The Neutral Zero Method - A Principle of Measuring Joint Function

Chr. Ryf, M.D.* and A. Weymann**

* Head of Surgery, Spital Davos , 7270 Davos Platz, Switzerland
** Registrar, Spital Davos , 7270 Davos Platz, Switzerland

Abstract

The material presented in this article was considered well-suited to production as an electronic publication utilizing the advantages of information technology, including animation, colour photography, and opportunities for the user to participate in an interactive learning process as well as having an excellent reference at his fingertips. The text is based on an AO Bulletin published in 1971 by H.U. Debrunner. The principal tests of joint mobility are illustrated and explained in detail. The illustrations presented here are only the most essential, more than 200 further figures, video clips, photos and animations are available on the CD-ROM (text in English, German and French) which can be ordered using the form at the end of the supplement. The outcome is a novel multimedia publication containing material of special interest to the traumatologist and associated disciplines. Though it certainly cannot replace the classical textbooks, it nevertheless provides a valuable supplement and aid to understanding.

1. Introduction

The principles of the neutral zero method were first published under that name by Cave and Roberts in 1936 (1-4). After undergoing various methodological revisions and adaptations (Müller, 1970 (5), zero transit method), the neutral zero method achieved international recognition among the appropriate specialist societies, most notably with reference to the introduction of electronic data processing for medical documentation.

As a method for measurement and documentation it fulfils the requirements of simplicity, precision and reproducibility. Much credit is due to H.U. Debrunner (6, 7), who published the "Neutral Zero Method" - now the recognised standard for testing joint mobility - together with other important measuring methods for the locomotor system, and issued it in the form of a small booklet (AO Bulletin, 1971). Today, it still provides a concise standard guide for all medical specialists dealing with the human locomotor system (8). This article is a revised and up-dated version of the original communication.

2. Principles of measurement

2.1 The neutral zero method

The principle of joint measurement by the neutral zero method is to measure the movement of a joint from a defined neutral 0-position. The measured angle gives the magnitude of movement. When carrying out the investigation, it is important to distinguish the end position of the movement from the direction of the movement. For example, movement from a flexed position of 10° to one of 50° represents a flexion movement, whereas restoration to the original position represents an extension movement, even though the neutral 0-position has not been reached.

The 0-position of a joint is defined in terms of the normal anatomical position: upright stance, arms hanging, thumbs directed forwards, the functional longitudinal axes of the feet parallel and separated by a space equal to the distance between the hips, and the

gaze directed forwards and horizontally. This normal anatomical position (0-position) should be reproduced as closely as possible for all the investigations.

The normal values are equivalent to the average range of joint movement in healthy adults. However, comparison of each pair of joints is essential when defining any abnormal finding. Measurements from unpaired joints (or in amputees) have to be compared with the normal values from subjects of the same age and physique. It is usual to measure both the active and passive movement ranges of the joint. The figures given below are the active values. Passive values are larger.

In the examination protocol, every joint movement and its counter movement is defined by three numbers: the two ends of the range of movement and the 0-position (= neutral position). If the 0-position is passed, the zero is always located between the two measured end position values.

Readings: Joint, left or right side, direction of movement, numerical values, active, passive:

Example:
Hip joint, right, flexion/extension:
active: 120°/0°/10°, passive: 130°/0°/15°.

If the neutral position is not attained (e.g. in patients with contractures or pain at the end of the range of movement), the numeral 0 is inserted either in front of or behind the two measured readings.

Restriction of joint movement can be unambiguously documented in this way.

Example:
Hip joint, right, flexion/extension:
active: 120°/30°/0°, passive: 125°/30°/0°
Comment: this represents a 30° flexion contracture in the hip joint.

2.2 Length and girth measurement

Like measurements of joint movement, length and girth measurements are also performed in the normal anatomical position and should always be compared with measurements on the opposite side if at all possible. Measurements of length are made between well defined, easily palpable reference points, usually bony. The reference points must be precisely ascertainable and must also be reproducibly located by a different observer. Measurements of girth are performed at unambiguously defined points, usually at whole number intervals from clearly identified reference points (e.g. circumference of thigh 20 cm above the patella). It is customary to record measurements of the maximum and minimum girth of each part of the body.

2.3 Measuring instruments

Measuring rule: employed for measuring overall body length or height. Usually constructed of stable material and mounted in a fixed position.

Measuring tape: for girth and length measurements of the trunk and limbs.

Sliding calliper gauge: a graduated scale with two jaws, one fixed and the other movable, for measuring distances between points situated opposite one another (e.g. for measuring the distance between the lateral and medial malleoli).

