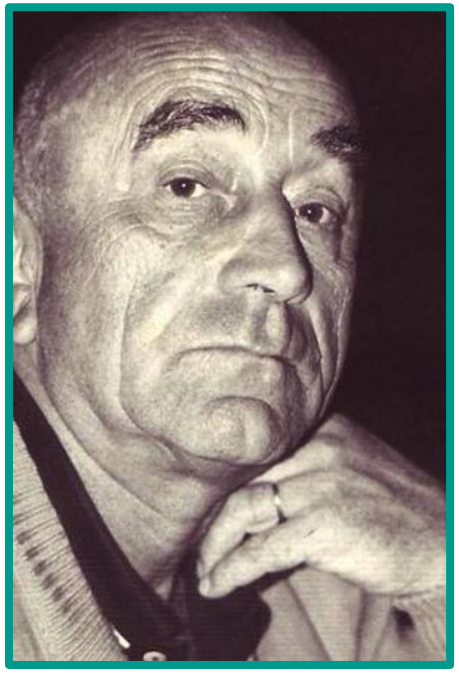
Dynamic Neuromuscular Stabilization (DNS) perspective on the development assessment and rehabilitative approach towards stability

PRAGUE SCHOOL OF REHABILITATION



PROF. VOJTA



PROF. LEWIT



PROF. JANDA



PROF. KOLÁŘ

- Kolar’s approach to dynamic neuromuscular stabilization (DNS) is a complex approach
  - Encompasses principles of **developmental kinesiology** during the first year of life
  - Define posture, breathing pattern and functional joint centration from a neurodevelopmental perspective
  - Derives ideal quality of these functional stereotypes from central (neurological) programs maturing during early postural ontogenesis



3 levels of motor control

1. Spinal & brain stem level
2. Subcortical level

Inborn Motor Functions

3. Cortical level

Learned Motor Functions

DEVELOPMENTAL ASSESSMENT

Utilize observation of three reactions/movements:

1. Neonatal reflexes
2. Postural reactions
3. Spontaneous movement







Neonatal reflexes - newborn stage

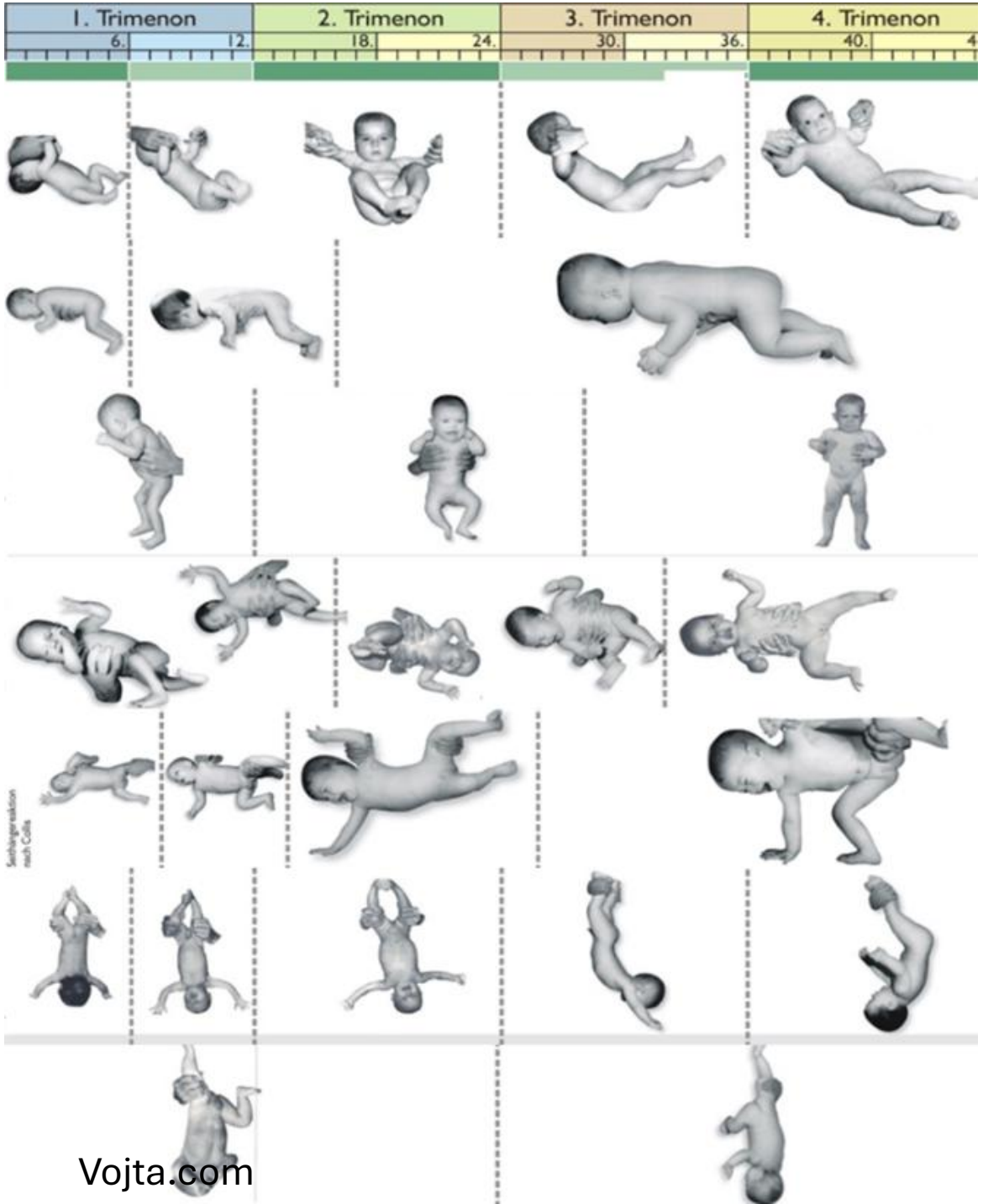
REFLEX	TIME FRAME/ PHYSIOLOGY	PATHOLOGY
SUCKING	UP TO 3M	AFTER 6M
SEARCHING	UP TO 3M	AFTER 6M
ROOTING	UP TO 3M	
BABKIN	0-4W	AFTER 6W
DOLL´S EYE PHENOMENON	0-4W	AFTER 6W
STEPPING AUTOMATISM	0-4W	AFTER 3M
GALANT	0-4M	AFTER 6M

Neonatal reflexes - newborn stage

REFLEX	TIME FRAME/ PHYSIOLOGY	PATHOLOGY
MORO REACTION	0-6W	AFTER 3M
HEEL REFLEX	0-4W	AFTER 3M
SUPRAPUBIC REFLEX	0-4W	AFTER 3M
CROSSED EXTENSION REFLEX	0-6W	AFTER 3M
PALMAR REFLEX	0-3M	AFTER 6M
PLANTAR REFLEX	0-8/9M	
ACOUSTIC FACIAL	FROM 10TH DAY	IF NEGATIVE AFTER 4M
PRIMITIVE SUPPORT OF THE LOWER EXTREMITIES	0-4W	AFTER 3M
VISUAL-FACIAL REFLEX ACOUSTIC-FACIAL REFLEX	FROM 3M FROM 10 DAY	IF NEGATIVE IF NEGATIVE

Postural reaction

1. Traction test
2. Landau reaction
3. Axillary suspension
4. Vojta´s side tilt reaction
5. Collis horizontal suspension
6. Peiper Isbert vertical suspension
7. Collis vertical suspension



Vojta.com

Postural Reactions

- Provoked reflex-postures/movements as a result of specific passive changes in body position
- Responses are continually modified depending on the acquired developmental stage, they proceed in various phases
- Involve complex responses rather than a simple reflex, thus named postural reactions

Postural Reactions *(cont.)*

- Provides a "window" to child's developmental status during a pediatric neurological exam

- This response does not result from motor learning, but will be the same in all children of the same age with a normal CNS.

- This response depends on postural function resulting from muscular co-contraction, corresponding to the stage of maturity reached by the CNS

Traction test

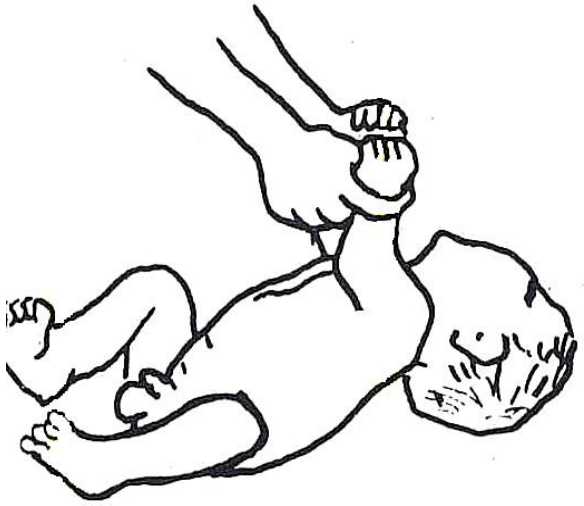
- Performance: Baby is supine; fixing the wrists, clinician pulls the baby toward sitting position, but only as far as 45 degrees



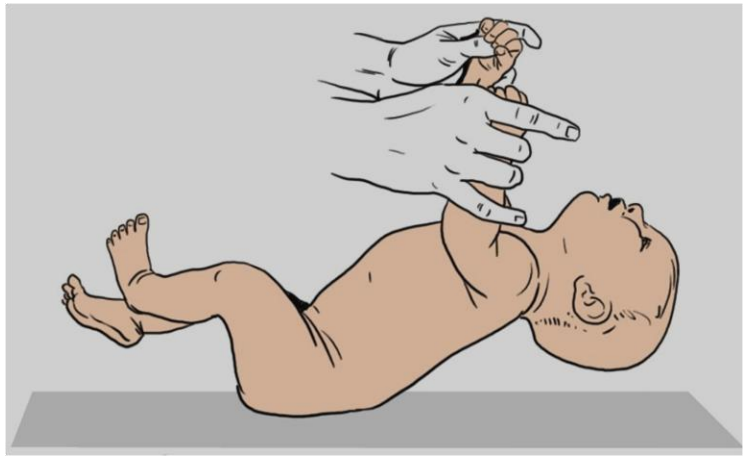


Traction test: 1st phase
1st – 6th week

- Head hanging back, no activity of deep neck flexors
- Semiflexion at the legs
- At the end of this phase, flexion synergy starts which is fully completed by end of 2nd trimester.



No deep neck flexors (DNF) activity



4 weeks – first signs of DNF activation





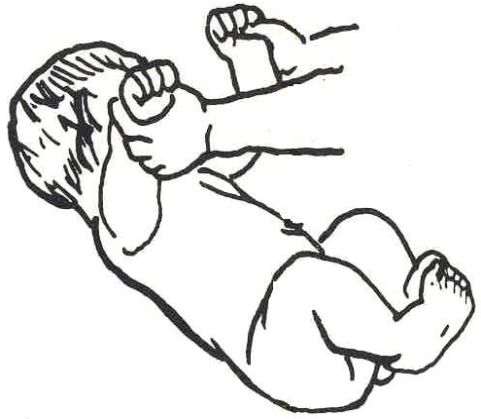
Traction test: 2nd phase
7th week – 6th month

3 MONTHS

- Early flexion synergy:

✓ Neck and trunk flexion: Head is in one line with trunk

✓ Leg flexion: 90° at hips and knees, neutral position in ankles





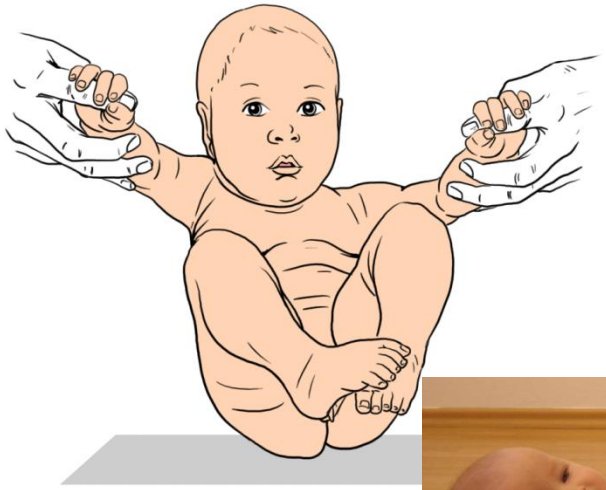
6 MONTHS

- Full flexion synergy:

✓ Chin touching the the chest

✓ Maximum leg flexion: thighs touching the belly

✓ Starts to pull the body toward the clinician (elbow flexion)

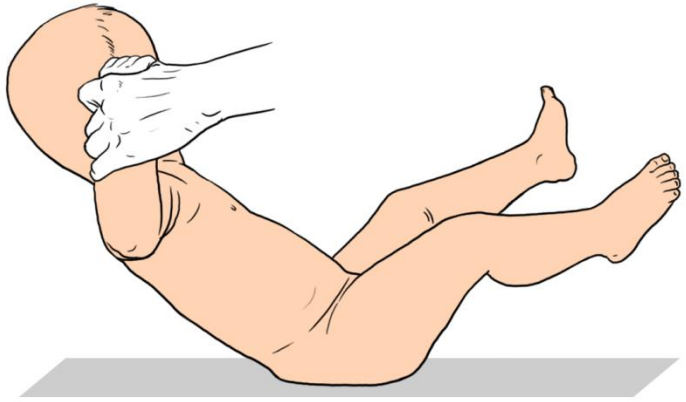




Traction test: 3rd phase
7th month – 9th month

- Increasing pulling up (elbow flexion) by baby
- Flexion synergy of trunk and legs decreases
- Gluteal support
- Deceased knee flexion = sign of verticalization

