the Shaperator

MAT Companion Guide

October 2024

Foreword

This MAT Companion Guide has been created as a resource to assist Occupational Therapists and Allied Health Professionals when using The Shaperator. It contains relevant definitions, terminology and detailed sections on the Mechanical Assessment Tool, postural assessments and wheelchair seating assessment process.

Contents

Part 1
Important Bony Landmarks

Iliac crest

See image 3.

The iliac crest can be found by placing your thumbs and index fingers each side of the waist at the height of the belly button, then sliding your hands inferiorly to feel on both sides the bony lumps of the iliac crest.

Posterior Superior Iliac Spine (PSIS)

See image 3.

The PSIS, often referred to as the 'dimples', are located between the buttocks and the waist and can be identified by holding each iliac crest and moving your thumbs backward to locate the bony landmarks situated just above the midpoint of the buttock fold.

Ischial Tuberosity (IT)

See image 1.

The ITs are the sharp, bony notches on the inferior aspect of the pelvis. When seated, these can be palpated by sliding your hand with palm up from the side aspect of the client, underneath the buttocks. The client's IT may be felt against your fingertips. The orientation of the ITs in relation to the ASIS and PSIS will give you feedback on whether there is posterior or anterior pelvic tilt involvement.

Anterior Superior Iliac Spine (ASIS)

See image 1.

The ASIS can be found by palpating the iliac crest and sliding your fingers forward to a sharp notch; above the femur / thigh bone when seated.

Greater Trochanter (GT)

See images 1 & 2.

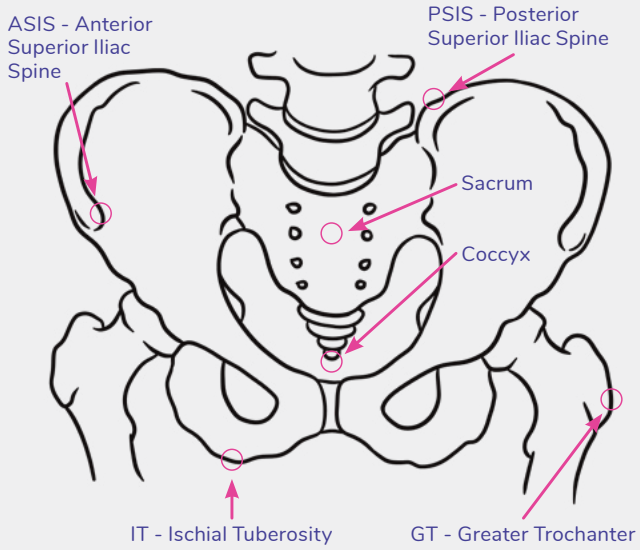
The GTs can be found by placing the ball of your hand over the lateral aspect of the thigh, inferior to the iliac crest, then pressing in and rotating around until you find the hard, bony notch. To ensure you have the right landmark, you can move the leg around whilst palpating the GT providing there is no contraindications to ranging.

Sacrum

See images 1 & 3.

The sacrum is located at the base of the spine, between the two hip bones. It is a triangular-shaped bone that forms the posterior part of the pelvis, connecting the spine to the pelvis. You can find it by palpating the area just above the tailbone and below the lower back.

Pelvis



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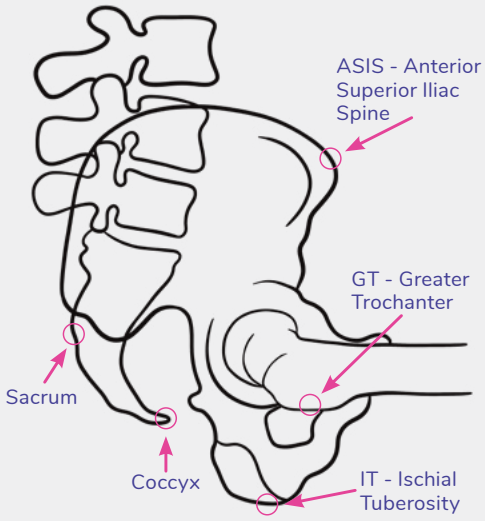

