Protocol: Standardized clinical examination using goniometry to measure passive joint range of motion [3,4]

Test	Position	Passive movement	Measurement of angle	Typical angle
Modified Thomas test [1]	Supine with the pelvis located at the end of the table	The assessor flexes both legs to the chest to ensure a standardized position of the pelvis (ASIS aligned over the PSIS), then the assessor keeps the contralateral leg in this position while passively moving the ipsilateral leg to full hip extension. A stretch is provided at the end of the movement to ensure measuring the end ROM. The ASIS is palpated throughout the passive movement to control for movement of the pelvis.	The angle between the horizontal axis and the long axis of the femur is measured with a goniometer. Hip extension beyond neutral is recorded as a positive angle. Hip flexion is recorded as a negative angle.	0°
Knee extension [1]	Supine, anatomical position	The assessor passively extends the knee by pulling the tibia up and pushing the femur down. A stretch is provided at the end of the movement to ensure measuring the end ROM.	The angle between the long axis of the femur and the long axis of the tibia is measured with a goniometer. Knee hyperextension beyond neutral is recorded as a positive angle. Knee flexion is recorded as a negative angle.	0-5°
True (bilateral) popliteal angle [1]	Supine, hip flexion in both legs	The assessor flexes both legs to ensure a standardized position of the pelvis (ASIS aligned over the PSIS), then the assessor passively extends the knee towards knee extension, while the hip is in 90° of hip flexion. A stretch is provided at the end of the movement to ensure measuring the end ROM. The ASIS is palpated throughout the passive movement to control for movement of the pelvis	The angle between the vertical and the long axis of the femur is measured with a goniometer. The angle is recorded as a negative angle.	-15° to 0°
Unilateral popliteal angle [1]	Supine, hip flexion in evaluated limb	The assessor flexes the evaluated leg. The contralateral limb is stabilized in extension. The knee of the evaluated limb is moved into maximal extension. A stretch is provided at the end of the movement to ensure measuring the end ROM. The ASIS is palpated throughout the passive movement to control for movement of the pelvis.	The angle between the vertical and the long axis of the femur is measured with a goniometer. The angle is recorded as a negative angle.	-35° to -20°
Ankle dorsiflexion with knee extended, Silfversköld Test [1]	Supine, anatomical position	The assessor passively moves the ankle towards dorsiflexion, while keeping the knee in full extension. The movement of the assessor is initiated at the heel (fingers wrap around the heel) to avoid increased motion throughout the midfoot. A stretch is provided at the end of the movement to ensure measuring the end ROM.	The angle from the anatomical position. Dorsiflexion beyond the anatomical position is recorded as a positive angle. Plantar flexion is recorded as a negative angle.	10° to 20°
Ankle dorsiflexion with knee flexed, Silfversköld Test [1]	Supine, ipsilateral leg is in 90° knee flexion	The assessor passively moves the ankle towards dorsiflexion, while keeping the knee in 90° of flexion. The movement of the assessor is initiated at the heel (fingers wrap around the heel) to avoid increased motion throughout the midfoot. A stretch is provided at the end of the movement to ensure measuring the end ROM.	The angle from the anatomical position. Dorsiflexion beyond the anatomical position is recorded as a positive angle. Plantar flexion is recorded as a negative angle.	20° to 30°

Ankle plantar flexion	Supine, anatomical position	The examinator lifts the evaluated leg and slightly flexes the knee joint. The ankle is than moved towards plantarflexion. A stretch is provided at the end of the movement to ensure measuring the end ROM.	The angle from the anatomical position. Plantar flexion beyong the anatomical position is recorded as a positive angle.	45° - normal

Abbreviations: ASIS, anterior superior iliac spine; PSIS, posterior superior iliac spine; ROM, range of motion.

During a standardized clinical examination, goniometry was used to measure the passive range of motion (ROM) of hip extension (modified Thomas test [1]), hip adduction (with extended hip and knee of the assessed leg and hip and knee flexed in 90° of the contralateral leg [2]), knee extension [1], hamstrings (true popliteal angle [1]), and ankle dorsiflexion (with knee extended and knee flexed in 90° [1]) (A detailed description is provided in the table above). Previous studies reported acceptable intra-rater and inter-rater reliability of these measures [1]. Passive ROM was measured in degrees.

Manual Muscle Testing (MMT)

Strength can be evaluated clinically by manual testing. Manual muscle testing involves the clinician applying resistance to a specific movement while the patient attempts to contract the targeted muscle. The clinician assesses the muscle's ability to generate force. Strength scores indicate:

1. Evidence of slight contraction of the muscle but joint motion is not visible
2. Complete range of motion in gravity eliminated plane
3. Perfect motion against gravity
4. Motion against gravity with some (moderate resistance)
5. Motion against gravity with maximal resistance

Clinical stiffness scale for Duchenne muscular dystrophy:

During the passive movements described above, stiffness was rated by the assessors based on the resistance they felt during the movement:

- 0 = no increased resistance
- 1 = minimal increased resistance at the end of the range of motion
- 2 = increased resistance
- 3 = highly pronounced resistance

This scale is based on the structure of the Ashworth scale, but references to neurally induced increases in resistance (e.g., a 'catch') were removed because abnormal muscle tone does not contribute to increased resistance in DMD.

Selectivity [5]

The selectivity of different muscle groups is evaluated by a standardized but subjective score.

- 0 = no selective control, no (or minimal) contraction of the demanded muscles
- 0.5 = small contraction, but almost no motion, and/or a lot of co-contraction

- 1 = mild selective control, not all muscles working in a correct way, no smooth motion, with co-contraction (not always), limited range

- 1.5 = good contraction, with correct muscles, but slightly limited range because of co-contraction or no perfect smooth motion

- 2 = perfect control, perfect contraction with the correct muscles

Selective Control Assessment of the lower extremity (SCALE) [6]

Selective voluntary motor control (SVMC) can be defined as the ability to perform isolated joint movement without using mass flexor⁄ extensor patterns or undesired movement at other joints, such as mirroring. The Selective Control Assessment of the Lower Extremity (SCALE) is a clinical tool developed to quantify SVMC in patients with CP.

- 0 = No isolated movement; only synergy-based or no movement.
- 1 = Impaired selective movement with some synergy or compensation.
- 2 = Normal selective movement, full isolation, and control.

References:

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3. Vandekerckhove I, Van den Hauwe M, Dewit T, Molenberghs G, Goemans N, De Waele L, et al. Longitudinal trajectories of muscle impairments in growing boys with Duchenne muscular dystrophy. medRxiv Prepr. 2024. doi:https://doi.org/10.1101/2024.06.30.24309742
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