Calliper gauge: callipers with straight or curved arms and a millimetre scale (e.g. pelvic callipers).

Elevation boards: for measuring leg length differences by raising one leg (put boards under the shorter leg until the pelvis is horizontal). Boards 5, 10, 20 and 40 mm in thickness are generally used.

Angle gauge (goniometer): scale with graduations between 1° and 5°. Arms 10 to 30 cm in length. Smaller versions are available for small joints (e.g. finger goniometer).

Clinometer: instrument for measuring the deviation of any part of the body from the vertical or horizontal, usually constructed on the basis of a plumb line or a spirit level.

3. Joint measurements

3.1 Spinal column (columna vertebralis)

0-position:
Upright anatomical stance, pelvis horizontal across the frontal plane (any leg length differences corrected by inserting boards), sloping downwards and forwards at approximately 12° in the sagittal plane. Lordosis of the lumbar spine and the cervical spine, kyphosis of the thoracic spine.

Reference points:
Spinous processes, sternum, costal arches, iliac crest, posterior and anterior superior iliac spines and sacrum.

3.1.1 Lumbar and thoracic spine

Finger to floor distance (flexion of spinal column as a whole):

Measurement of the space between the tips of the fingers and the floor with the entire spinal column in maximal flexion. Note the participation of the hip

joints in the flexion. This measurement can also be performed sitting or standing.

Schober's sign:
Lumbar spine: first skin mark over spinous process S1, second skin mark in 0-position 10 cm cranially. Measure the increase in the distance between the two skin marks at maximal flexion (normal: approximately 5 cm).

Thoracic spine: first skin mark over spinous process C7, second skin mark 30 cm caudally from first. Measure the increase in the distance between the skin marks at maximal flexion (normal: approximately 8 cm).

Protocol:
Schober lumbar spine 10 cm/15 cm
Schober thoracic spine 30 cm/38 cm
Analogous measurements during extension:

Protocol:
Schober lumbar spine 10 cm/7 cm
Schober thoracic spine 30 cm/26 cm

Measurement of curvature of the thoracic and the lumbar spine:
Normal: individual.
Measure the angle of curvature of the thoracic spine between the spinous processes Th 2-3 and Th 12-L1 with the subject standing upright in the 0-position and then at maximal flexion and maximal extension. Analogous measurement of lordosis of the lumbar spine.

Extension of the thoracic spine:
Normal: individual differences usually about 30°. Measurement in degrees of angle. With the subject standing and leaning forwards, measurement of the thoracic spine (during which the lumbar spine should be flexed) or lying prone on a hard surface.

Lateral flexion of the spinal column:
Normal: individual differences usually about 30°-40°.

Measurement in degrees of angle with the subject standing.

Rotation of the spinal column:
Normal: individual differences usually about 30°.

Measure the rotation of the shoulder girdle in degrees of angle with reference to the fixed pelvic girdle. Position sitting or standing.

3.1.2 Cervical spine

Flexion/ extension:
Normal: 35°-45°/0°/35°-45°
Inclination/ reclination, bending forwards/bending backwards. Measurement in degrees of angle or as the distance between the sternum and the point of the chin.

Lateral flexion to left or to right:
Normal: 45°/0°/45°
Bending sideways.
Measurement in degrees of angle or as the interval between the ear lobe and shoulder (caution: possible error due to elevation of the shoulder girdle).

Positive/ negative rotation:
Normal: 60°-80°/0°/60°-80°
Measurement in degrees of angle.

3.2 Shoulder and shoulder girdle joints

The combination of movements in the shoulder girdle and in the shoulder joint together allow the arm a total range of movement in relation to the thorax amounting to more than a hemisphere. It is important to distinguish between movements in the shoulder girdle and movements in the shoulder joint because serious restriction of shoulder joint function can be compensated by shoulder girdle movements. When testing the range of movement in the scapulo-humeral joint, it is important to fix the scapula so that misleading results are avoided. Simultaneous testing of both sides together prevents errors in the measurements due to movements of the trunk.

3.2.1 Shoulder joint (articulatio humeri)

0-position:
Standing, arm hanging laterally beside the trunk, thumbs directed forward.

Reference points:
Skeletal axis of the upper arm, forearm used as a pointer when measuring rotation, acromion; superior and inferior angles of scapula, spine of scapula, clavicle.

Elevation:
Movements in any direction from caudal to cranial are termed elevations. Standard measurements are confined to measurements of vertical movements in the principal planes of the body (flexion/extension and abduction/adduction).