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Image source: aci.health.nsw.gov.au

Posterior

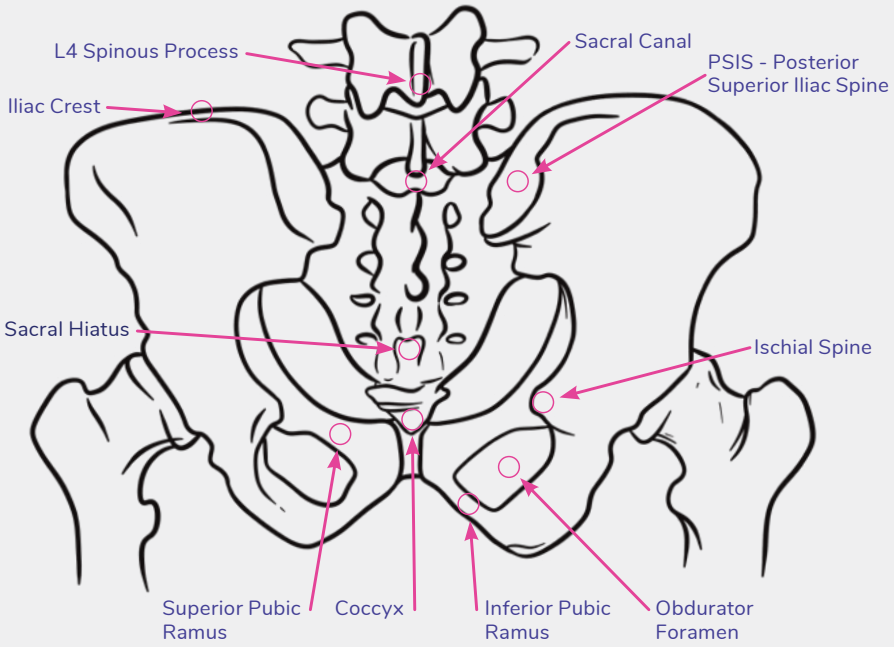

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Image source: bodycollegewiki.net/Pelvic_Landmarks

Clinical Terminology

Pelvis

Pelvic Tilt Angle

Observed in the sagittal plane.

Describes the angle and position of the pelvis in either anterior or posterior directions, with respect to the horizontal.

If the ASIS is located at a higher angle than the PSIS, this indicates the pelvis is positioned in posterior pelvic tilt.

If the ASIS is located at a lower angle than the PSIS, this indicates the pelvis is positioned in anterior pelvic tilt.

Pelvic Obliquity Angle

Observed in the frontal plane.

The angle of orientation of the pelvis with respect to the horizontal, viewed from the front *(Waugh & Crane, 2013)*.

A pelvic obliquity can be determined by locating and palpating your client's ASIS and comparing their orientation to horizontal and to one another.

A left pelvic obliquity is indicated when the left ASIS is lower, when compared to the right ASIS. A right pelvic obliquity is indicated when the right ASIS is lower, when compared to the left ASIS.

Pelvic Rotation Angle

Observed in the transverse plane.

The angle of orientation of the pelvis in the transverse plane with respect to the wheelchair frame, viewed from the top *(Waugh & Crane, 2013)*.

A rotation can be identified by palpating the client's ASIS, where one side is positioned more posteriorly while the other side is oriented anteriorly.

If the left ASIS is posterior to the right ASIS, this indicates a left pelvic rotation.

If the right ASIS is posterior to the left ASIS, this indicates a right pelvic rotation.

The presence of a pelvic rotation may cause a leg length discrepancy in relation to the seat depth of a wheelchair. Additionally, a pelvic rotation may indicate the presence of a trunk rotation.

Trunk

Kyphosis/Lordosis

Observed in the sagittal plane.