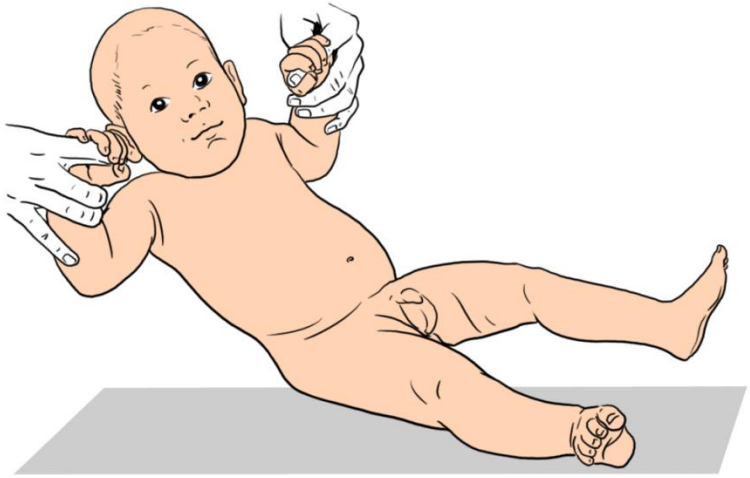
7 months – legs are
high above floor





Traction test: 4th phase
10th month – 14th month

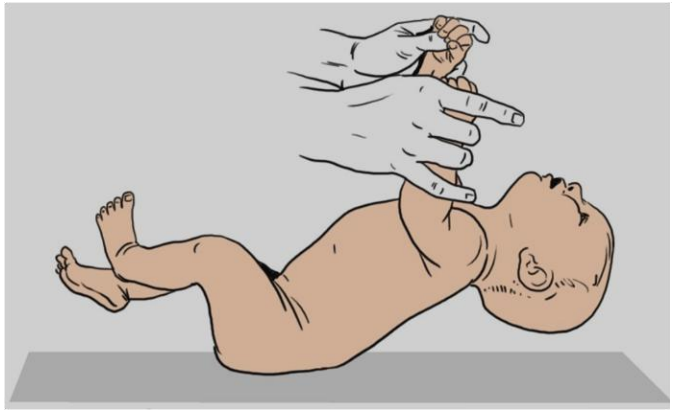
- Baby pulls body toward clinician's hands
- Head in one line with the trunk
- Abduction and extension of the legs
- Legs on the floor
- Flexion in LS junction





Postural Reactions – e.g. Traction Test
Motor response specific to developmental age

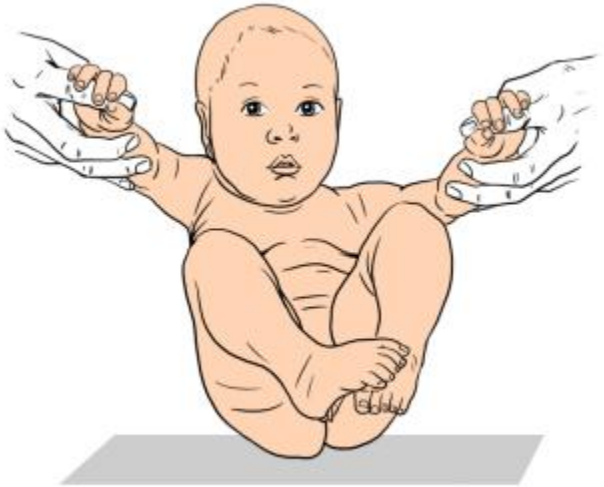
neonatus



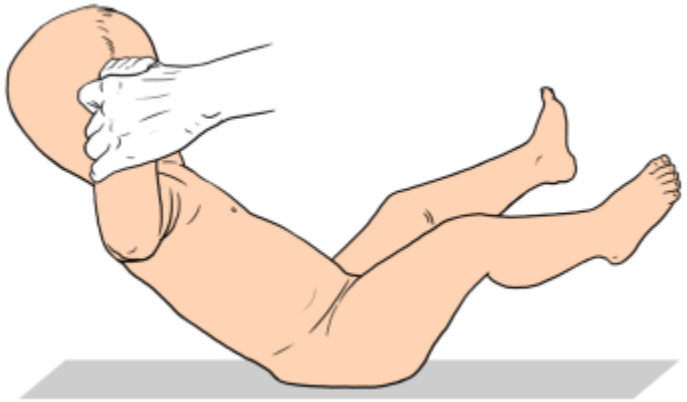
3 months



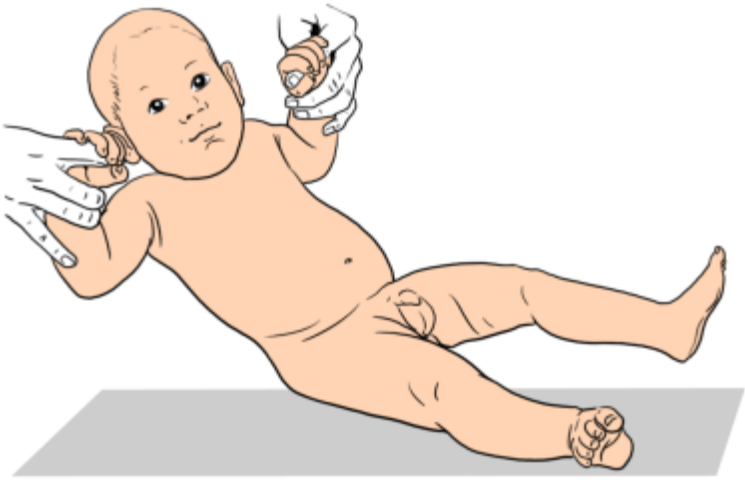
6 months



7-8 months



10-11 months



Video – Abnormal pattern





Landau’s test

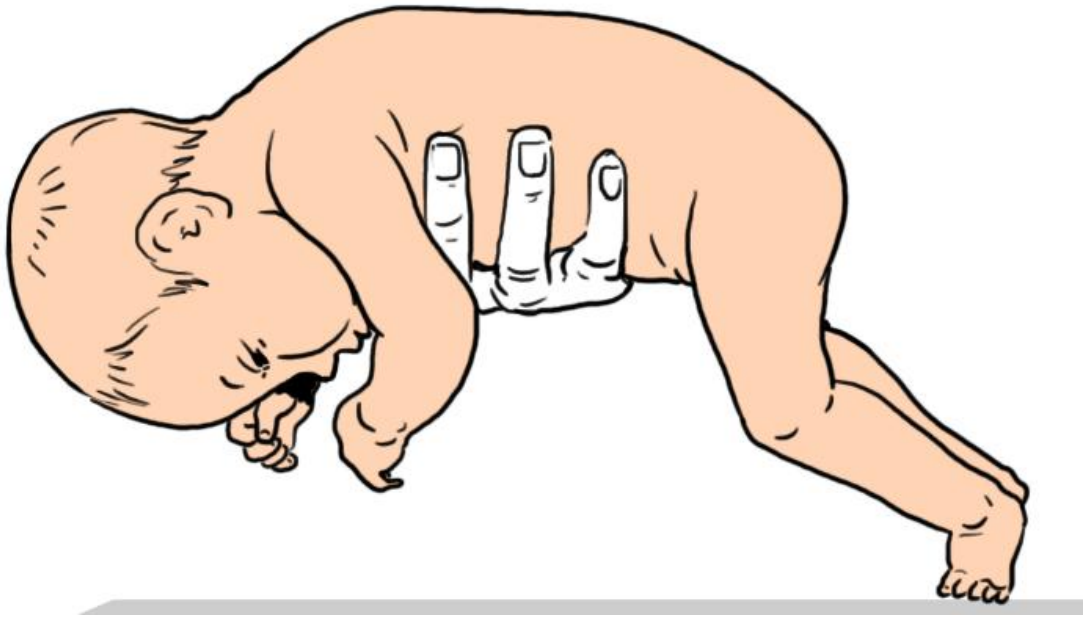
- Performance: strictly horizontal position, baby’s abdomen placed on opened therapist‘s palm. For correct evaluation, the baby must be calm, not crying



Landau's test: 1st phase
1st – 6th week

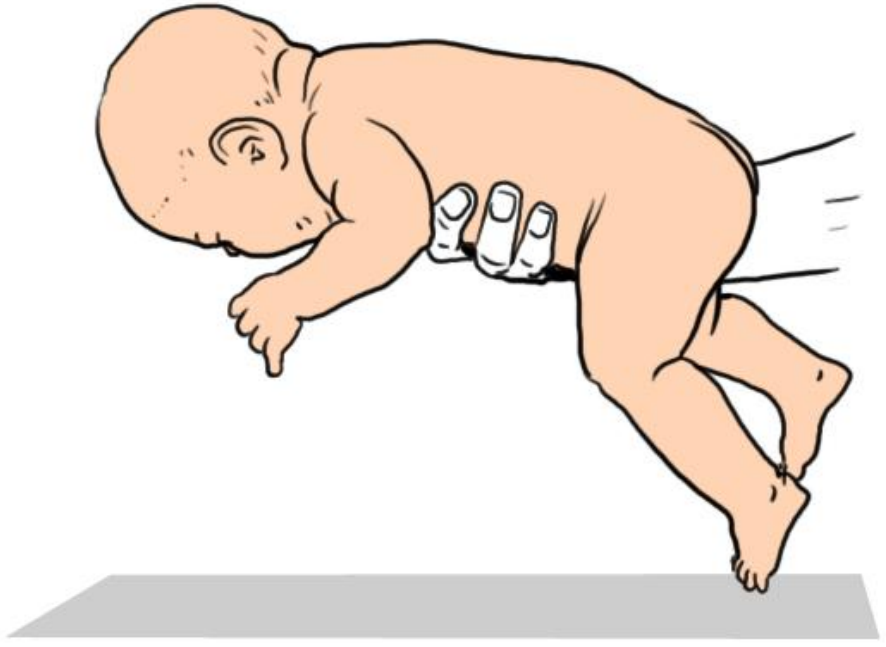
- Head and pelvis slightly below the horizontal line
- Slight flexion of the trunk and arms
- Free semiflexion of the legs
- Baby rests on the sternum, no active support





Landau's test: 2nd phase
7th week – 3rd month

- Symmetrical neck extension – starts from mid T spine (not reclination = CC hyperextension)
- Pelvis below the horizontal line
- All extremities: slight semiflexion
- In spontaneous motor activity in prone position the baby is supported on the elbows (medial epicondyles)
- Corresponds to 3 months developmentally

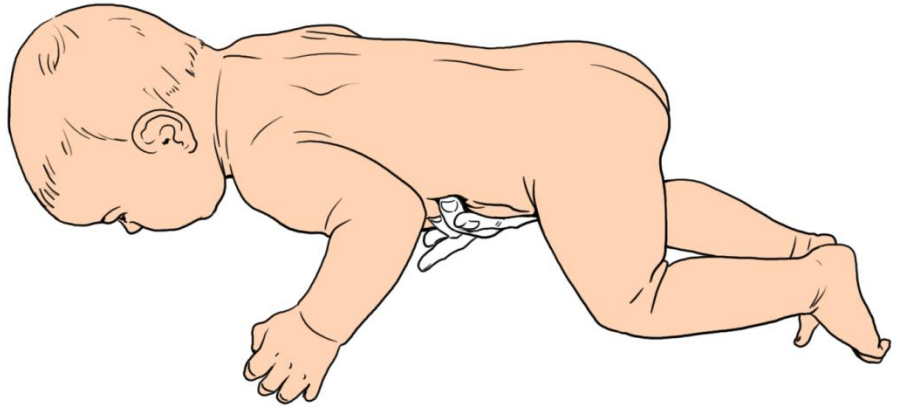






Landau's test: 3rd phase
4th month – 6th month

- Spinal extension as far as the L spine
- Flexion of the legs, 90° at the hips and knees
- Semiflexion at the arms
- Corresponding spontaneuous postural pattern is prone position with bilateral palm support





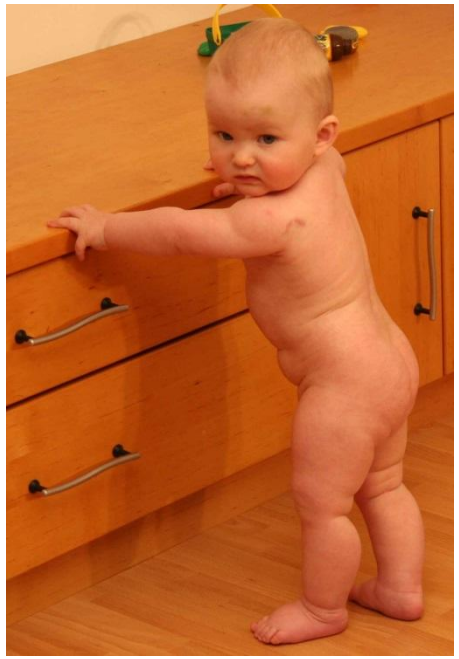
(6 month)



Landau's test: 4th phase
7th – 8th month

- Neck and trunk extension
- All extremities in free extension
- Corresponds to stance with support in spontaneous motor activity





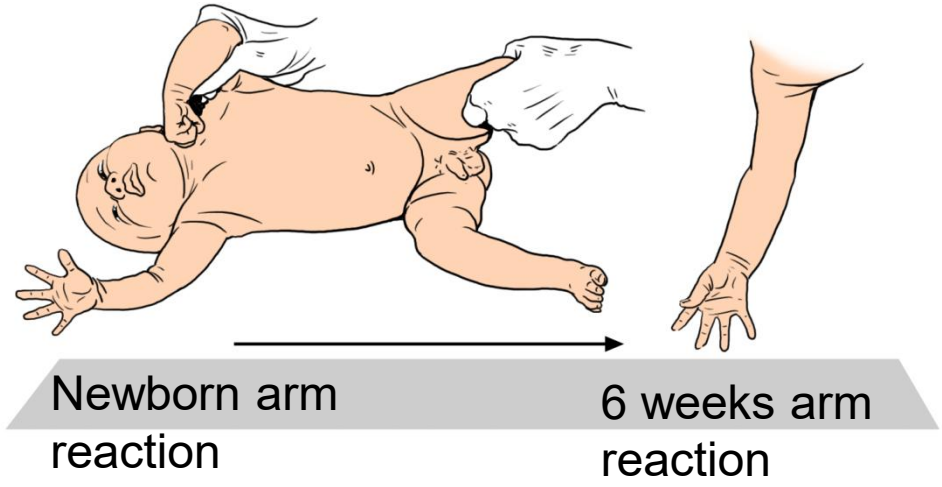
Horizontal suspension according to Collis

- Performance: the therapist fixes baby‘s arm and same sided leg, lifting the baby to horizontal position. The height to which the body equals the length of baby‘s arm
- Reaction of free (i.e. not fixed) extremities and head is assessed .