Flexion/extension (Fig. 1):
Normal: 65°/0°/35°
Synonym: Anteversion/retroversion.
Elevation of the arm from the neutral 0-position in the sagittal plane around the frontotransverse axis forwards or backwards. Any elevation beyond 65° forwards or 35° backwards requires rotation of the scapula. To prevent any synchronous participation of the scapula at the beginning of abduction, the scapula should be fixed manually.

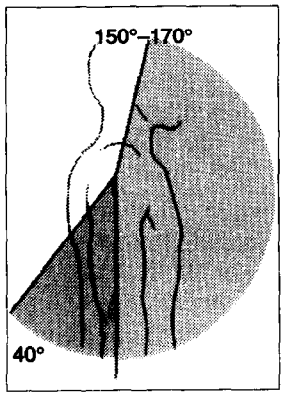

Fig. 1

Abduction/adduction (Fig. 2):
Normal: 90°/0°/10°
Movement of the arm in the frontal plane around the sagittotransverse axis. Abduction beyond 90° requires external rotation in the shoulder joint, while abduction beyond 120° requires rotation of the scapula as well.

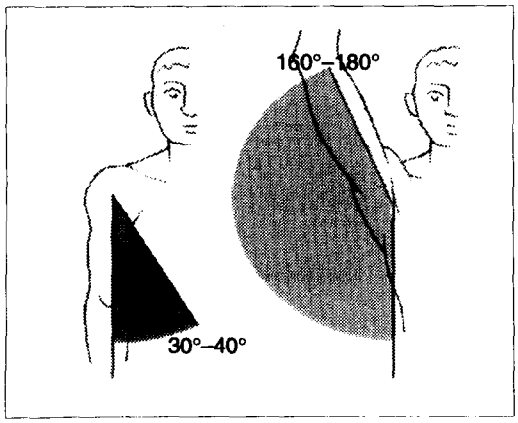

Fig. 2

Horizontal flexion/horizontal extension (Fig. 3):
Normal: 130°/0°/40°-50°
Starting position: 90° abduction. The movement is carried out in the transverse plane around the frontosagittal axis.

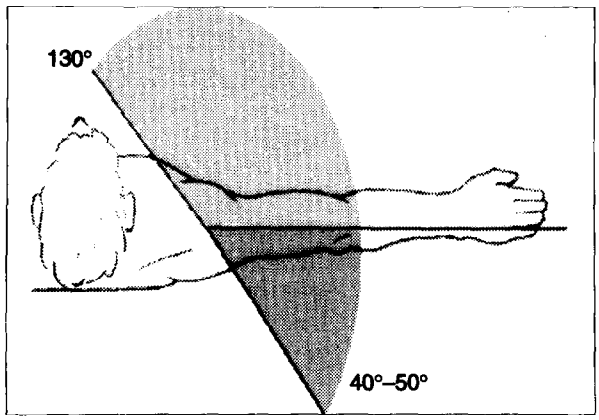

Fig. 3

External rotation/internal rotation (Fig. 4):
Normal: 40°-60°/0°/95°
Arm hanging down, elbow flexed at 90° with the forearm directed forwards. Movement in the transverse plane around the frontosagittal axis. Measurement of maximal external rotation in the shoulder joint and of maximal internal rotation, i.e. as far behind the back as the hand can be held.

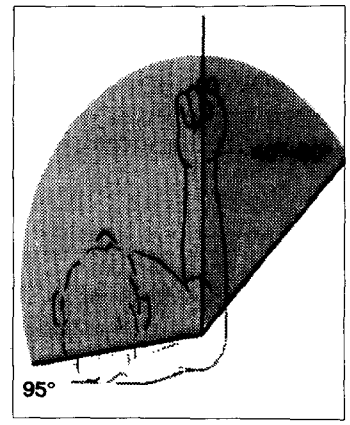

Fig. 4

External rotation/internal rotation at 90° abduction (Fig. 5):
Normal: 70°/0°/70°
Starting position: 90° abduction. Elbow flexed at 90° and forearm directed forwards. Movement in the sagittal plane around the frontotransverse axis.