Kyphosis refers to an exaggerated outward curvature of the cervical and thoracic spine, often accompanied by a flattened lumbar curve. This condition may also present with cervical hyperextension and a posterior pelvic tilt.

Lordosis refers to an exaggerated inward curvature of the lower thoracic and lumbar spine, resulting in a pronounced swayback appearance. This condition may also present with cervical extension and an anterior pelvic tilt.

Scoliosis

Observed in the frontal plane.

Scoliosis refers to an abnormal lateral curvature of the spine and can appear as an 'S' or 'C' shape. This condition may also present with pelvic obliquity.

The direction of the curvature can be described as a left or right sided convex scoliosis.

Rotation Angle

Observed in the transverse plane.

Rotation angle describes the trunk rotation in a direction to the left or to the right.

During left trunk rotation, the right shoulder moves forward, and the left shoulder moves backward. During right trunk rotation, the left shoulder moves forward, and the right shoulder moves backward.

Hip

Adduction

Observed in the frontal plane.

Adduction of the hip refers to the movement of the leg toward the midline of the body.

Abduction

Observed in the frontal plane.

Abduction of the hip refers to the movement of the leg away from the body's midline.

Internal Rotation

Observed in the frontal plane.

Describes the hip joint rotates towards midline so the knee is positioned inward from neutral thigh alignment.

External Rotation

Observed in the frontal plane.

Describes the hip joint rotating away from midline so the knee is positioned outward from the neutral thigh alignment.

Body Segment Angles

Thigh to Trunk Angle

The angle between the thigh and the trunk, viewed from the side.

This angle is used to help determine the desired seat-to-back support angle for a straight back support.

Thigh to Lower Leg Angle

The angle between the thigh and the lower leg, viewed from the side.

The thigh to lower leg support angle can then be used to help in the selection of the wheelchair's lower leg support assembly.

Lower Leg to Foot Angle

The angle between the lower leg and the foot, viewed from the side.

The lower leg to foot angle reflects the position of ankle dorsiflexion or plantarflexion and is used to help determine the desired lower leg support to foot support angle.

Feet

Inversion

Viewed in the frontal plane.

Describes the position of the foot moving inward towards midline.

Eversion

Viewed in the frontal plane.

Describes the position of the foot moving outward from midline.

Head and Neck

Extension

Viewed in the sagittal plane.

Describes the movement of the head tilting backwards, looking upwards.

Flexion

Viewed in the sagittal plane.

Describes the movement of the head bending forwards, looking downwards.

Neck Lateral Flexion

Viewed from the frontal plane.

Describes the position of the head with the ear moving towards the shoulder.

Neck Rotation

Viewed from the transverse plane.

Describes the head in a position where it turns to the side.

Upper Limbs

Retracted

Scapular retraction describes the action of the shoulder blades moving inward towards midline or towards each other.

Protraction

Scapular protraction describes the action of the shoulder blades moving outwards from the midline and away from one another.

Elbow and Forearm

Contracted

A contracted elbow, often referred to as an elbow contracture, is a condition where the elbow joint loses its normal range of motion, resulting in stiffness and a limited ability to fully extend or flex the arm.

Wrist

Contracted

A contracted wrist is a condition where the wrist joint loses its normal range of motion, affecting its ability to maintain a neutral alignment.

Part 2
Wheelchair Seating Assessment Process

Wheelchair seating and positioning is a problem-solving exercise. To solve the problem, a therapist is required to undertake a thorough assessment which includes a physical evaluation called the Mechanical Assessment Tool (MAT).

Mechanical Assessment Tool: Supine and Sitting Assessment

The Mechanical Assessment Tool (MAT) has been integrated into The Shaperator configurator to support therapists to reflect on the capabilities and limitations of the client in reference to their wheelchair seating and positioning goals. An understanding of the individual's biomechanics and postural presentation enables the therapist to:

- Enhance understanding of the MAT and its application to wheelchair seating and positioning.
- Clinically determine appropriate products to support their clients' postural needs and seating requirements.
- Facilitate clinical reasoning which assists the therapist to justify their product recommendation to the funding body. Deeply understanding the client's requirements means the funding body is more likely to understand why the recommended products are the most effective and beneficial for their client.