Horizontal suspension according to Collis: Phase 1a: 0 – 6th week

- Free (bottom) Arm: Moro reaction, at the end of 6th week Moro changes to active abduction
- Free (bottom) Leg: Adduction at the hip, 90° flexion at hip and knee, neutral position at ankle
- Head hangs down, is not held actively against gravity yet

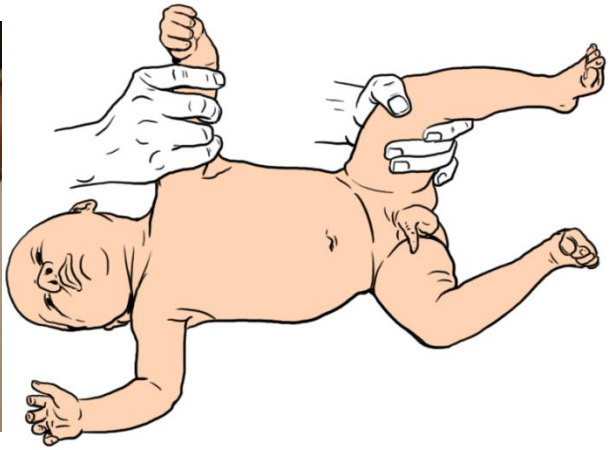




Horizontal suspension according to Collis: Phase 1b: 7th – 12th week

- Arm: at 7th weeks occurs active abduction, palm opened until 3 months elbow flexion increases; at the end of 3rd month palm closed, previously neutral forearm position (or even slight supination) gradually switches to pronation
- Leg: same position as 1a phase: Adduction at the hip, 90° flexion at hip and knee, neutral position at ankle
- Head is held against gravity

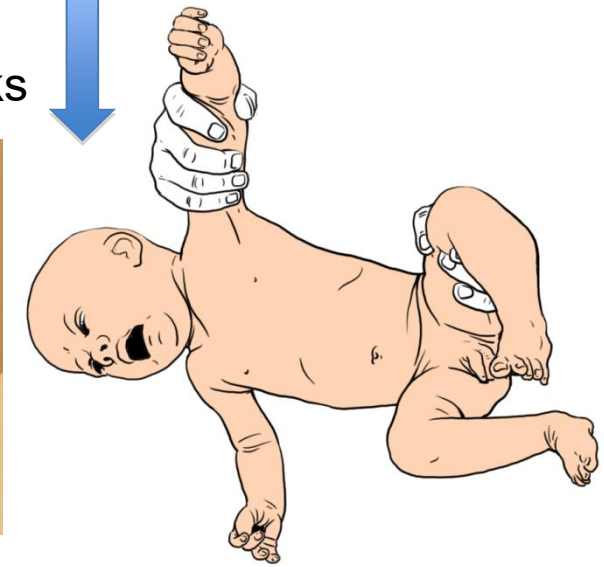




7 weeks

12 weeks

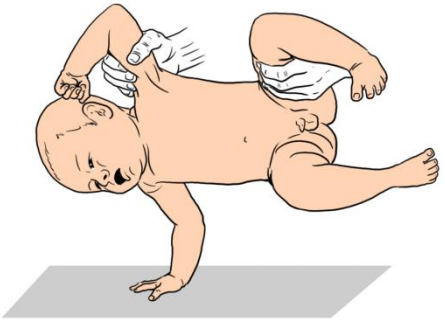




Horizontal suspension according to Collis: Phase 2: 4th – 6th month

- Arm – increasing pronation , palm gradually opens from hypothenar side, simultaneous wrist dorsal flexion, at the end of 5th month, the palm is opened as far as the 3rd finger , 6th month – the whole palm is opened, extension of all fingers.
- In spontaneous motor activity this phase corresponds with support on opened palms
- As soon as pronation occurs, wrist dorsal flexion occurs at the same time, palm opens, grasping reflex vanishes and baby starts to grasp, already using radial grasp
- Pronation is a sign of differentiated function of the arms (supporting, grasping)
- Leg: flexion at all joints, knee starts facing the floor, adduction at the hip gradually changes to abduction

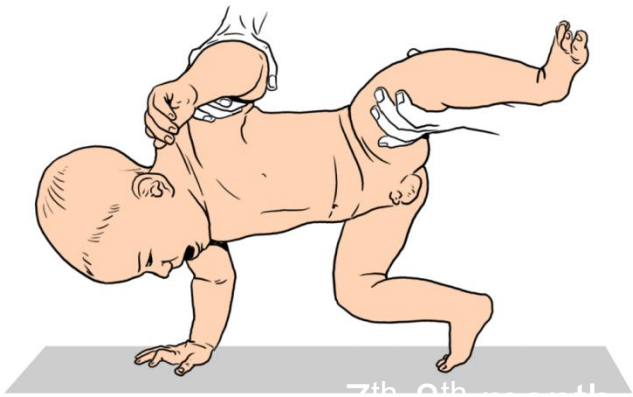




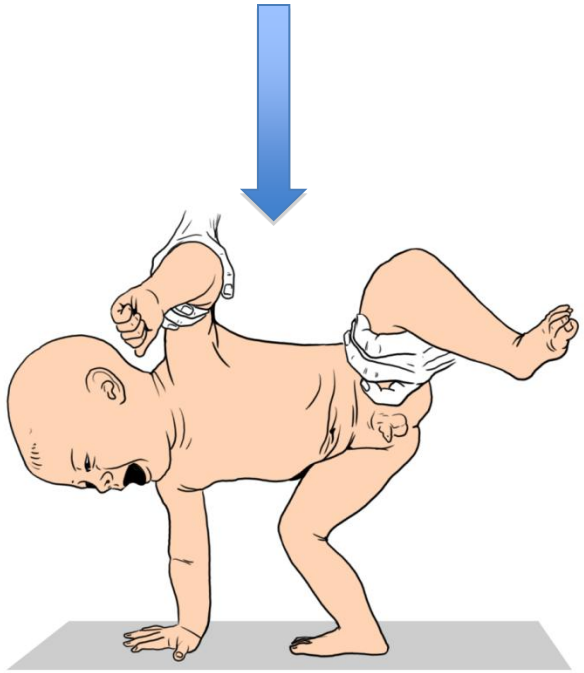


Horizontal suspension according to Collis: Phase 3: 7th – 10th month

- Arm supported on the opened palm
- Starts support on bottom leg/foot where still is flexion 90° at hip, knee extension increases
- End of 8th month- hip abduction, support on whole sole of bottom leg
- In spontaneous motor activity corresponds oblique sit, baby can sit on his/her own, by the end of this phase from quadruped position switches to standing position with arm support.









Horizontal suspension according to Collis: Phase 3: 7th – 10th month



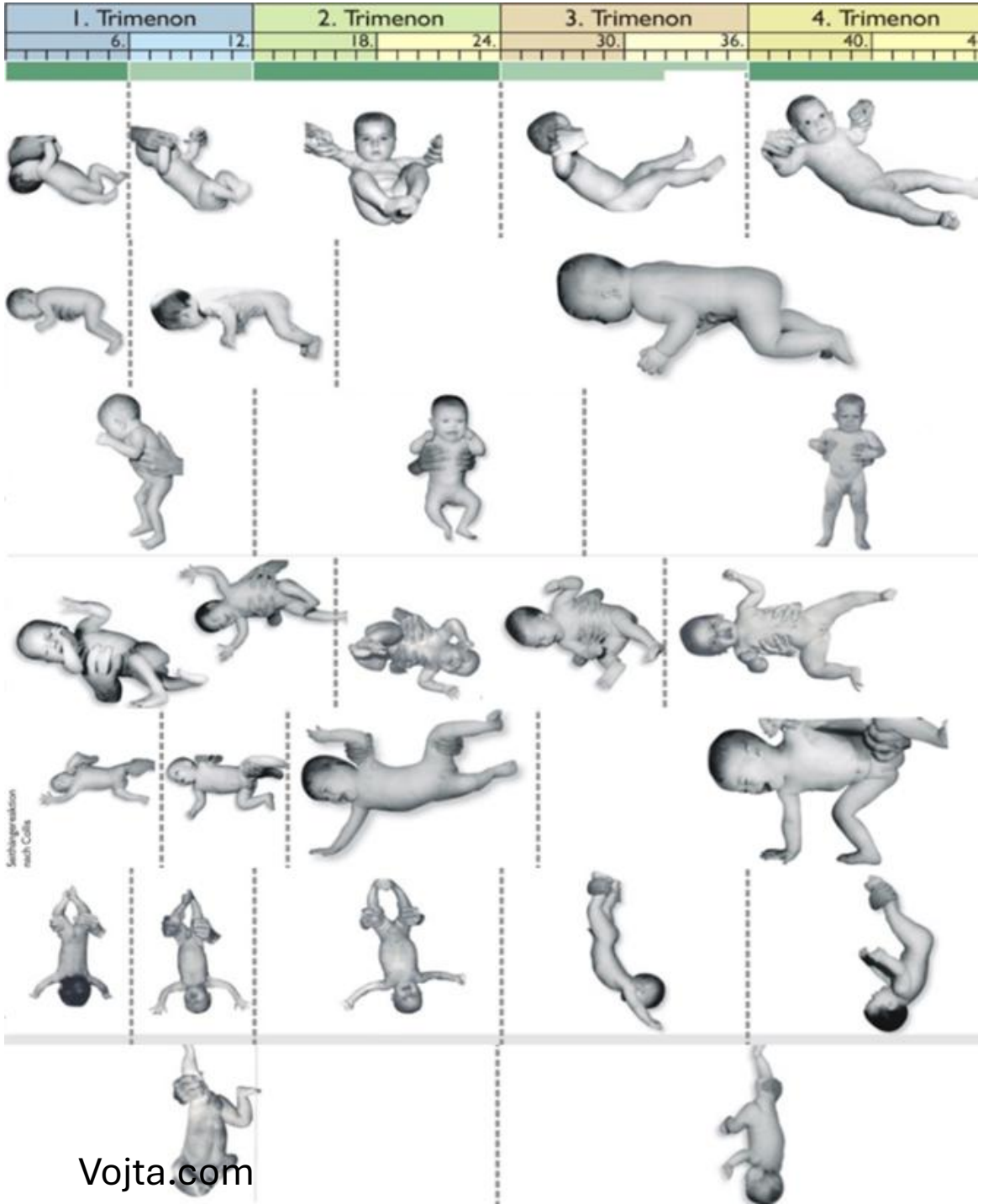
7 months



10 months

Postural reaction

1. Traction test
2. Landau reaction
3. Axillary suspension
4. Vojta´s side tilt reaction
5. Collis horizontal suspension
6. Peiper Isbert vertical suspension
7. Collis vertical suspension



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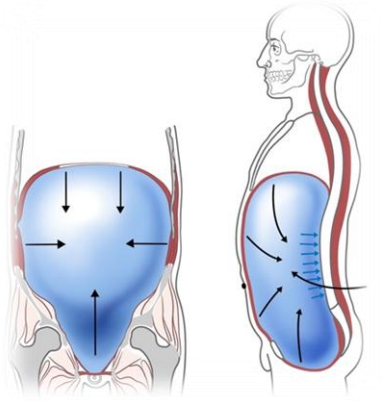
Spontaneous Movements Key Milestones

0-28day	Newborn, Holokinetic movement, asymmetry
6w	Fencer, beginning of external rotation activity, more abdominal activity
3m	Sagittal stabilization, symmetry, isolated mvt of the head and eyes
4.5m	Differentiation of the limbs, spine, abdominal muscles
6m	Turning over
7.5m	Oblique sit, the trunk is uprighted in frontal plane
8-10m	Sit, crawling, first attempt to reach vertical plane
14-16m	Gait development