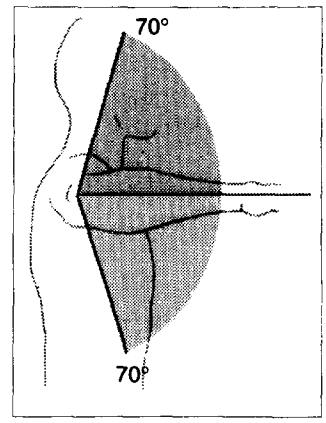

Fig. 5

3.2.2 Shoulder girdle joints (articulatio sternoclavicularis and articulatio acromioclavicularis)

The movements of the shoulder girdle can as a rule only be estimated, or at best compared with those of the opposite side. During these movements the scapula rotates around the thoracic wall, thus bringing the glenoid cavity into various different starting positions in relation to the trunk.

0-position:
Usual neutral position.

Reference points:
Acromion, superior and inferior angles of scapula, spine of scapula, clavicle, sternum and thorax.

Flexion/extension:
Normal: individual norm, opposite side healthy.
Synonyms: Forwards movement/backwards movement, protraction/retraction.

Elevation/depression:
Normal: individual norm, opposite side healthy.
Synonyms: Raising/lowering.

Rotation of the scapula on the thorax:
Normal: individual norm, opposite side healthy.

3.2.3 Combined movements:

The global movements of the shoulder joint and shoulder girdle joints provide certain clinically important functions.

Apron string grip (Fig. 6):
Place the hand on the back and raise it from the buttocks as far as possible towards the scapula. Measure the distance between the tip of the thumb and the vertebra prominens or record the landmarks reached by the thumb.
Normal: gluteal, lumbosacral, L3, Th12, Th6.

Nape of neck grip (Fig. 6):
Place the hand on the nape of the neck and lower it on to the back.
Normal: Hands as far as the ears, hands behind the head, hands behind the head and arms at maximal abduction, hands on the head, hands behind the head and arms at maximal abduction, bring the hands from the head into the elevated position. Touch the opposite shoulder with the hand. Touch the opposite ear with the hand passed above the head.

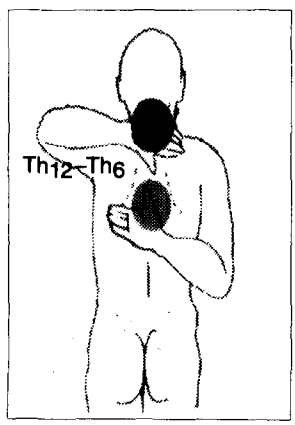

Fig. 6

3.3 Elbow joint (articulatio cubiti)

0-position:
With the upper limb hanging down, the axes of the upper arm and forearm are in the sagittal plane and the thumbs are directed forward.

Reference points:
Skeletal axes of the ulna and the humerus, lateral and medial humeral epicondyles, and olecranon.

Flexion/extension:
Normal: 150°/0°/0°-10°
Extension beyond the neutral zero position is dependent on age, sex and ethnic origin (children, women, and people of Asiatic origin have, on average, larger values).

3.4 Forearm joints (articulationes radio-ulnares proximalis et distalis)

0-position:
Upright stance, elbows close to the trunk and flexed at 90°. Forearm horizontal and directed forwards, wrist in the zero position, thumbs pointing upwards.

Reference points:
Axis of upper arm, axis through the styloid processes of radius and ulna (distal pointer).

Pronation/supination:
Normal: 80°-90°/0°/80°-90°
Movement: Rotation of the forearm around its longitudinal axis, the palm of the hand being turned to face downwards (pronation) and upwards (supination).

3.5 Wrist joint (articulationes radio-carpalis et ulno-carpalis)

0-position:
Metacarpals I-IV and the axis of the forearm are located in the sagittal plane, straight line between forearm axis and the longitudinal axis of the third metacarpal bone. The forearm is in the zero position between pronation/supination.

Reference points:
Forearm axis, metacarpal III.

Flexion/extension:
Normal: 50°-60°/0°/35°-60°
Synonyms: palmar flexion/dorsal extension, bending/straightening.
The finger joints should be freely moveable (passive insufficiency under conditions of wrist extension with extended finger joints, or with wrist flexion with flexed finger joints).

Radial abduction/ulnar abduction:
Normal: 20°-30°/0°/30°-40°

Synonyms: radial deviation/ulnar deviation.
Measurement is performed with the forearm in pronation. Greater ulnar abduction is possible in supination.

3.6 Joints of the hand and fingers

0-position:
The longitudinal axes of metacarpals I-IV and of the phalanges are parallel, there is a straight line between the forearm axis and the longitudinal axis of the middle finger; the thumb is placed against the index finger.

Reference points:
Metacarpals, phalanges, finger joints, finger tips, palmar furrows, thenar and hypothenar eminences.