The MAT is a crucial step in the process to optimise an individual's positioning, comfort, and function in their wheelchair. Wheelchair seating can be complex. Medifab's aim is to provide a user-friendly resource to best support clinicians in their wheelchair seating assessments in using The Shaperator. By following the steps highlighted in The Shaperator, clinicians will be encouraged to be systematic and accurate in their information gathering, and consistent in their measurements and collation of information.

Before we begin...

To conduct the MAT, you will need to be able to:

- Locate bony landmarks of the pelvis.
- Understand the structure of the client's skeleton and the influence of the various muscle groups on the articulation of the joints.
- Understand body planes and ranges of movement to identify reducible and non-reducible deformities.

For those new to wheelchair seating, the *Medifab Clinical Education Team* recommends revisiting basic musculoskeletal anatomy and biomechanics. Specifically, refreshing your understanding of standard joint ranges, articulating muscles and tendons, and their relationship to achieve movement will greatly benefit your understanding of the dynamics of wheelchair seating.

Useful Resources

The internet has various accessible tools and resources to use to build theoretical knowledge and understanding of postural assessment and intervention planning for wheelchair seating and positioning. One such resource that is available for clinicians is the *NSW Governments ACI State Spinal Cord Injury Service* website.

The *Spinal Seating Education Modules* provides clinicians with online learning modules to build foundational knowledge in seating assessment and intervention.

This online resource by *Kelly Waugh (2013)* at the University of Colorado aims to enhance understanding of wheelchair seating measures and angles, and how these impact on wheelchair configuration.

To better understand relative body segment angles please refer to the following pages of the above listed resource:

- **Page 23 - 24:** Relative angles
- **Page 45:** General instructions

The relative body segment angles seen on the MAT are clinically relevant as they align with primary seating angles of the body support system. These primary seating angles are used to set up the wheelchair configuration to align with the individual's optimal joint ranges.

Step 1: MAT – observation of optimal range of motion.
Step 2: Body segment angles translation.
Step 3: Wheelchair seating angles for your client, respecting optimal joint ranges.

We use the words 'optimal joint range' with purpose. Each client has specific levels of postural control, range of movement, presentations of tone and spasticity that must be carefully considered in their wheelchair configuration. To achieve optimal posture for our client in wheelchair seating, we must particularly focus on:

- Stability, balance and alignment.
- Supporting non-destructive resting postures.
- Prioritisation of function.
- Prioritisation of pressure distribution.
- Supporting physiological functioning.