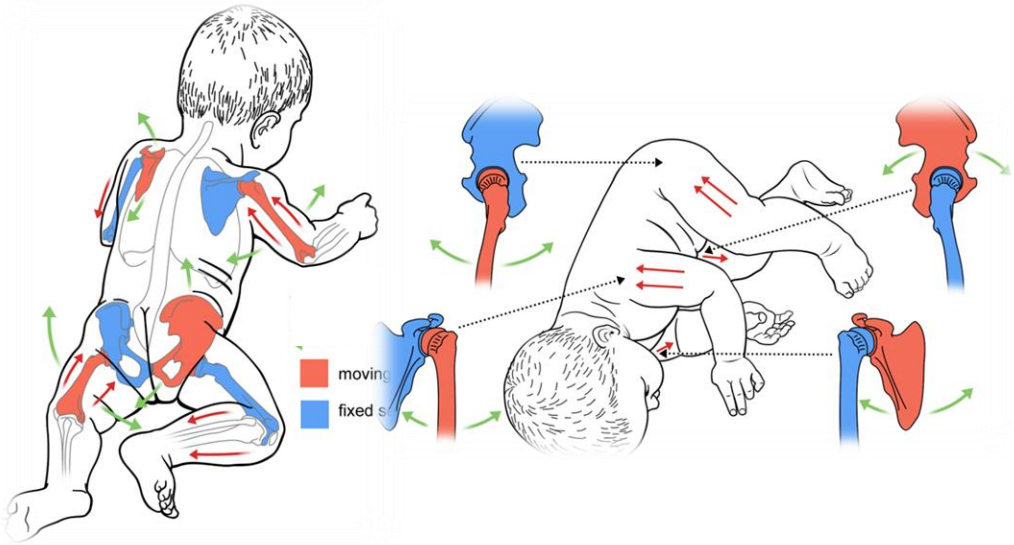


MATURATION OF POSTURAL LOCOMOTION FUNCTION



1st Phase 0-3M

- Sagittal stabilization = trunk stabilization



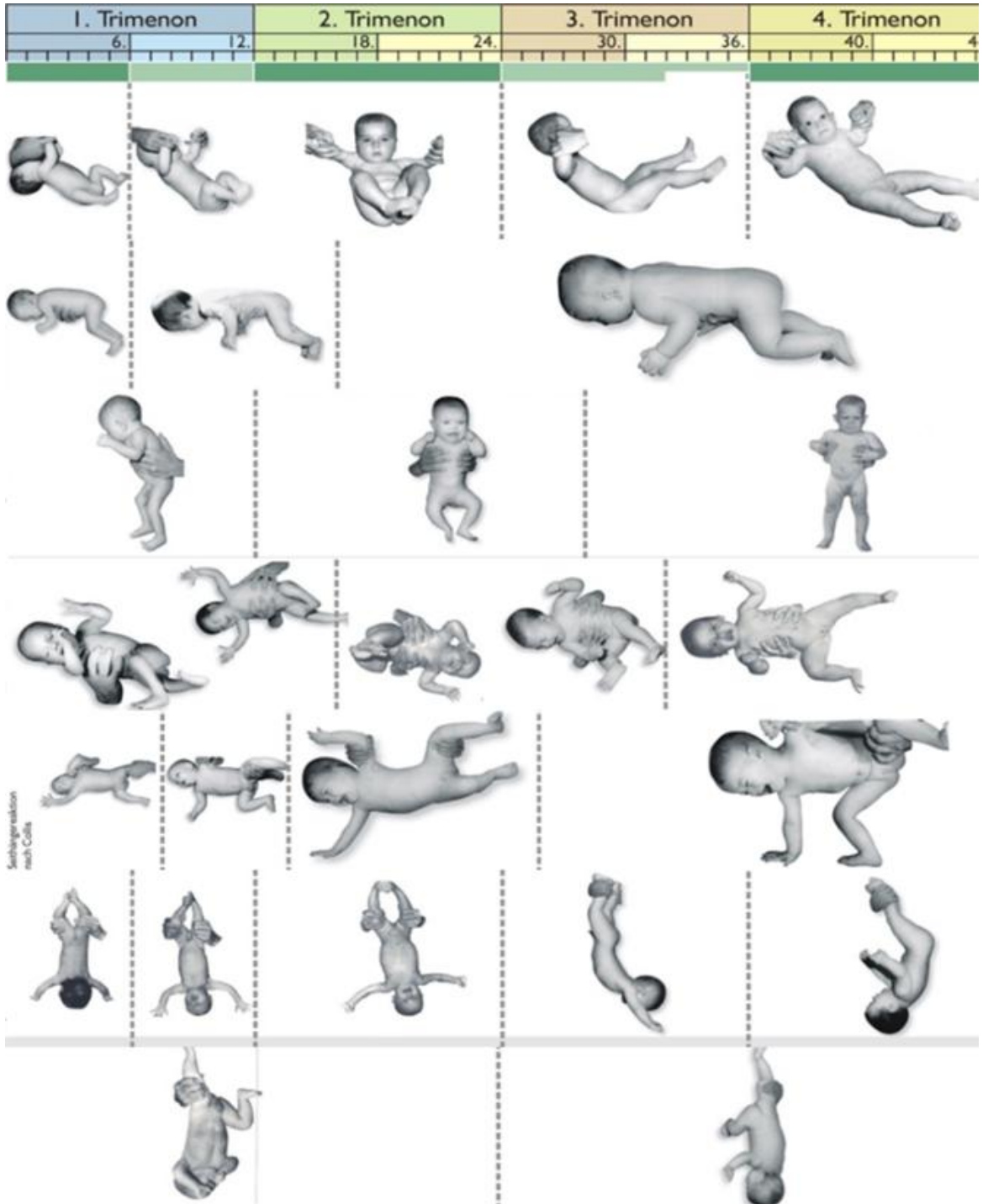
2nd Phase around 4.5M

- **Limb differentiation**



3rd Phase around 8M

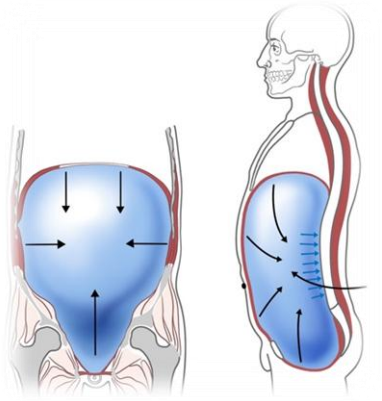
- Locomotion from point A to point B


1. Trimenon
2. Trimenon
3. Trimenon
4. Trimenon
6.
12.
18.
24.
30.
36.
40.


4 months
SUPINE
4.5 months
PRONE
5 months
SIDE-LYING
5 months
SUPINE
6 months
PRONE
6 months
SUPINE
7 months
PRONE
7 months
QUADRUPED

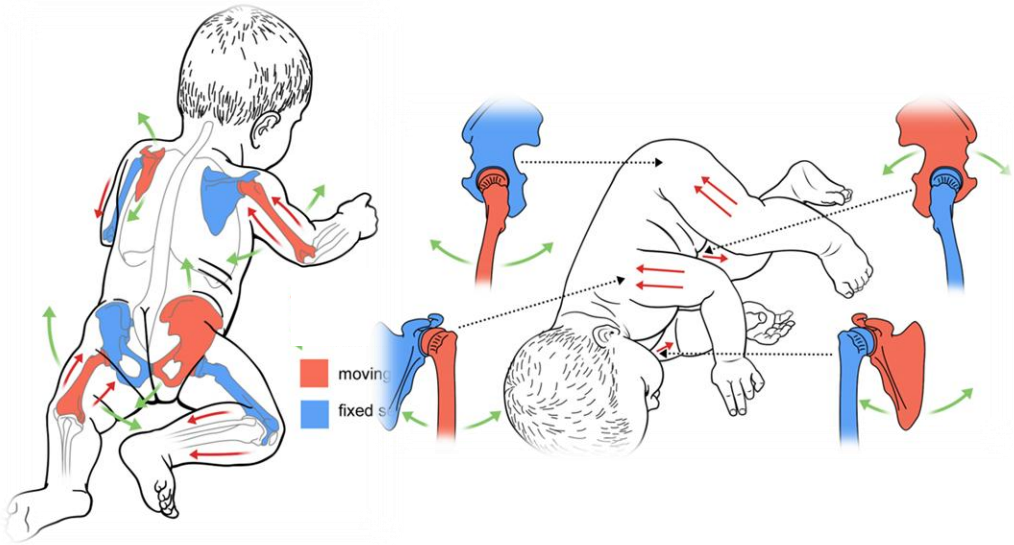

9 months
CRAWLING
10 months
SIDE-SITTING TO QUADRUPED TRANS
11 months
HIGH KNEELING
12 months
SQUAT
10 months
SITTING
11 months
TRIPOD
12 months
BEAR
13 months
TRANSITION TO STANDING

MATURATION OF POSTURAL LOCOMOTION FUNCTION



1st Phase 0-3M

- Sagittal stabilization = trunk stabilization



2nd Phase around 4.5M

- **Limb differentiation**

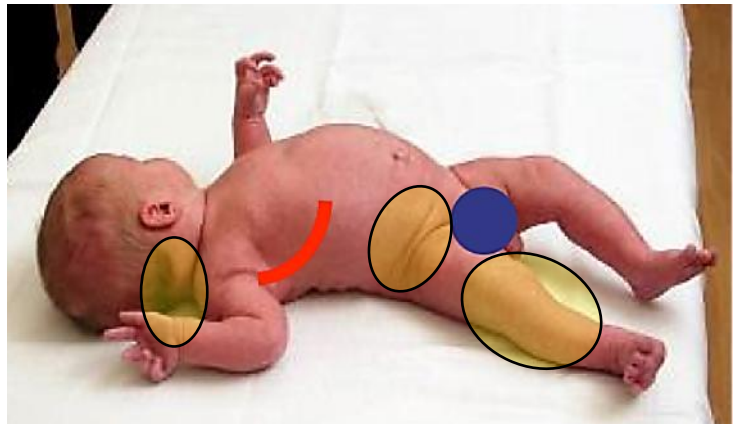


3rd Phase around 8M

- Locomotion from point A to point B

When the challenge or strain is more than the CNS can handle, the athlete will restore to a more primitive stabilizing strategy, often representing newborn posture.

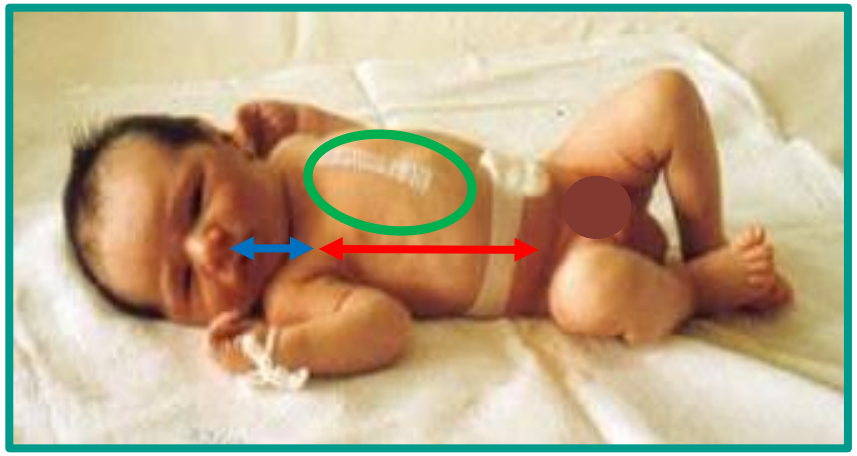




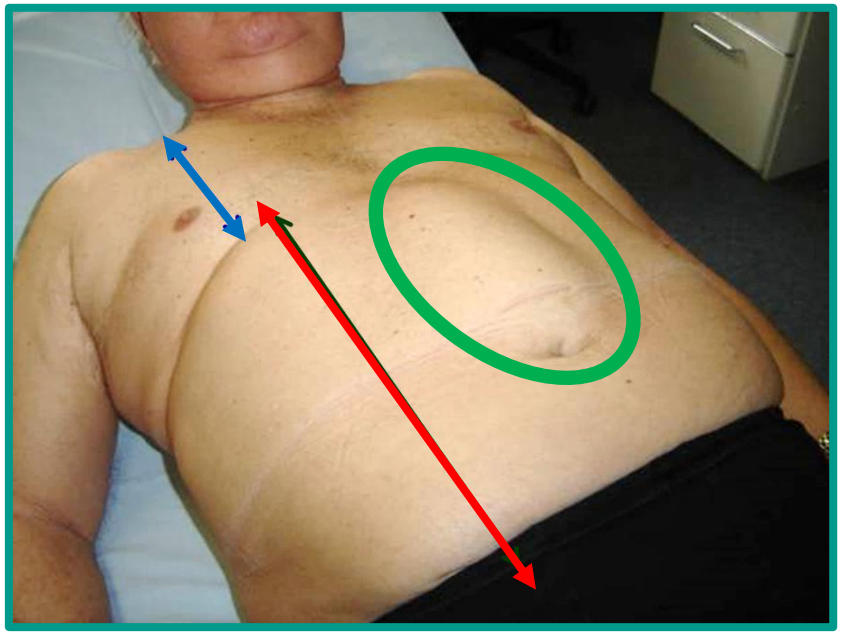


DYNAMIC NEUROMUSCULAR STABILIZATION

Healthy newborn



Poor pattern in adulthood



SAME MARKERS

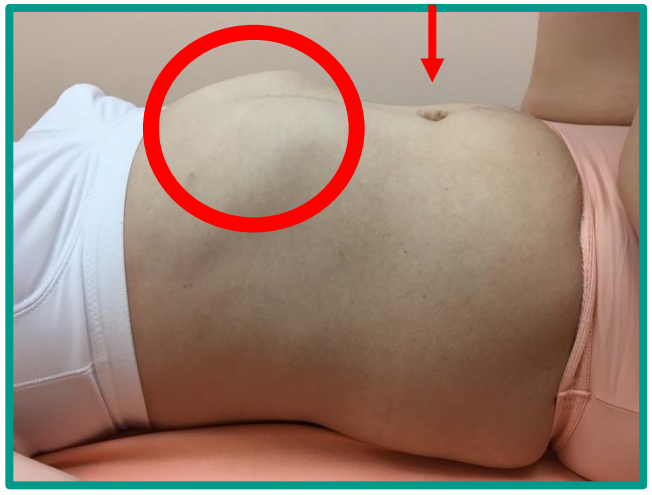
- Short chest in cranial position
- Hypotonia of the abdominal wall
- Diastasis in the rectus abdominis

DNS ASSESSMENT









DNS ASSESSMENT

- **DNS assessment** is based on the comparison of the patient´s stabilizing pattern to that of a healthy infant
- **DNS treatment** is based on the ontogenetic postural locomotor patterns

PRIMARY GOAL OF THE TREATMENT TO OPTIMIZE THE DISTRIBUTION OF INTERNAL FORCES OF MUSCLES THAT ACT ON EACH SEGMENT OF THE SPINE AND/OR ANY OTHER JOINTS OR SEGMENTS (EFFICIENCY OF MOVEMENT)

DNS TREATMENT









DNS TREATMENT

- **We can use:**
  1) Static position
  2) Assisted position
  3) Resistance of the anticipatory motion
  4) Guide the motion manually and/or verbally









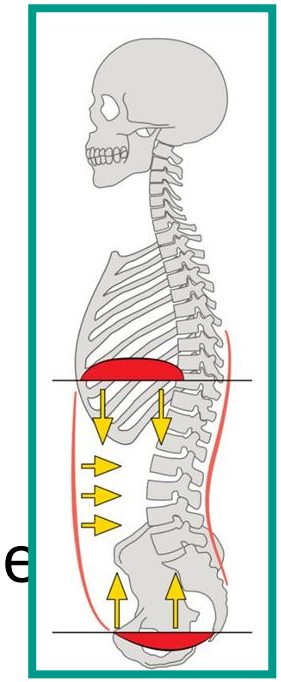
DYNAMIC NEUROMUSCULAR STABILIZATION

- Understanding of **developmental kinesiology** provides a framework to appreciate the regional interdependence and the interlinking of the skeleton, joints, and musculature during movement.
- Muscles must be trained in both their **stabilization** and **dynamic** (movement producing) **functions**.