Anatomical nomenclature of the digits:
Consecutive numbering from thumb (I) to little finger (V).

Anatomical nomenclature of the finger joints:
CM = Carpometacarpal joint (in particular the saddle joint of the thumb: CM I)
MP = Metacarpophalangeal joint
PIP = Proximal interphalangeal joint
DIP = Distal interphalangeal joint

3.6.1 Thumb joints (articulationes pollicis)

The main movements take place in the CM joint and are combined with movements in the MP and IP joint. The ordinary movements of the thumb are complex and consist of flexion/extension, abduction/adduction, rotation and circumduction.

Combined measurements of function (e.g. distance from fingertips to hollow of palm) are of greater usefulness in everyday clinical practice than isolated joint measurements.

Radial abduction/radial adduction of the thumb:
Measurement of the abduction angle between the axes of metacarpals I and II. Testing at the level of the palm (with the hand laid flat). Adduction as far as the neutral position, further adduction along the inner surface of the hand = transpalmar adduction.
Normal: 70°/0°/0°

Palmar abduction/palmar adduction (antepulsion/retropulsion) of the thumb: Movement at right angles to the plane of the palm and towards the palm. Adduction as far as the neutral position.
Normal: 70°/0°/0°

Circumduction of the thumb:
Movement of metacarpal I at the CM joint, starting from maximal radial abduction, towards the ulnar margin of the hand, maintaining the widest possible angle between metacarpals I and II. 0-position: maximal radial abduction.
Normal: 0°/0°/120°

Rotation of the thumb:
Measurement of the angle between thumb nail and palmar plane. 0-position: position of rotation at maximal radial abduction. End-position: position of rotation at maximal opposition.

Extension/flexion of the thumb at the MP joint:
0-position: MC I, proximal phalanx and distal phalanx in a straight line.
Normal: 0°-10°/0°/50°

Extension/flexion of the thumb at the IP joint:
0-position: MC I, proximal phalanx and distal phalanx in a straight line.
Normal: 0°-20°/0°/80°

Extension/flexion-adduction of the thumb:
Maximal transpalmar adduction with bending of all thumb joints and apposition of the thumb to the palm.

Opposition of the thumb with the thumb joints extended:
End position of the thumb after maximal circumduction and internal rotation of the first metacarpophalangeal unit with maximal extension of all thumb joints. Measurement of the distance between the flexure crease of the distal thumb joint and the intersection point between the distal palmar flexion crease and metacarpal III, metacarpal I being held as far as possible at right angles to the palm.

Opposition of the thumb with the thumb joints flexed.

This comes closer to actual practice and is more useful for assessing opposition. Measurement of the distance between the ball of the thumb and the base of the little finger. In complete opposition these two are touching.

Retroposition of the thumb:
The thumb is placed in a position opposite to that which it occupies in opposition. With the palm lying flat and the thumb elevated backwards, measure the distance between the ball of the thumb and the underlying surface.

Retroposition may be impossible even in normal people.

3.6.2 Finger joints (articulationes digitorum)

Flexion/extension of the MP joints:
Normal: 90°/0°/0°-30°

Flexion/extension of the PIP joints:
Normal: 100°/0°/0°

Flexion/extension of the DIP joints:
Normal: 90°/0°/0

Fingertips - hollow palm distance:
Functionally important combined movement of all finger joints. Measurement fingertip - distal palmar crease: flexion PIP and DIP. Measurement fingertip - proximal palmar crease: flexion MP, PIP and DIP.

Abduction/adduction of fingers II-V:
Spread out the fingers and then bring them together. Movement in the MP joints away from and towards the third metacarpophalangeal unit. Measurement of the distance between the corresponding fingertips (from the axis of the middle finger or the distance between the index fingertip and little fingertip).

3.7 Hip joint (articulatio coxae)

0-position:
Pelvis inclined forwards at 12°, longitudinal axis of thigh in frontal plane, and patella directed forwards.

Reference points:
Iliac crest, anterior iliac spine, posterior superior iliac spine, greater trochanter, femoral condyles and longitudinal axis of femur. Any contractures affecting the knee joint must be taken into account when testing the movements of the hip.