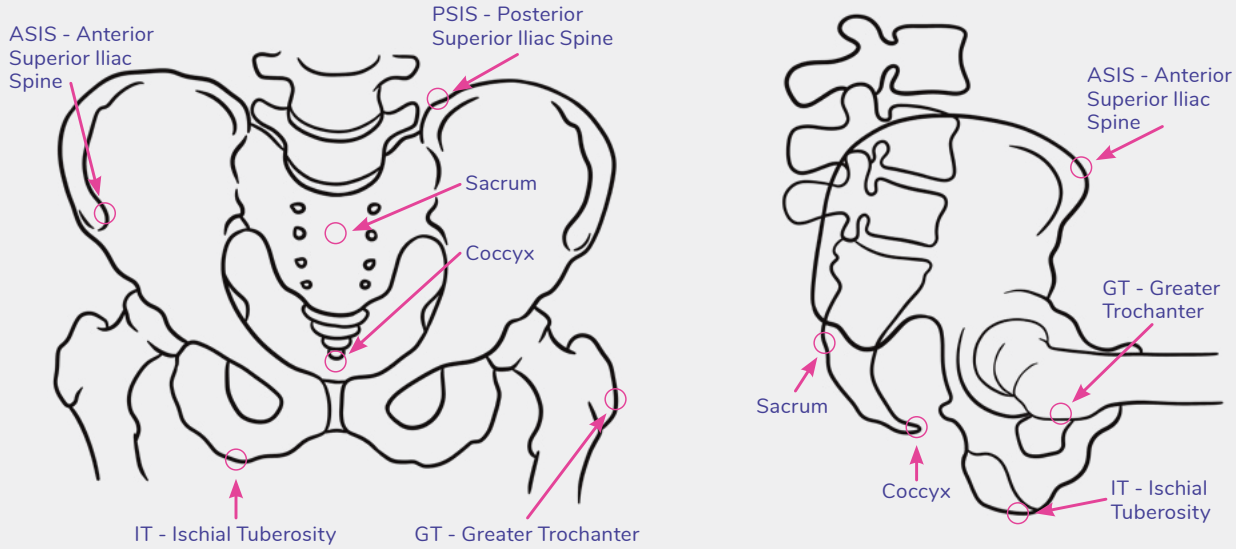
Before we go on, please remember that Medifab's four interrelated goals in wheelchair seating are to optimise:

- Functional capability
- Pressure management
- Postural stability
- Client comfort

It is important to be able to locate and palpate the above bony prominences to gauge the position of the pelvis in sitting and lying and which presentations are reducible or non-reducible.

To determine the presence of postural deviations in the pelvis, one must locate and palpate the following bony prominences:

- ASIS
- PSIS
- Orientation of the ITs and sacrum



Source: www.aci.health.nsw.gov.au

Overview of the wheelchair seating assessment process

Step 1: Initial assessment/information gathering.

Step 2: Mechanical Assessment Tool (MAT)

a. Analysis of client's posture in current wheelchair seating system and review of equipment in place.
b. Supine assessment on plinth.
c. Sitting assessment on plinth – simulation of supports.

Step 3: Translation of findings into product parameters.

Step 4: Trial and clinical justification.

Step 5: Delivery and follow-up.

In order to complete the wheelchair seating assessment, the following equipment is required:

- Firm assessment surface such as a plinth.
- Goniometer.
- Measurement tape.
- Full length dressing mirror may be helpful if performing the MAT without assistance from another therapist. The mirror will be used to confirm body segment angle findings.
- An extra pair of hands may be required to complete the physical assessment of the client. Be sure to review this need in the initial stages of the assessment process and factor it in as per the funding bodies requirement.

Step 1: Gather information and develop clear goals and expectations

a. Use The Shaperator's postural assessment, or
b. Complete the Spex *Client Data Assessment form for Wheelchair Seating*.

Be sure to:

- Identify the problem(s) that may be contributing to the individual's postural presentation.
- Discuss and establish goals/expectations with the client/caregivers.
- Begin to hypothesise causative factors to presentations. Consider both the internal (person-related) and external factors (equipment-related).

Step 2: Mechanical Assessment Tool (MAT)

Take your time gathering information and setting clear goals and expectations to provide the best chance for a successful trial for each individual involved. If possible, it is always best to have a support person to assist in the completion of the MAT.

The most accurate measurements and results will be achieved when the client is positioned on a flat surface such as a plinth or firm mattress.

Please do not position the client on hard surfaces when they have pressure injury concerns. The MAT should only be carried out when clinically appropriate and there are no pressure injury concerns.

Step 2a: Analyse posture of client using current seating system

Key objectives:

- Allow time to observe and make a hypothesis of the possible causes of the client's presentation, using their current seating system.
- Make sure the client is in their 'usual posture'. It is important to view your client's posture in their current seating system at different points in time throughout the day.
- Identify any possible postural destructive tendencies. Can you reduce it? Is it non-reducible?