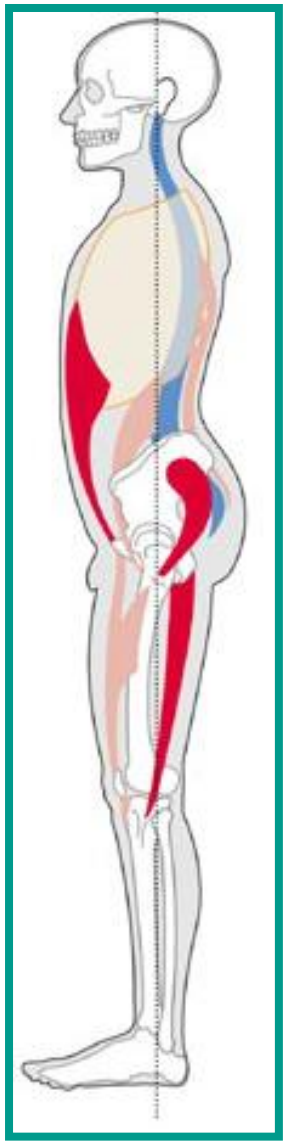


GOAL OF DNS

- To improve or normalize the quality of…
  - Respiratory patterns
  - Postural stabilization patterns
  - Locomotion patterns
- Integrate the proper postural-locomotion and respiratory function within ADL and sport performance







Functional joint centration

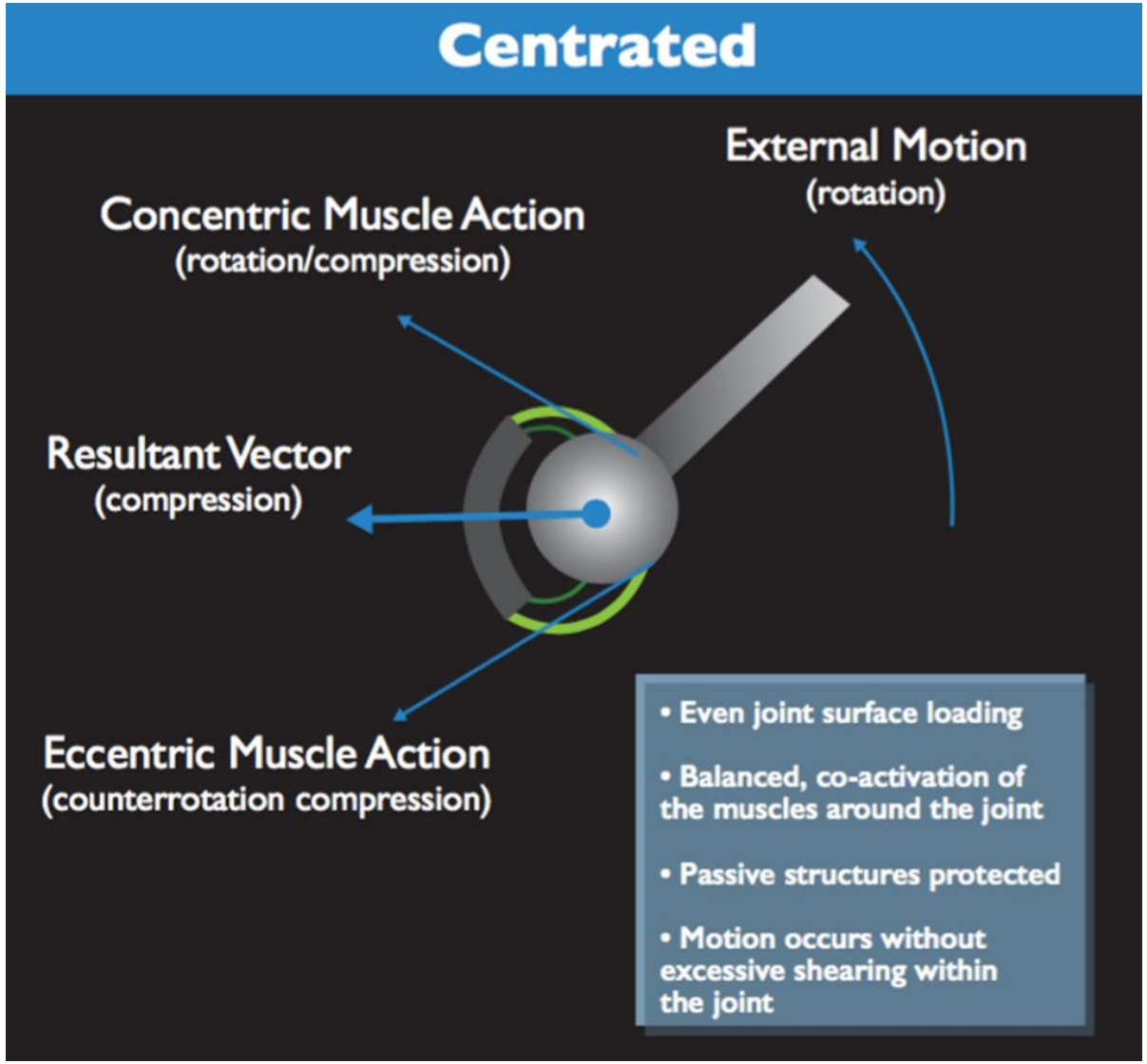
- Assumes that core stability and basic extremity locomotor function are mainly under the subcortical control.

- If CNS control is adequate, and **muscles are activated in balance**, then each posture and spontaneous movement automatically brings all the joints into a **FUNCTIONALLY CENTRATED POSITION.**



Functional joint centration

- A functionally centrated (neutral or functionally optimal) joint is not a static position but a dynamic neuromuscular strategy of movement and stabilization.
- The joint is in the most optimal position
- The centrated joint has the greatest interosseous contact, which allows for optimal load transfer across the joint and throughout the kinetic chain
- This ensures: maximum force-loading, minimum tension in passive structures (i.e. joint capsule and the ligaments),
- protection of all joint structures during loading and movement.



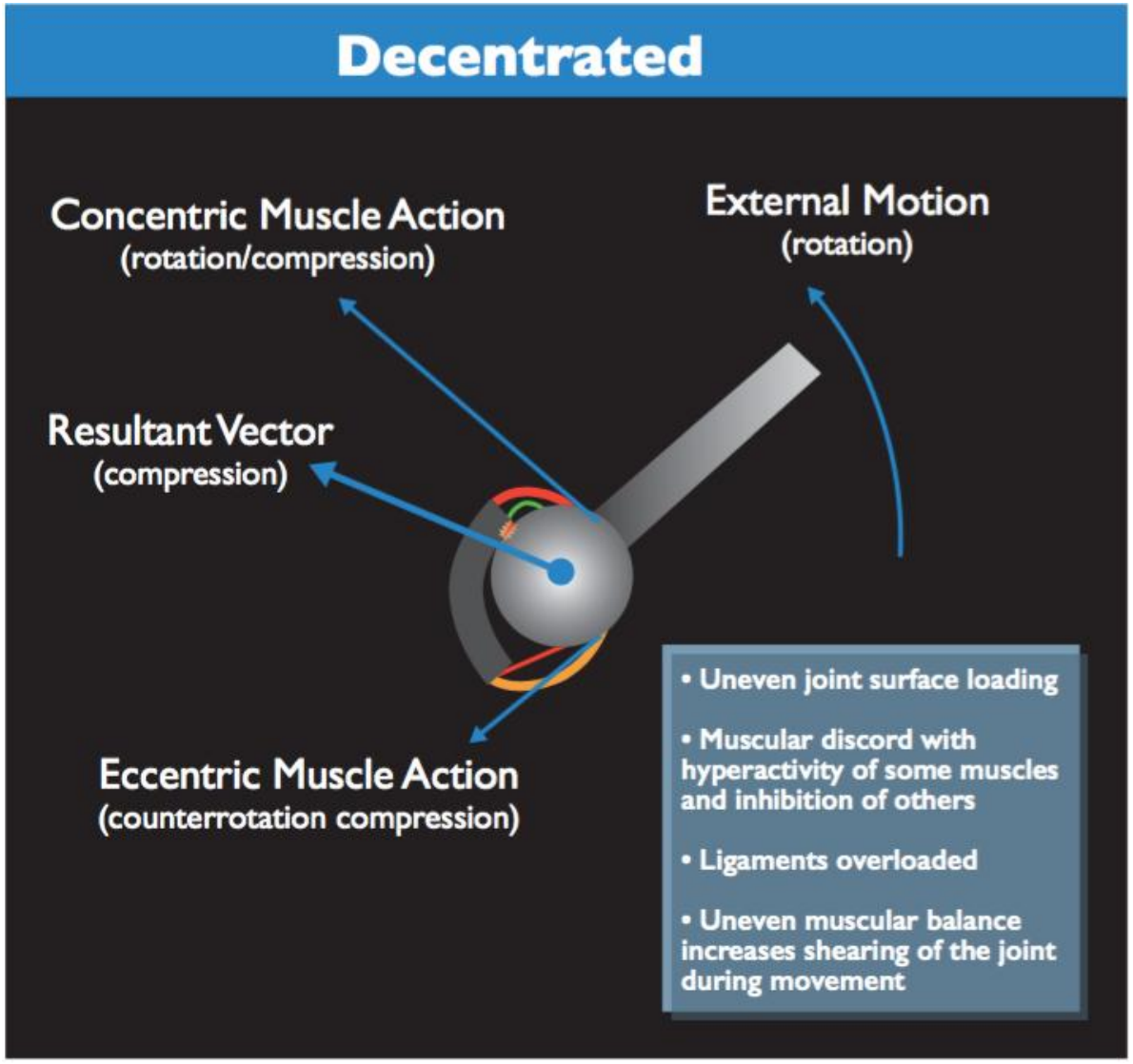
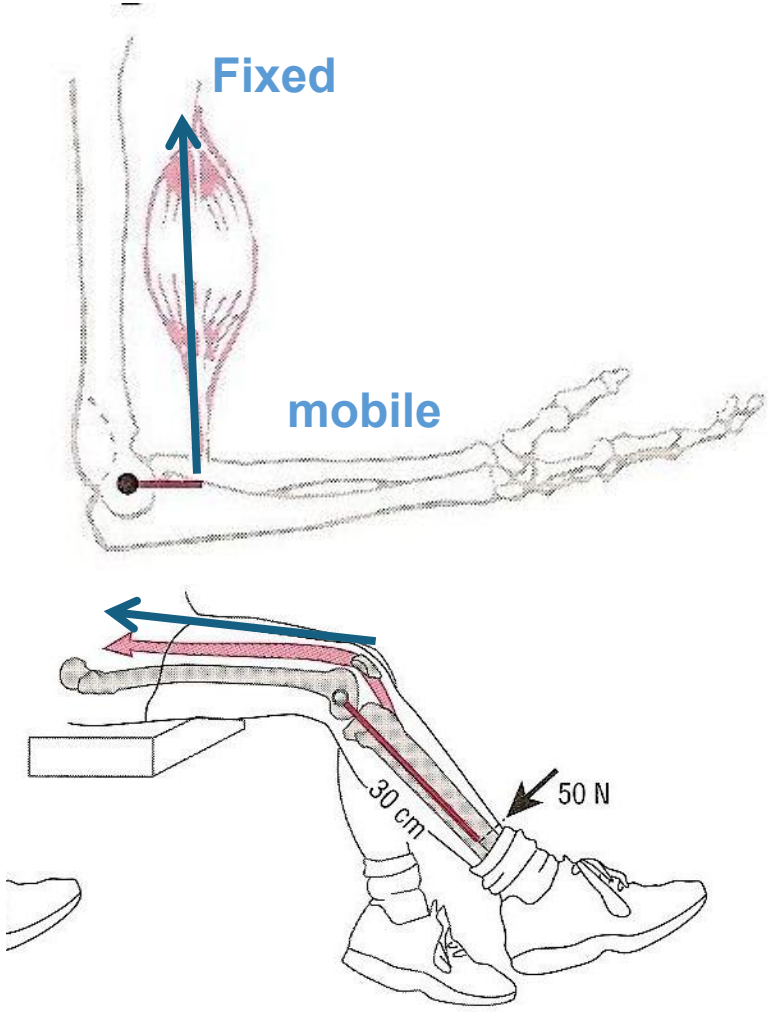


Diagram by DNS instructor Richard Ulm, DC.

Rintala M, Ulm R, Jezkova M, Kobesova A. Czech Get-up. *NSCA Coach.* 2016;3(2):30-8. ISSN 2376-0982 *Online*. https://www.nsca.com/publications/reports-and-journals/nsca-coach/

OPEN KINEMATIC CHAIN

- If the proximal muscle attachment is stabilized fixed, then the distal end of the muscle moves toward the proximal mobile part

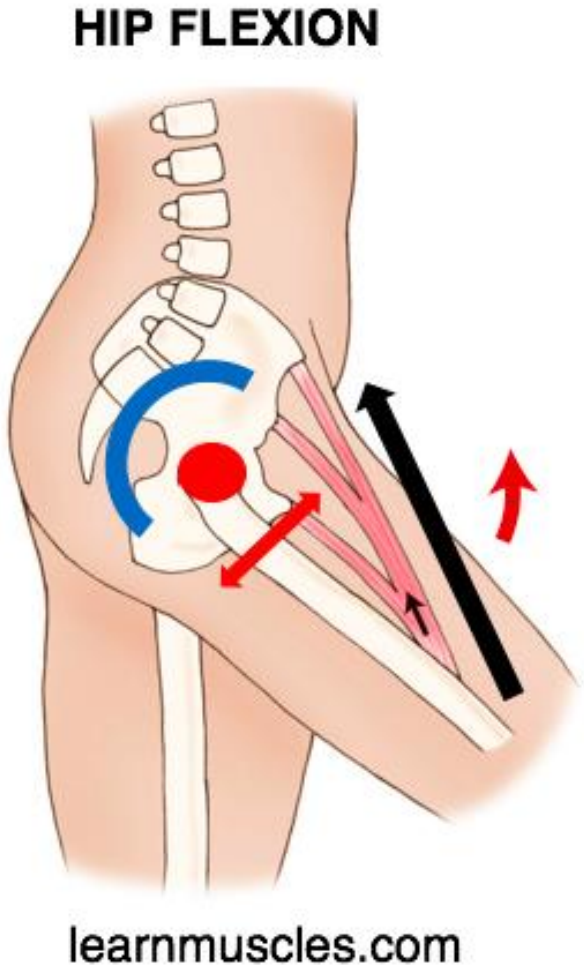


Proximal muscle pull = stepping forward movement.