Flexion/extension (Fig. 7):
Normal: 130°/0°/10°
Measurement of flexion with the knee bent (to relax the hamstring muscles). Measurement of extension with the knee straight (to relax the quadriceps femoris muscle). Testing of flexion with the patient lying on the back: contralateral hip joint in the zero position. Flex the hip joint to be tested until the pelvis begins to rotate (= maximal flexion of the hip joint). Testing of flexion in the lateral position (lying on the contralateral side): contralateral hip joint in the zero position. Fixation of the pelvis (tilted 12° forwards) by the examiner. Guided flexion of the hip joint under test until the pelvis begins to rotate. Testing extension with the patient lying on the back: secure the thigh under examination to the mattress. Flex the contralateral hip joint until the pelvis is at maximal elevation. The angle of elevation of the pelvis gives a measure of the extension of the hip joint under examination. Testing extension in the lateral position (lying on the contralateral side): secure the contralateral hip joint in maximal flexion. The leg being examined is then extended under the examiner's guidance until the pelvis begins to move as well.

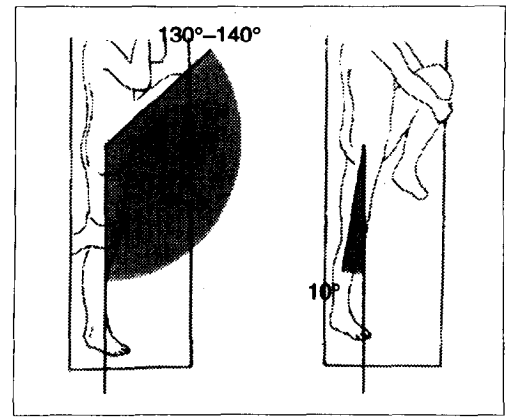

Fig. 7

Abduction/adduction (Fig. 8):
Normal: 30°-50°/0°/20°-30°
When measuring adduction, the contralateral hip joint must be slightly flexed.

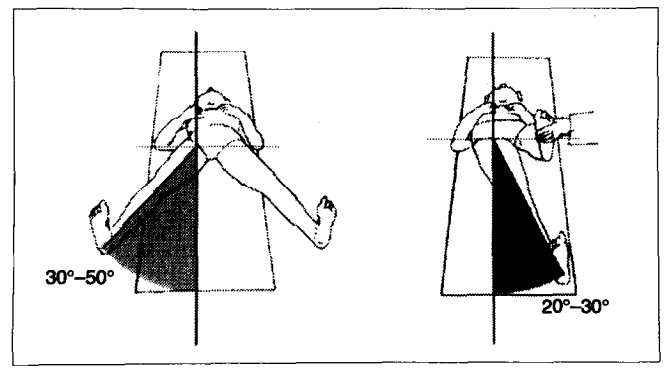

Fig. 8

Abduction/adduction at 90° flexion (Fig. 9):
Normal: 50-80°/0°/20°
In infants, abduction is possible only in the flexed position. When the movements of the hip are seriously restricted, measurement of abduction is usually feasible in the mid-flexed position only (make a note on the measurement protocol!).

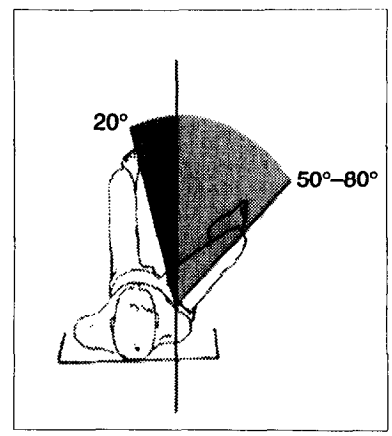

Fig. 9

External rotation/internal rotation (Fig. 10):
Normal: 40°-50°/0°/30°-40°
Measurement with the patient lying face down and the knee flexed at 90°; the lower leg is used as a pointer.

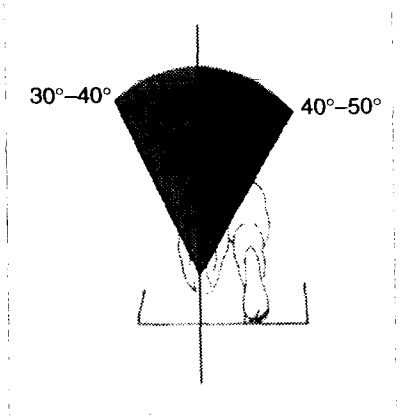

Fig. 10

External rotation/internal rotation at 90° flexion (Fig. 11):

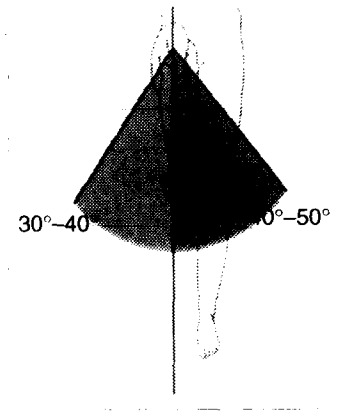

Fig. 11

Normal: 40°-50°/0°/30°-40°
Measurement with the patient lying on the back; hip and knee both flexed at 90°. Caution: During external rotation, the axis of the lower leg points inwards! If hip joint movements are severely restricted, measurement of rotation is often possible only in a position of mid-flexion (make a note on the protocol).