- Note areas of excessive pressure and/or shear.
- Observe movement patterns in their seating system.
- Is the client operating the wheelchair? How functional are they in their wheelchair?
  - Consider the use of outcome measures – an example is *The Wheelchair Outcome Measure (WhOM)*, Department of Occupational Science & Occupational Therapy, University of British Columbia.
- Identify the positives and negatives of the current seating system with your client. There may be important things that your client likes and needs about their current seating system that need to be considered in the outcome review.

Step 2b: Supine assessment on plinth

Client is assessed on the plinth, ideally in supine. If you are unable to perform the MAT in the community, there are Suppliers that offer consult rooms that are available to clinicians to perform a physical assessment of their client. Plinths and hoists may be available. Please reach out to your local supplier to check the booking process and availability.

Key objectives:

- Check the client's skin integrity immediately after transfer.
- Give the client time to settle into supine position. The client may require adjustments to the bed or the addition of pillows/rolled up towels to get comfortable and/or meet their postural presentation.
- Take this opportunity to assess and measure the client's current seating system, and thoroughly check the overall condition of both the seating and wheelchair.
- Determine optimal range of motion and flexibility away from postural deviations within that range.

Steps:

1. Straighten the body towards neutral. Note the following:
   a. Deviations (pelvis – spine – head) in alignment.
   b. Pain.
   c. Abnormal reflexes.
   d. Muscle tone.
   e. 'Life-box' (If you are unfamiliar with this term, please research Sharon Sutherland, Physiotherapist and 24-hour postural care specialist.).
2. Attempt to correct asymmetries.
   a. Observe the effects of these 'corrections' on other body segments.
   b. Are the deformities reducible or non-reducible?
3. Assess the range of movement of lower limbs:
   a. Pelvis:
      i. Locate ASIS and PSIS.
      ii. Check the pelvic tilt angle.
      iii. Check for pelvic obliquity.
      iv. Check for pelvic rotation.
   b. Hip joint:
      This is done by flexing the hip and assessing when the pelvis starts to tilt out of neutral or the client's optimal alignment.
      i. Check range of motion in flexion or the client's optimal alignment.
      ii. Check range of motion in abduction/adduction.
      iii. Check range of motion in internal/external rotation.
   c. Knee joint:
      Knee ROM is to be assessed from the client's optimal hip flexion ROM.
      i. Check range of motion in flexion.
      ii. Check range of motion in extension.

d. Ankle joint:
    i. Check range of motion in dorsiflexion/plantarflexion.
    ii. Check range of motion in eversion/inversion.

4. Assess range of motion in head and neck:
    a. For the head range of motion assessment, take great care and ask the client to perform active range of motion within tolerances.
    b. Identify level of head control:
        i. Independent/restricted/absent.
    c. Assess resting posture across three planes. Identify asymmetries and whether they can self-correct.
        i. Check cervical curves and identity deviations in resting posture.
        ii. Check range of motion in flexion/extension.
        iii. Check range of motion in lateral flexion.
        iv. Check range of motion in rotation.

5. Assess range of motion in upper limbs:
    a. Shoulder girdle presentation:
        i. Normal/retracted/protracted.
    b. Unilateral shoulder passive range of motion:
        i. Flexion (to 90°).
        ii. Extension.
        iii. Abduction/adduction.
        iv. External/internal rotation.
    c. Unilateral elbow passive range of motion:
        i. Flexion.
        ii. Supination.
        iii. Pronation.
    d. Hand function:
        i. Wrist presentation: neutral/contracted position.

Step 2c: Sitting MAT Assessment

The assessment is performed with the client sitting on a firm surface, such as a plinth or chair, with feet supported on the floor or on a foot block. Consider the client's balance during the assessment. If the client is a 'dependent sitter' or 'propped sitter,' two clinicians may be needed to manually support the pelvis and trunk for the sitting assessment and support simulation tasks. Observe safety and provide necessary support where required.