(Neumann, 2002)

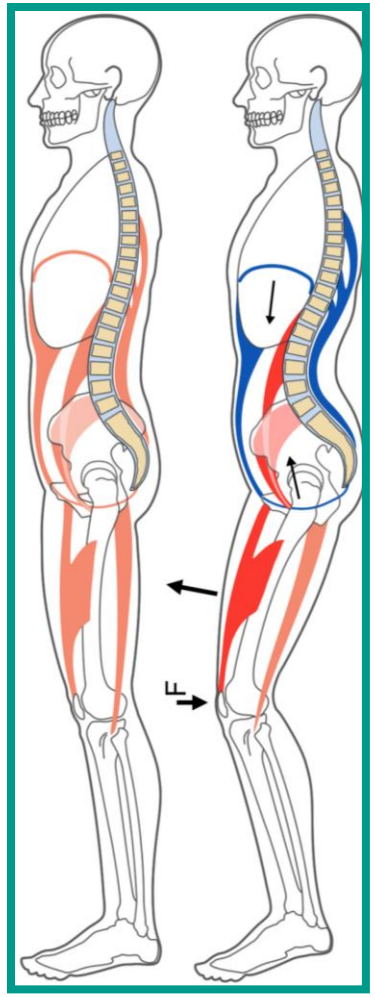
OPEN KINEMATIC CHAIN

- Stepping forward function of extremities (reaching/walking)
- **Head (mobile) is moving in** the **socket (fixed)**

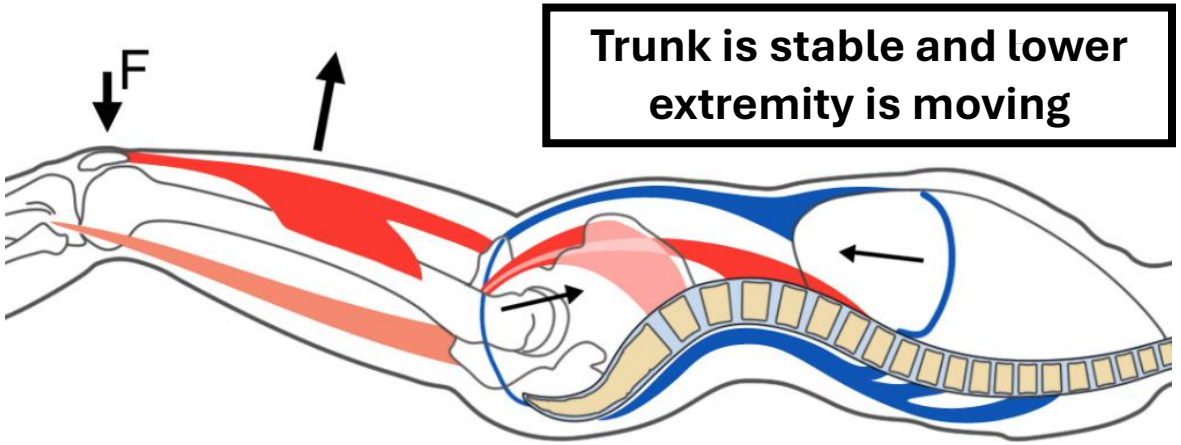


picture alternation by DNS team

OPEN KINEMATIC CHAIN

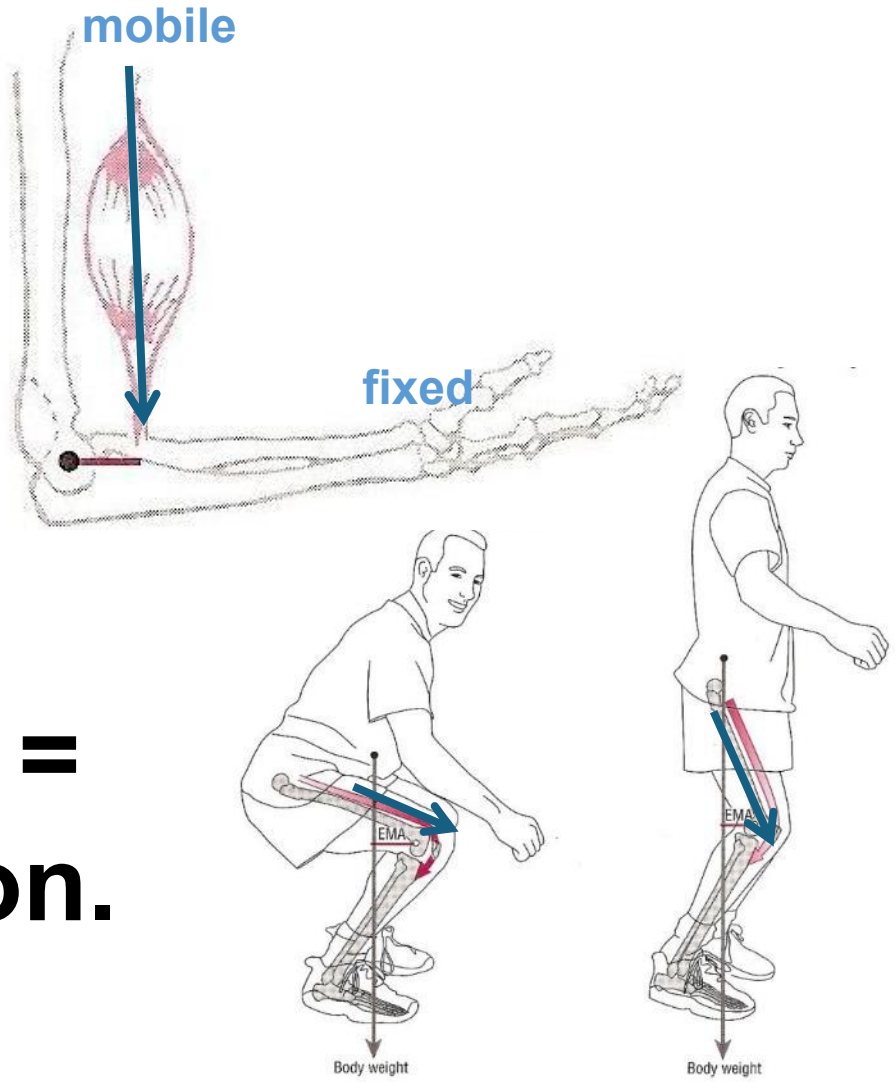


- Proximal muscle attachment is stabilized distal segment (on periphery) is moving towards fixed proximal muscle pull



CLOSED KINEMATIC CHAIN

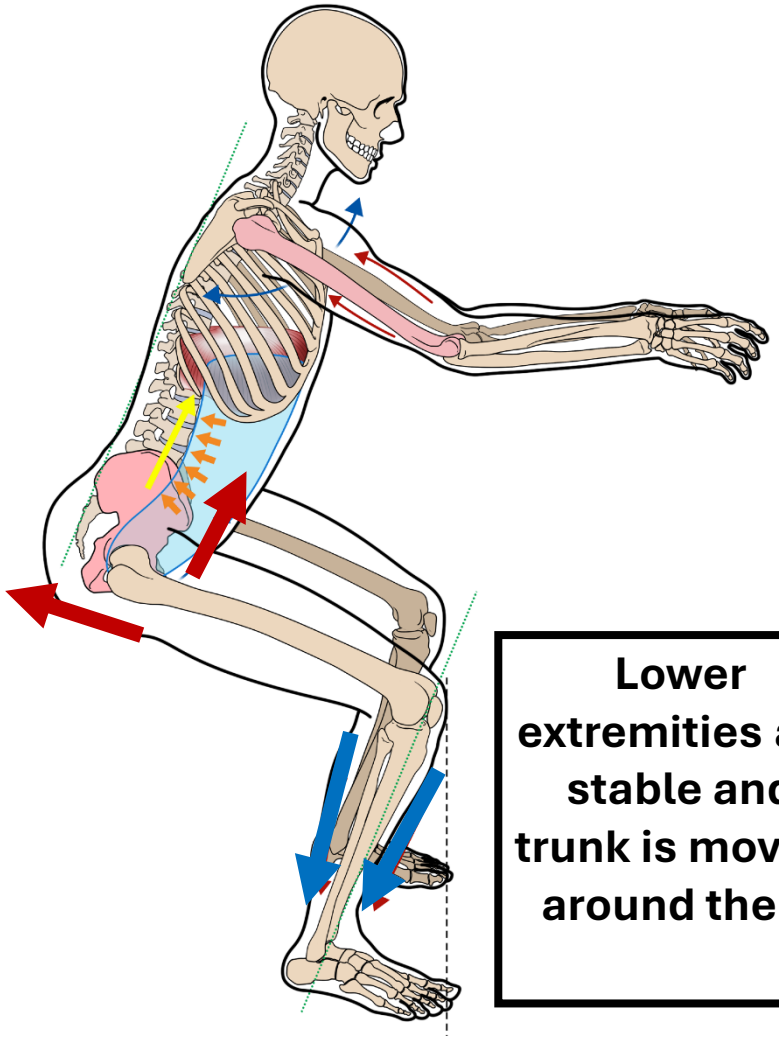
- If distal muscle attachment is fixed, then the proximal end of the muscle moves toward the distal mobile part [



Distal muscle pull = supporting function.

(Neumann, 2002)

CLOSED KINEMATIC CHAIN

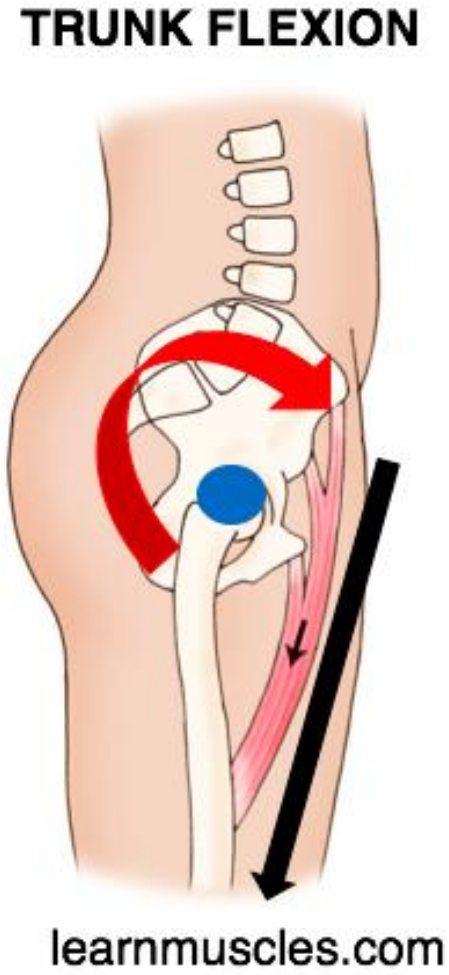


Lower extremities are stable and trunk is moving around them

- Distal muscle attachment is stabilized **(fixed)**
- Proximal segment of the joint is moving **(mobile)** against fixed distal muscle pull

CLOSED KINEMATIC CHAIN

- Support function of the extremities
- **Socket (PM) is moving over** the **head (PF)**



picture alternation by DNS team

Two patterns displayed in ontogeny

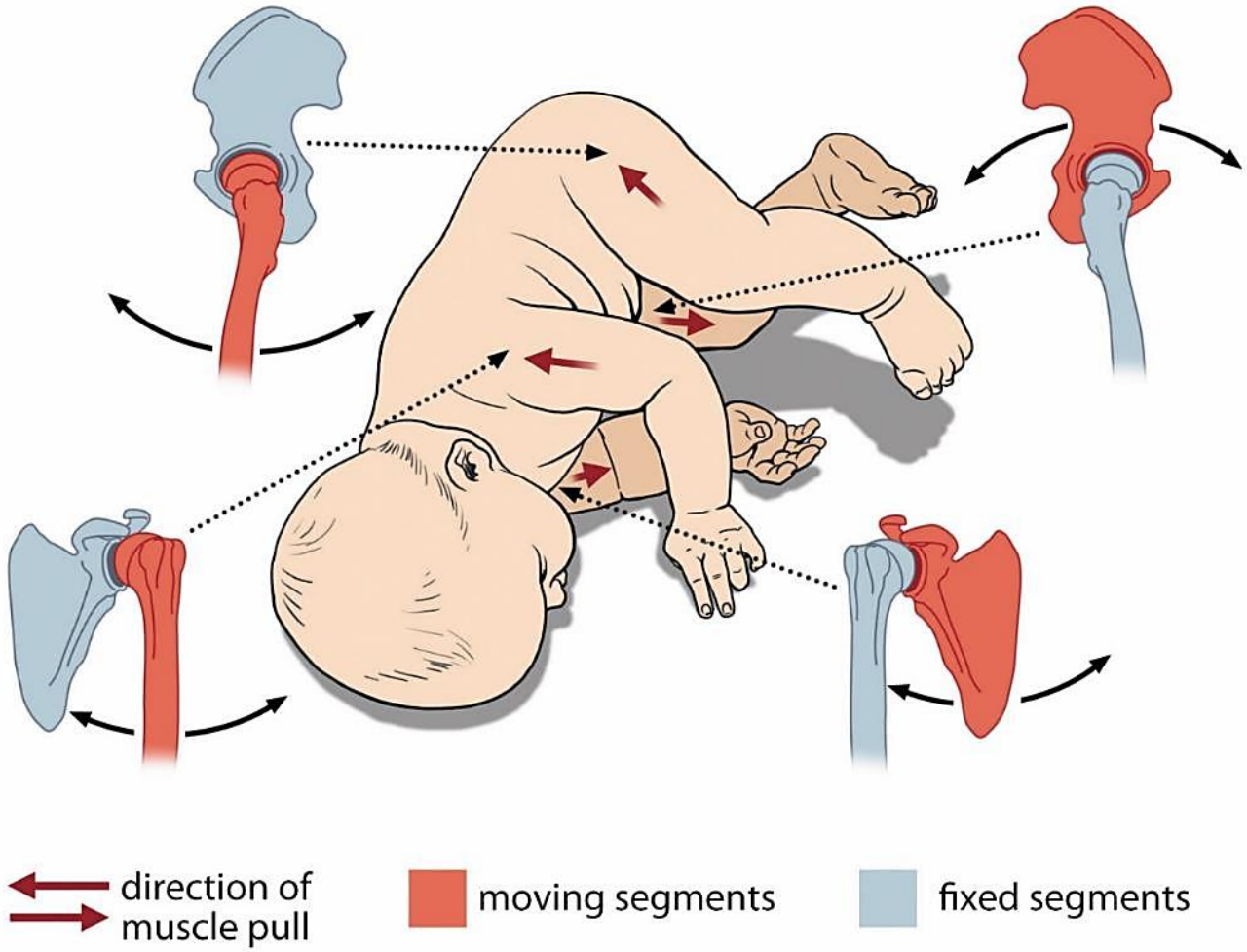
Ipsilateral pattern

- Developed from a supine position
- Initially seen in the child rolling over
- Underlying extremities are in supporting function, upper lying in phasic function