3.8 Knee joint (articulatio genus)

0-position:
The axes of the thigh and lower leg are located in the frontal plane, forming an angle of approximately 170° towards the lateral (physiological valgus) position.

Reference points:
Axes of thigh and lower leg, medial and lateral femoral condyles: medial and lateral joint clefts, tibial tuberosity, head of fibula, upper and lower poles of the patella.

Flexion/extension:
Normal: 120°-150°/0°/5°-10°
Even the slightest contractures of the thigh muscles must be taken into account. Complete relaxation of muscles spanning two joints: flexion of the knee joint when the hip joint is bent, and extension when it is straightened.

External rotation/internal rotation at 90° flexion:
Normal: 40°/0°/10°-30°
With the limb in the 0-position, no rotation movements are possible.

Abduction/adduction:
No active movement is possible.

3.9 Ankle joint (articulatio talocruralis)

0-position:
The longitudinal axis of the foot is at right angles to the longitudinal axis of the leg (as when standing upright).

Reference points:
Medial and lateral malleoli, anterior border of tibia, axis of calcaneus, lateral border of foot, metatarsal V, head of talus, navicular bone.

The ankle joint is a hinge joint. In a position of plantar flexion minor lateral shifts and rotational movements are possible, but barely measurable. In the position of dorsal extension the talus is firmly fixed within the malleolar fork. Function is measured with the knee slightly flexed to ensure complete relaxation of the Achilles tendon.

Flexion/extension:
Normal: 40°-50°/0°/20°-30°
Measurement with the foot hanging freely: the posterior part of the foot has a smaller range of movement than the forefoot, the reason being that slight flexion and extension movements are possible in the transverse tarsal joint and the tarsometatarsal joints. Movement in the ankle joint alone can be measured exactly along the axis of the calcaneus (measurement on the radiograph). For clinically exact measurement of plantar flexion/dorsal extension, place the foot flat on the floor. The lower leg is inclined to its maximal extent backwards or forwards. Measure the angular movement along the axis of the lower leg, while the sole of the foot remains flat on the floor.

3.10 Tarsal joints

0-position:
The longitudinal axis of the foot is at right angles to

the longitudinal axis of the leg (as when standing upright).

These are predominantly complex, combined movements in the subtalar, talocalcaneonavicular, midtarsal and tarsometatarsal joints. However, to distinguish movements in the midfoot from those in the forefoot, movements in each of the above named joints must be measured separately. Nomenclature of the movements of the foot is not consistent or uniform.

3.10.1 Subtalar joint and talocalcaneonavicular joint

Eversion /inversion:
Normal: 30°/0°/60°
Movement axis: oblique, from anterior-medial-superior to posterior-lateral-inferior. The operator fixes the lower leg with one hand and rotates the entire foot around the oblique axis of the subtalar and talocalcaneonavicular joints. Relevance of this measurement: generally only in comparison with the opposite side. For ordinary purposes, an estimate of any restriction of movement expressed in steps of one-quarter is of sufficient accuracy. Precise measurement is possible only with special instruments. Alternative method of measurement: distance from the tuberosity of metatarsal V to the tip of the lateral malleolus in the neutral position, in maximal eversion and in maximal inversion.

3.10.2 Forefoot joints

Pronation /supination:
Normal: 15°/0°/35°
Twisting of the forefoot on the hindfoot (the forefoot remains unaltered in its position relative to the hindfoot during eversion/inversion). Rotation axis: longitudinally through the calcaneus and the third toe. Twisting is performed with the foot set at a right angle, and the heel fixed with one hand while the forefoot is put through pronation/supination with the other hand. Relevance: compare with the contralateral side. Any restriction of movement can be expressed in fractions. Caution: in Anglo-American usage pronation/supination = eversion/inversion.

3.11 Toe joints

0-position:
The longitudinal axes of metatarsals I-V and the phalanges run parallel.

Reference points: Metatarsals, phalanges.

Anatomical nomenclature of the toes: consecutive numbering from the big toe (I) to the little toe (V).

