from pictures of the subjects, at the beginning of the recording, with the IMU data. The Euler angles YX'Y'' for shoulder, and ZX'Y'' for elbow and wrist were taken as convention [5]. Range of motion (ROM) and angular velocities of the joints and workspace area (A) of the hand, in the frontal plane, were evaluated in line with the literature[6]. The relative workspace area (%) was normalized using the maximum achievable area for each child. Correlations between these metrics and the clinical score were assessed via the Spearman coefficient (ρ) [7].

### Results

Figure 1 shows the correlation between the workspace area and the clinical score for each clinical scale. Significant correlations were found for clinical score against workspace area in the frontal plane (RULM: $\rho = 0.87$, $p < 0.05$; PUL: $\rho = 0.9$, $p < 0.05$), as well as against the ROM of the shoulder (RULM: $\rho = 0.85$, $p < 0.05$; PUL: $\rho = 0.76$, $p < 0.05$).

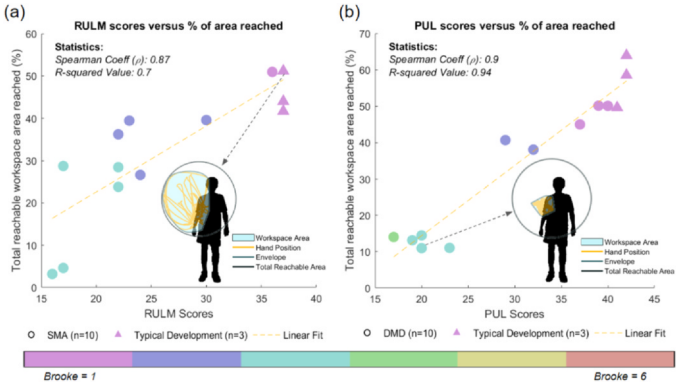


*Figure 1: Correlation between the workspace area and the clinical score for RULM (a) and PUL (b)*

### Discussion

The metrics acquired through the IMU-based system show significant correlations with the clinical score. This result represents the first step toward proving the efficacy of the system for the assessment of upper limb functionality in DMD and SMA. Additionally, the data acquired through IMUs offer clinicians additional insights beyond simple observation. Further investigation into this supplementary information is necessary to provide therapists with more objective data.

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https://doi.org/10.1016/j.gaitpost.2024.07.080

## Countermovement jump reveals decreased functional outcome despite subjective improvement after ACL reconstruction


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### Introduction

Injury to the anterior cruciate ligament (ACL) is a prevalent sports-related injury that significantly diminishes knee stability and overall functional performance. Treatment typically involves ACL reconstruction. Evaluating whether a patient is ready to return to activity (RTA) requires a combination of subjective and objective methods. Subjectively, this includes using patient-reported outcome measures through validated questionnaires to assess knee function [1], [2], [3]. Objectively, it involves examining various functional performance indicators [4]. Despite the widespread use of these traditional metrics, there is a lack of research exploring the correlation between patients perceived functional abilities and their actual performance outcomes. Such insights could be crucial for clinical assessments. The countermovement jump (CMJ) test, which assesses lower limb functionality, shows promise as a tool to improve protocols for safely reintegrating athletes into sports following an ACL injury.

### Research Question

The primary aim of the study was to explore how patients perceived functional abilities of the knee function correlates with objective measurements from the CMJ test, both pre and post-ACL reconstruction.

### Methods

Twenty-four ACL-injured participants were assed prior to surgery (pre-operative) and then 10 months after ACL-reconstruction (post-operative), and twenty-five healthy participants completed CMJs. Patients perceived functional abilities was quantified using patient reported questionnaires, and related to objective functional performance indicators (kinematic and kinetic measures). A mixed-model design explored relationships between subjective measures and objective functional performance indicators.

### Results

After reconstruction, patient perceived functional abilities improved most prominently in the Knee injury and Osteoarthritis Outcome Score (KOOS) for the sports and recreation ($57.00 \pm 26.10$ to $74.75 \pm 18.53$, $p = 0.029$) and quality of life ($40.50 \pm 12.25$ to $58.13 \pm 17.10$, $p = 0.003$) subscales, however post-operative subjective scores remained significantly lower than healthy controls ($p < 0.05$). CMJ landing impulse symmetry ratios of controls matched the pre-operative group ($0.98 \pm 0.17$ and $1.03 \pm 0.28$, $p = 0.754$). Compared to pre-operative, impulse symmetry decreased in post-operative to $0.83 \pm 0.130$, $p = 0.039$, while unaffected limb peak vertical ground reaction forces (VGRFs) increased significantly from $14.98 \pm 2.71$N/kg to $17.75 \pm 2.71$N/kg, $p = 0.027$. Pre-operative Tegner activity scores negatively correlated with VGRFs ($-0.55 < rs < -0.43$, $p < 0.05$). Post-operative KOOS subsections had strong negative correlations with affected-knee extension power at CMJ take-off ($-0.73 < rs < -0.68$, $p < 0.001$), and jump height ($-0.80 < rs < -0.63$, $p < 0.001$).