Ipsilateral pattern

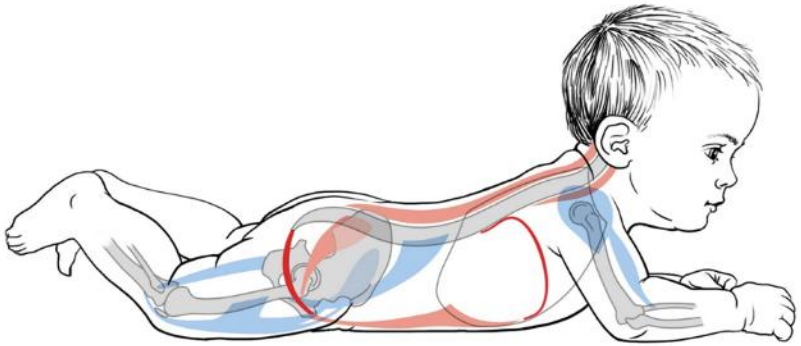


Two patterns displayed in ontogeny

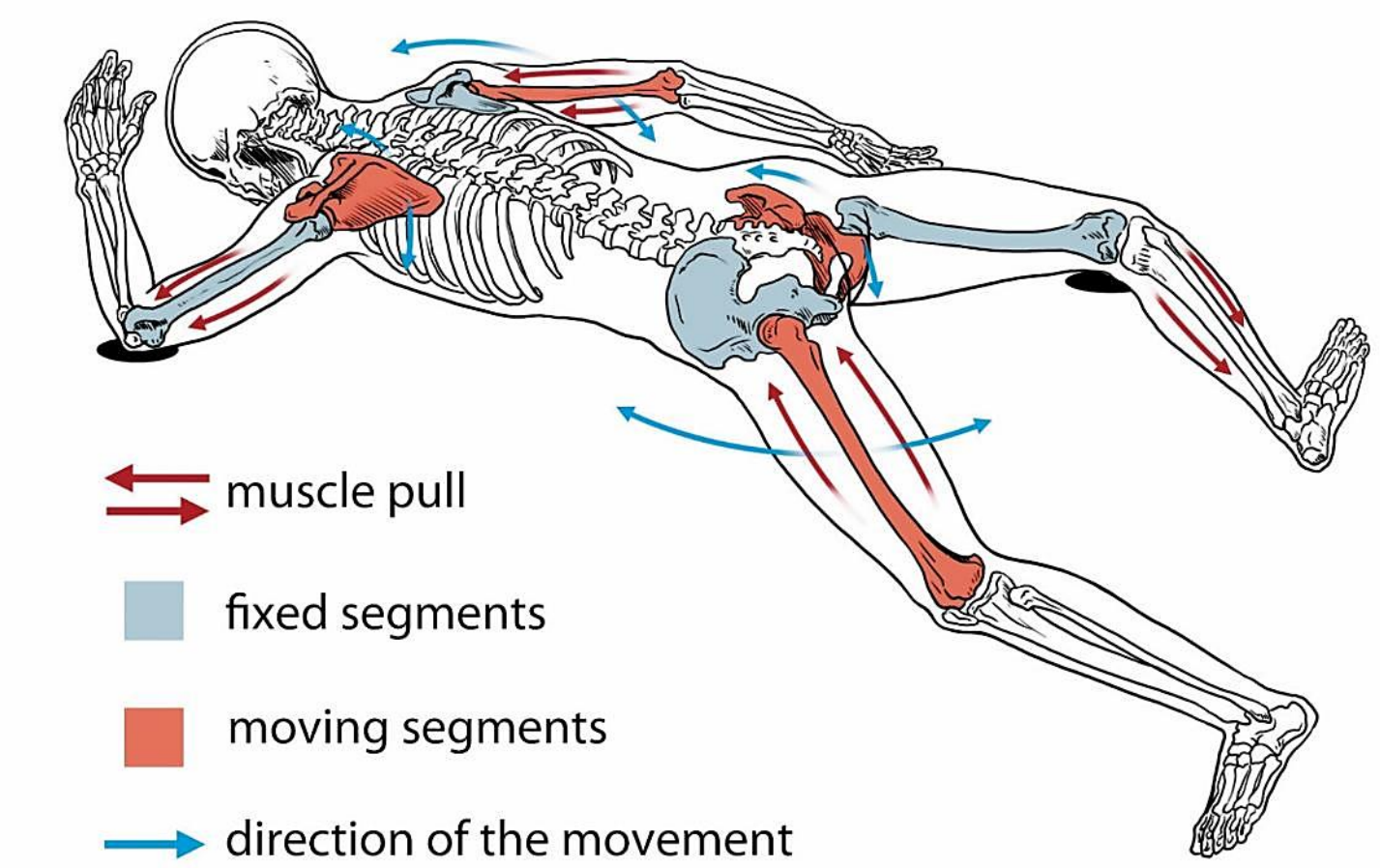
Contralateral Pattern

- Developed from a prone position
- Diagonal extremities are in supporting function, the other two in phasic function
- Presents after the ipsilateral pattern develops.



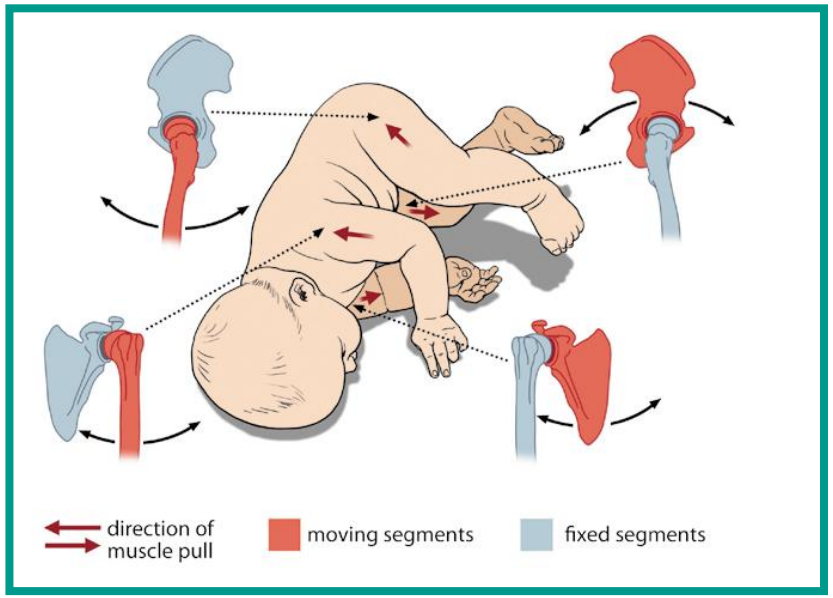


Contralateral Pattern



IPSILATERAL PATTERN

- Extremities on the same side have the same function
- Related to the turning process
- Axes of the shoulder and pelvis are rotating together
- Chest and pelvis remains mostly parallel



IPSILATERAL PATTERN







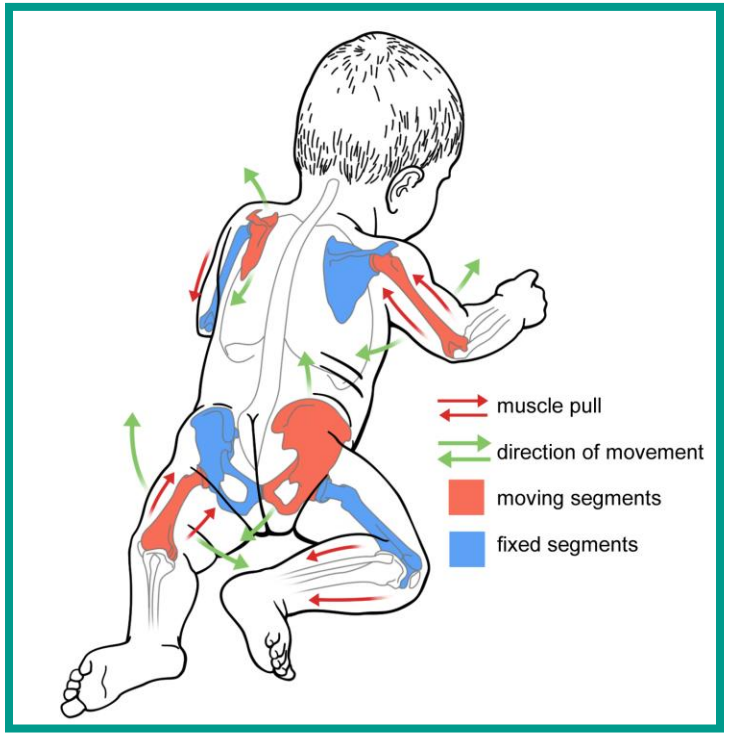






CONTRALATERAL PATTERN

- Contralateral extremities with the same function
- Related to movements forward and up
- Axes of the shoulder and pelvis are parallel but with coaxial counter-rotation to each other



CONTRALATERAL PATTERN











Ideal pattern of sagittal stabilization

- Even simple purposeful movement must be preceded and secured by the activity of stabilizers



- **Stabilization** – activity does not involve only just one muscle but always involves the **whole chain**

Quality of stabilization is the most important!

FUNCTIONAL STABILIZATION

- Is necessary for **safe, purposeful movement** of the extremities and head
- Essential in the course of **static loading** of the spine (e.g. sitting, standing)
- Insufficient stabilization is a frequent cause (etiology) of disturbance in the locomotor system

FUNCTIONAL STABILIZATION

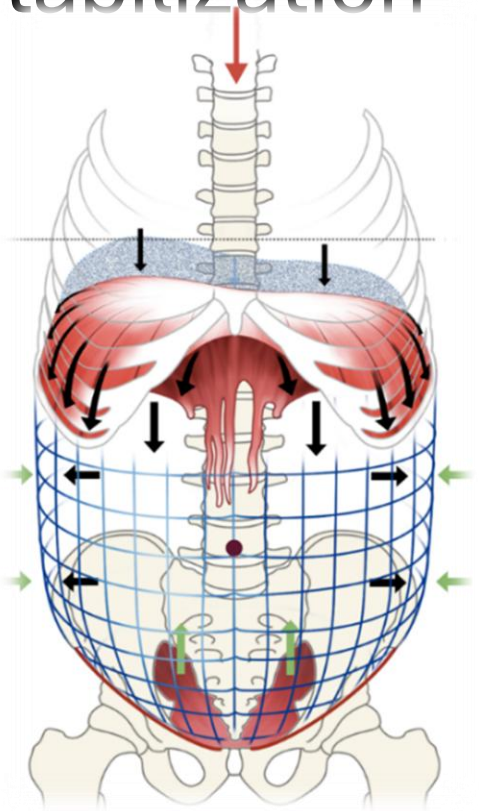
- Functional stabilization = GLOBAL PATTERN
- If one muscle (even part of it, such as with trigger points) is dysfunctional, then…

  -The whole stabilizing function is disturbed

  -The quality of the purposeful movement is compromised

Development of Spinal (core) Stabilization

- Short intersegmental spinal muscles (**multifidi**)
- The **deep neck flexors**
- The **diaphragm**
- The **abdominal wall**
- The **pelvic floor**

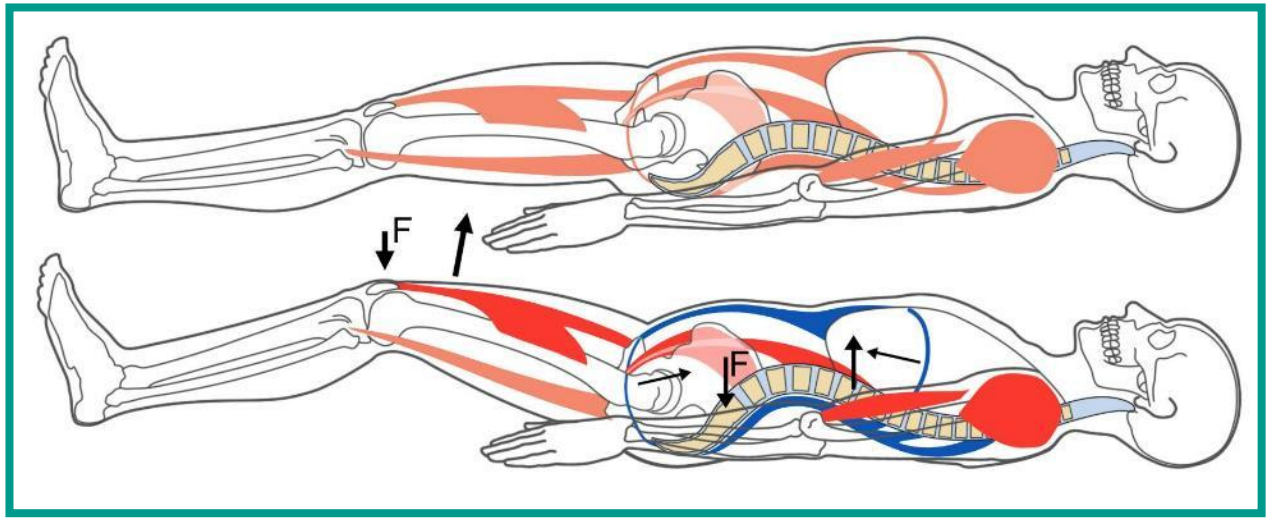


These muscles automatically activate **prior** to purposeful movement to establish a stable base

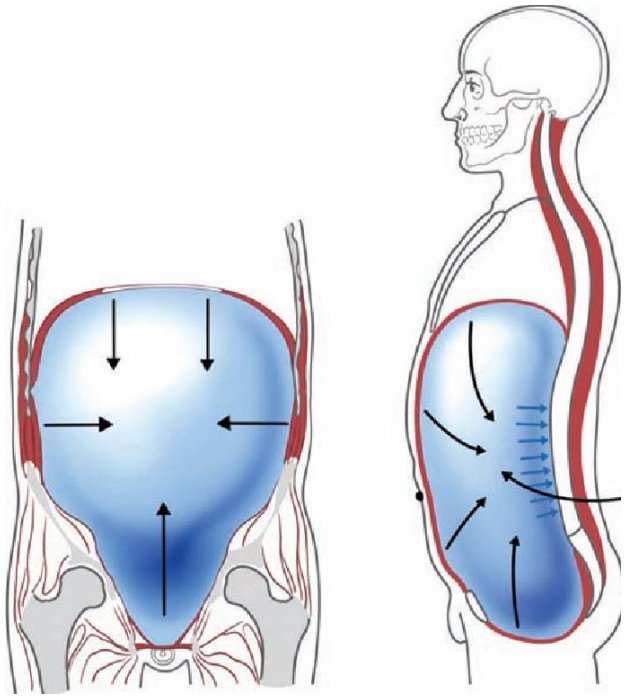
“Feed-forward Mechanism”

SPINAL (CORE) STABILIZATION

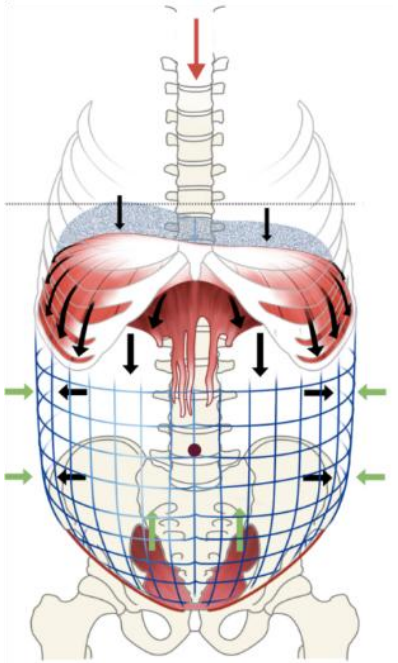
E.g. hip flexion: Feed forward stabilization mechanism:
First the stabilizers (diaphragm, pelvic floor, all parts of the abdominal wall) must activate to create a fixed point for open-chain hip flexion