Key objectives:

- Confirm supine findings. Sometimes available hip range of motion in supine is not tolerated in sitting.
- Assess sitting balance. Understand the impact of gravity on head and trunk.
- Assess flexibility away from the destructive tendencies.
    - Apply equal and opposing forces.
    - Consider the following:
        - Accommodation/correction
        - Skin integrity
        - Postural support
        - Functional ability
- Simulation is crucial to understand how forces act on the body (including the effect of gravity) and determine your client's tolerance for correction.
    - Use your hands and other means (towels, wedges etc) to simulate postures.
- Record tone, posture and functional balance against gravity.

Steps:

1. Assess your client's sitting balance requirements:
    a. Hands-free: a person who can control their sitting balance, even when both arms are lifted.
    b. Hands-dependent: a person who often uses one or both hands to maintain sitting balance when seated.
    c. Propped/dependent sitter: a person with significant loss of sitting balance who is unable to actively support themselves in an upright position. *(Level of Sitting Scale – Fife et al., (1991))*
2. Perform the sitting MAT Assessment and remember to take your time!

Key Body Segment Angles

The below definitions have been captured from the before mentioned resource by *Kelly Waugh (2013)*.

Thigh to Trunk Angle

(Section 2.2, page 46, Fig. 2.3)

Clinical relevance:

The thigh to trunk angle reflects the position of hip flexion, and it can be used to help determine the desired seat to back support angle in the case of a single angle (straight) back support.

Suggested procedure:

1. Locate body landmarks and body segment lines.
    a. Locate the lateral hip centre point, lateral femoral condyle, and lateral lower neck point (or their approximations). The sagittal trunk and thigh lines connect these points:
        - Lateral hip centre point: the most anterior point on the lateral surface of the greater trochanter.
        - Lateral femoral condyle: the point at the most lateral aspect of the lateral femoral condyle.
        - Lateral lower neck point approximated by:
            - The most anterior point on the acromion process if the shoulder complex is well aligned with the trunk, or
            - The centre point of a line between the C7 spinous process and the upper sternal notch.
        - Sagittal thigh line: the line passing through the lateral hip centre point and the lateral femoral condyle.
        - Sagittal trunk line: the line passing through the lateral lower neck point and the lateral hip centre point.
2. Measure the angle (using a goniometer):
    a. Place the goniometer centre over the greater trochanter or approximate lateral hip centre point.
    b. Align the stationary arm along the sagittal trunk line, pointing towards the acromion. Align the moveable arm along the sagittal thigh line, pointing towards the lateral femoral condyle.
    c. Read the value representing the anterior side of the angle, on the front side of the hip.

Typical values:

Values could fall between 60° and 180°, but for a seated individual, they are typically 90° to 120°.
The thigh to trunk angle is 90° in the Seated Reference Position (SRP).

Considerations:

- While the thigh to trunk angle reflects the seated person's angle of gross hip flexion, these two measures are supplementary angles and therefore have a different value. For example, if a person is sitting in a position of 75° of gross hip flexion, the thigh to trunk angle is 105° (Section 2.2, page 47, Fig. 2.4).
- The support surface angle which corresponds to the thigh to trunk angle is the seat to back support angle.

Please refer to page 47 of *listed resource* for further considerations regarding this body segment angle.

Thigh to Lower Leg Angle

(Section 2.3, page 48, fig. 2.5)

Clinical relevance:

The thigh to lower leg angle reflects the position of knee flexion and is used to help determine the desired seat to lower leg support angle. The seat to lower leg support angle can then be used to help in the selection of the wheelchair's lower leg support assembly.