Anatomical nomenclature of the toe joints:
MTP = metatarsophalangeal joint
PIP = proximal interphalangeal joint
DIP = distal interphalangeal joint

3.11.1 Joints of the big toe

Flexion/extension of the MTP joint
Normal: 45°/0°/70°

Flexion/extension of the IP joint:
Normal: 80°/0°/0°

3.11.2 Joints of toes II-V

Flexion/extension of the MTP joints:
Normal: 40°/0°/60°-80°

Flexion/extension of the PIP joints:
Normal: 35°/0°/0°

Flexion/extension of the DIP joints
Normal: 60°/0°/30°

4. Measurements of length

Vertebral column, trunk

Sitting height:
In adults and children over 10 years of age approximately 50% of total height.

Depth of thorax:
Sagittotransverse diameter measured from the inferior end of the sternum to the spinous process of the vertebra at the same horizontal level. Measured with pelvic callipers in maximal inspiration and maximal expiration.

Shoulder girdle

Shoulder breadth:
Distance between the tips of the acromion processes.

Upper limb

Overall limb length:
Measured with the subject standing and the arm hanging down. Distance between the tip of the acromion and the styloid process of the radius.

Upper arm length:
Distance between the tip of the acromion and the lateral epicondyle of the humerus.

Forearm length:
Distance between the lateral epicondyle of the humerus and the styloid process of the radius in maximal supination.

Length of ulna:
Distance between the tip of the olecranon and the styloid process of the ulna.

Hand length:
Distance between the line connecting the styloid processes of the radius and ulna and the tip of the longest finger.

Finger length:
Distance between the metacarpophalangeal joint and the fingertip. Measured on the dorsal surface with the metacarpophalangeal joint flexed.

Pelvis

Iliac crest breadth:
Greatest fronto-transverse distance between the iliac crests.

Trochanter breadth:
Distance between the greater trochanters.

Lower limb

Limb length:
Distance between the anterior superior iliac spine and the tip of the lateral malleolus. If the anterior superior iliac spine is absent, use the iliac crest as an anatomical reference point.

"Apparent" limb length:
Distance between umbilicus and the tip of the medial malleolus.

Thigh length:
Distance between the tip of the greater trochanter and the lateral knee joint cleft.

Alternative:
Distance between the anterior superior iliac spine and the lateral knee joint cleft.

Lower leg length:
Distance between the lateral knee joint cleft and the tip of the lateral malleolus.

Foot length:
Distance between the most posterior contour of the foot with the subject standing, and the tip of the longest toe.

5. Girth measurements

Head

Head circumference:
Measured horizontally.

Neck circumference:
Measured horizontally. Anteriorly at the level of the thyroid cartilage, posteriorly at the level of maximum lordosis.

Thorax

Chest circumference:
Measured at the lower border of the axilla with the arms hanging down. In women just above the mammary gland, in men just above the nipples. Measured in mid-respiration, at maximum inspiration and maximum expiration (= chest expansion).

Upper limb

Upper arm girth:
In slight abduction. Measured at the level of the insertion of the deltoid muscle with the elbow flexed at approximately 45°.

Biceps girth:
Measured 15 cm above the lateral epicondyle of the humerus with the elbow in the zero position. Equivalent to the maximum girth of the upper arm.

Epicondylar girth:
Measured directly above the two epicondyles with the elbow in the zero position.

Elbow girth:
Measured at the level of the olecranon with the elbow in the zero position.

Forearm girth:
10 cm and 20 cm distal to the lateral epicondyle of the humerus. Alternative: measure the maximum girth of the forearm and its minimum girth (directly above the wrist).

Wrist girth:
Directly above the styloid processes of the radius and ulna.

Midhand girth:
Measured above the heads of metacarpals II-V.

Finger girth:
Measured at the middle of the proximal, middle and terminal phalanx.

Finger joint girth:
Measured at the proximal and distal interphalangeal joints.

Lower limb

Thigh circumference:
Adults: 15 cm, 20 cm or 25 cm above the medial knee joint cleft. In children and in patients with severe

quadriceps atrophy: 6 cm and 10 cm cranial to the medial knee joint cleft. Alternative reference point: just above the patella (basis patellae).

Lower leg girth:
15 cm, 20 cm below the medial knee joint cleft. Alternative: measure the maximum and minimal girth (usually calf and ankle). Alternative reference point: lower border of the patella (apex patellae).

Foot circumference:
Heel: measured over heel and instep. Instep: transverse measurement over the navicular bone. Ball of toe: transverse measurement over the ball of the big toe.

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