Suggested procedure:

1. Locate landmarks and body segment lines.
    a. Identify the lateral femoral condyle, the lateral hip centre point and the lateral malleolus. The sagittal thigh and lower leg lines connect these points:
        - Lateral femoral condyle: point at most lateral aspect of the lateral femoral condyle.
        - Lateral hip centre point: approximated by the greater trochanter.
        - Lateral malleolus: point at most lateral aspect of lateral malleolus.
        - Sagittal thigh line: the line passing through the lateral hip centre point and the lateral femoral condyle.
        - Sagittal lower leg line: the line passing through the lateral femoral condyle and the lateral malleolus.
2. Measure the angle (using a goniometer):
    a. Place the goniometer centre over the lateral femoral condyle.
    b. Align the stationary arm along the sagittal thigh line, pointing towards the greater trochanter. Align the moveable arm along the sagittal lower leg line, pointing towards the lateral malleolus.
    c. Read the value representing the posterior side of the angle.

Typical values:

Values can fall between 45° and 180° (knee completely straight), but for a seated person they are typically 80° to 120°. The thigh to lower leg angle is 90° in the Seated Reference Position (SRP).

Considerations:

- The thigh to lower leg angle reflects the position of knee flexion, however these two measures are supplementary angles and therefore have different values. For example, if a person is sitting in a position of 70° of knee flexion, the thigh to lower leg angle would be 110°. (See section 2.3, page 49, fig. 2.6 and 2.7).
- The support surface angle which corresponds to the thigh to lower leg angle, is the seat to lower leg support angle.

Please refer to page 49 of ***listed resource*** for further considerations regarding this body segment angle.

Lower Leg to Foot Angle

(Section 2.4, page 50, fig 2.8)

Clinical relevance:

The lower leg to foot angle reflects the position of ankle dorsi/plantarflexion and is used to help determine the desired lower leg support to foot support angle.

Suggested procedure:

1. Locate landmarks and body segment lines:
    a. Identify the lateral femoral condyle and the lateral malleolus. The line passing through these points is the sagittal lower leg line.
    b. Locate the lateral heel point by projecting the sagittal leg line down to the bottom surface of the foot. Locate the lateral toe point. The line connecting the lateral heel point and the lateral toe point is the sagittal foot line.

- Lateral femoral condyle: point at most lateral aspect of the lateral femoral condyle.
- Lateral malleolus: point at most lateral aspect of lateral malleolus.
- Lateral heel point: the intersection of the sagittal lower leg line and the plantar surface (bottom) of the foot.
- Lateral toe point: the lateral distal protuberance of the fifth metatarsal.
- Sagittal lower leg line: the line passing through the lateral femoral condyle and the lateral malleolus.
- Sagittal foot line: the line passing through the lateral heel and toe points.

2. Measure angle (using a goniometer):
   a. Place the goniometer pivot centre over the lateral heel point.
   b. Align the stationary arm along the sagittal lower leg line, pointing up towards the lateral femoral condyle. Align the moveable arm along the sagittal foot line, pointing towards the lateral toe point.
   c. Read the value representing the anterior (front) side of the angle.

Typical values:

Values can fall between 60° and 150°, but for a seated individual they are typically 80 to 110°.
The lower leg to foot angle is 90° in the Seated Reference Position (SRP).

Considerations:

- The lower leg to foot angle reflects the position of ankle dorsiflexion, however these two measures have different values. A position of 0° of dorsiflexion or plantar flexion is equal to a lower leg to foot angle of 90°, as in the Seated Reference Position.
- If a person's ankle is in a position of 10° of ankle dorsiflexion, their lower leg to foot angle would be 80° (section 2.4, page 51, fig. 2.9). A 10-degree plantar flexion contracture would result in a lower leg to foot angle of 100°.

Summary

The *Clinical Education Team* at Medifab are proud of the training programs we provide to therapists across New Zealand and Australia. Our vision is to make a positive difference to people living with disabilities, along with the carers and therapists that support them. We believe that through education, we can make leaps and bounds towards achieving that vision.

If we want to improve the lives of people living with disabilities and medical conditions, we must share our knowledge with other health professionals. We do just that by presenting at conferences, exhibitions, workshops and our very own Medifab Professional Development Academy events around the world.

To find out more about our educational training events, please email our Clinical Education Team:

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