SAGITTAL STABILIZATION



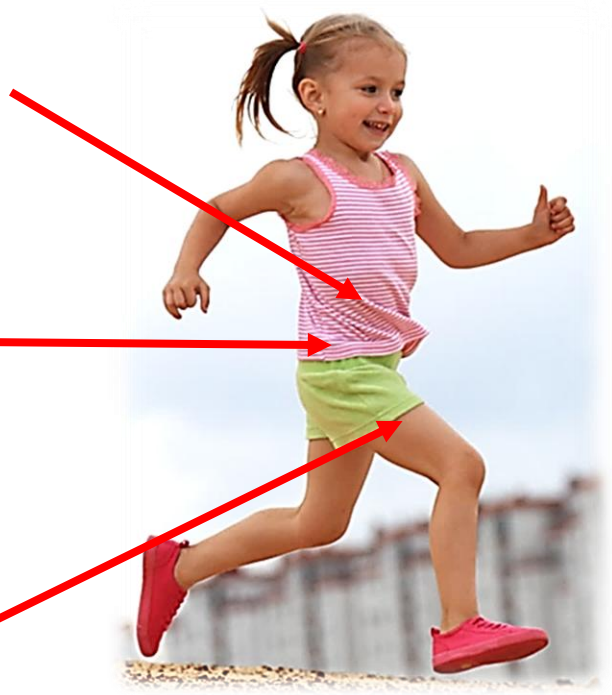
- Diaphragm
- Pelvic floor muscles
- Abdominal muscles
- Paraspinals muscles
- Short intersegmental muscles
- DNF
- Neck extensors



SPINAL (CORE) STABILIZATION

Stabilizers activate automatically (subconsciously)

Intra-abdominal pressure increases, balancing with the spinal extensors

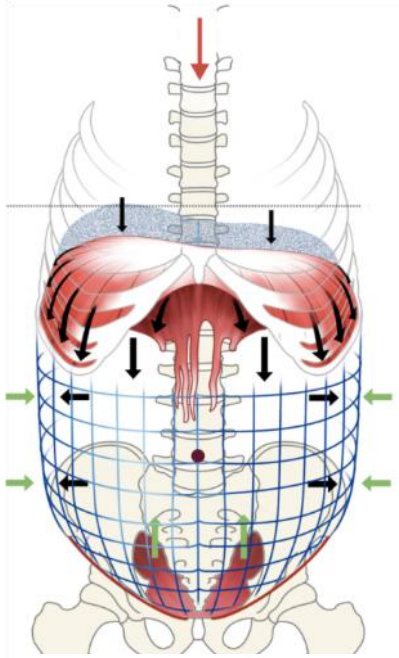


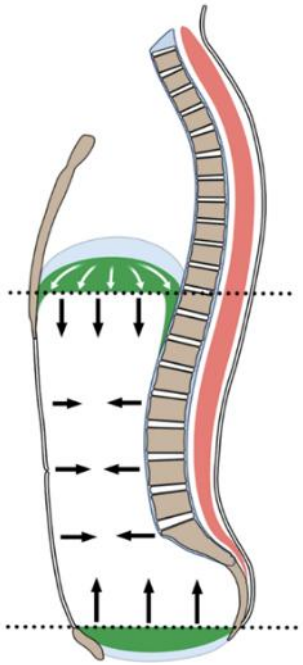
THEN

e.g. the hip flexors (iliopsoas, rectus femoris, sartorius, TFL) can be activated without decentrating the spinal segments, pelvis, and chest from their neutral position

IAP DISTRIBUTION WITH CORRECT ACTIVATION OF DIAPHRAGM

1. Physiological movement of the diaphragm should be part of all movement and exercise (feedforward mechanism)
2. Central tendon descends (abdominals hold the ribs to create the fixing point)
3. Lower ribs spread apart
4. IAP equally increases in all directions

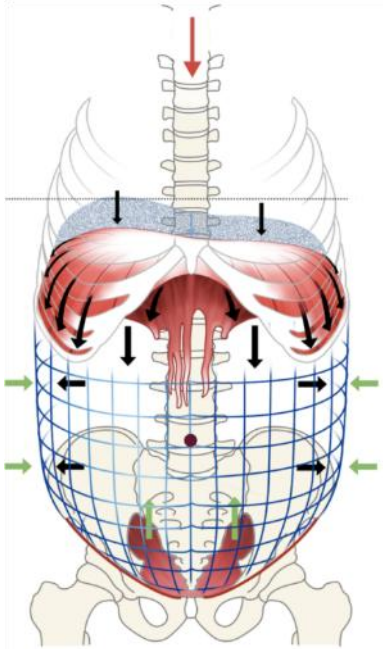


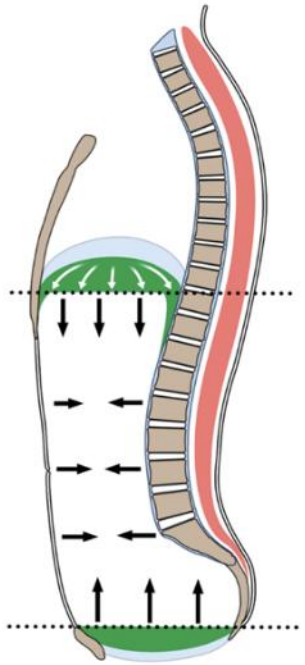


IAP DISTRIBUTION WITH CORRECT ACTIVATION OF DIAPHRAGM

5. Eccentric contraction and activity of abdominals, paraspinal muscles, QLs, serratus post. inf., pelvic floor occur.

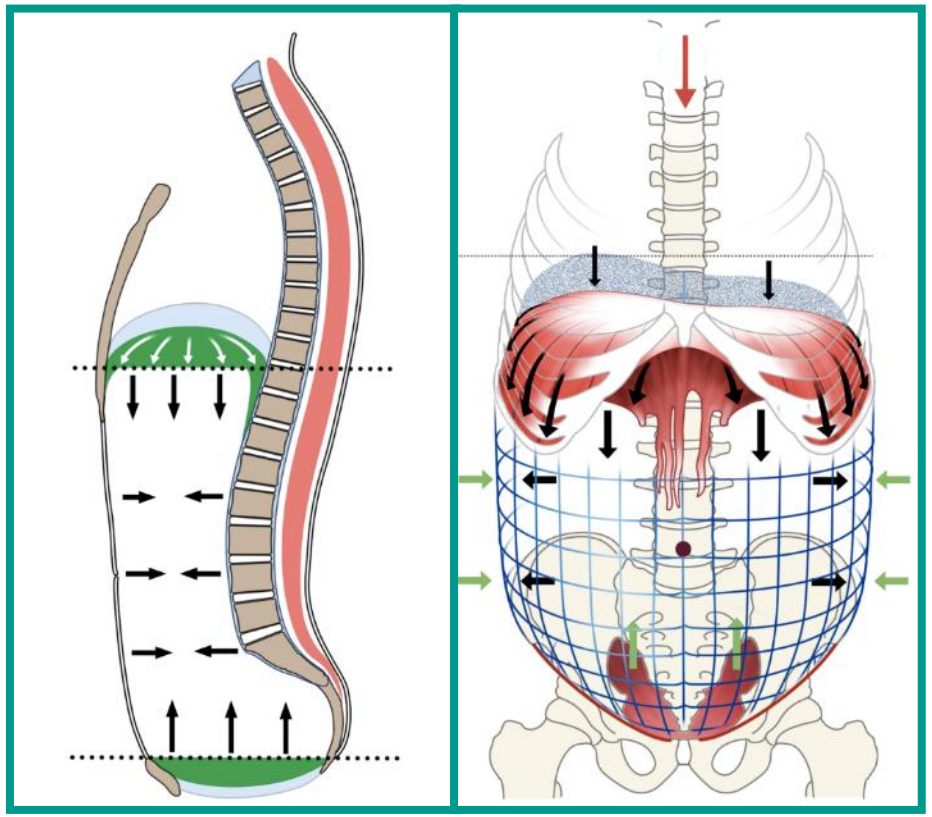
6. Concentric activity of abdominal muscles is coming into play



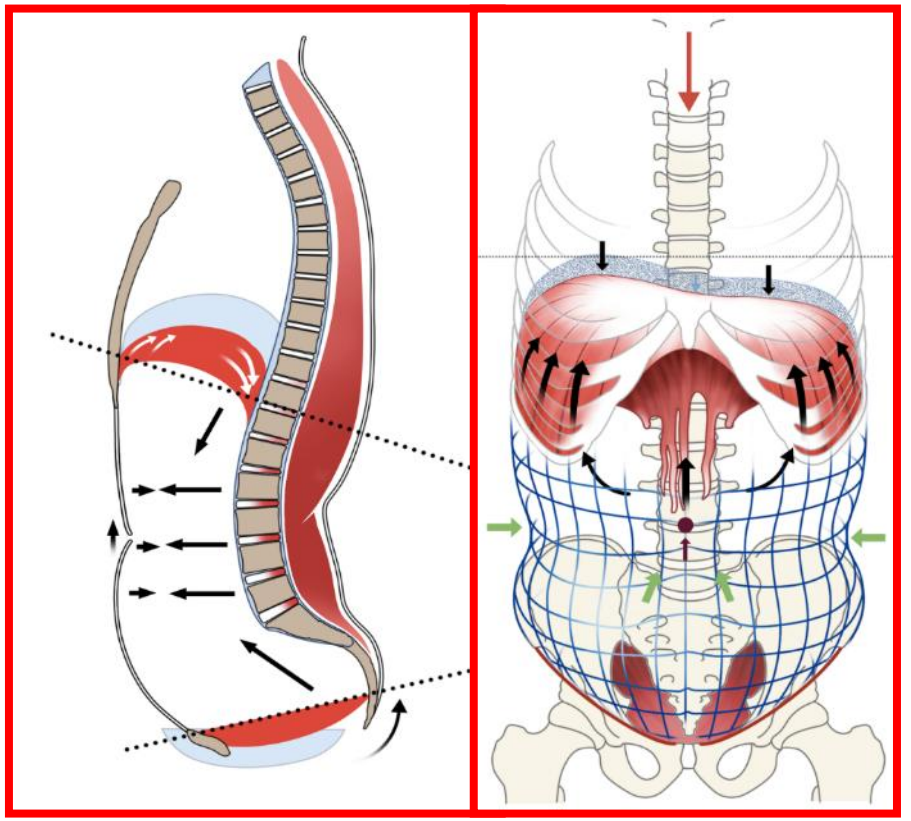


POSTURAL ACTIVITY OF THE DIAPHRAGM

Physiological



Pathological



LONG SIT ASSESSMENT

INITIAL POSITION

- Sit on or table
- Hands not supporting

INSTRUCTION

- Sit with an uprighted spine

PALPATION

- Coach
- Client self





LONG SIT + DIAPHRAGM ASSESS.

PALPATION

- Fingers above groins
- Fingers on the lateral side of the trunk



INSTRUCTION

1) Breathe normally
2) Inhale, exhale, push my fingers out
3) Maintain the pressure while keeping breathing

LONG SIT ASSESSMENT
CORRECT ALIGNMENT

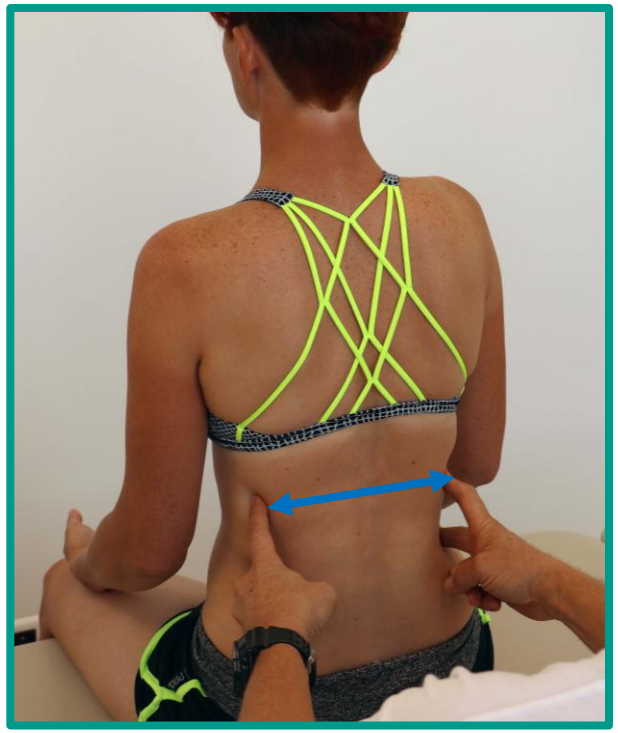
- Arms relaxed
- Pelvis in neutral position
- Lower extremities relaxed, resting on the table/mat



- Head aligned with the spine
- Abdominal wall connects pelvis and chest
- Spine uprighted

LONG SIT + DIAPHRAGM FUNCTION

CORRECT ACTIVATION



Before activation



After activation





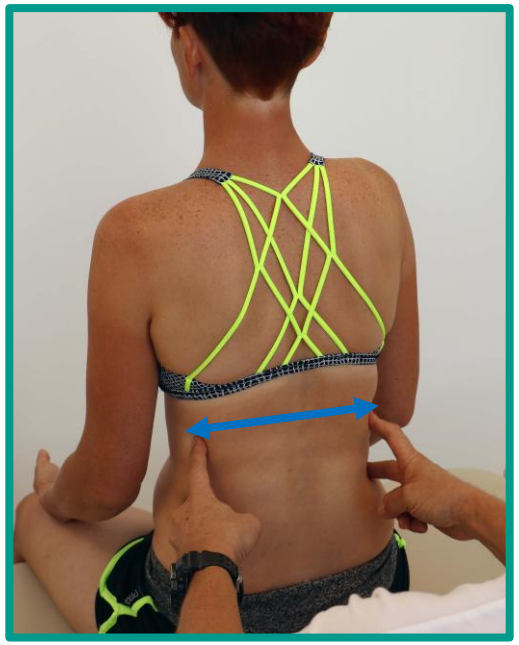
- There should be lateral expansion of the abdominal wall, symmetrical on both sides (size of expansion + force of expansion)

LONG SIT + DIAPHRAGM FUNCTION

CORRECT ACTIVATION



- Head and chest stay in the same position
- Sternum moves in costovertebral joints



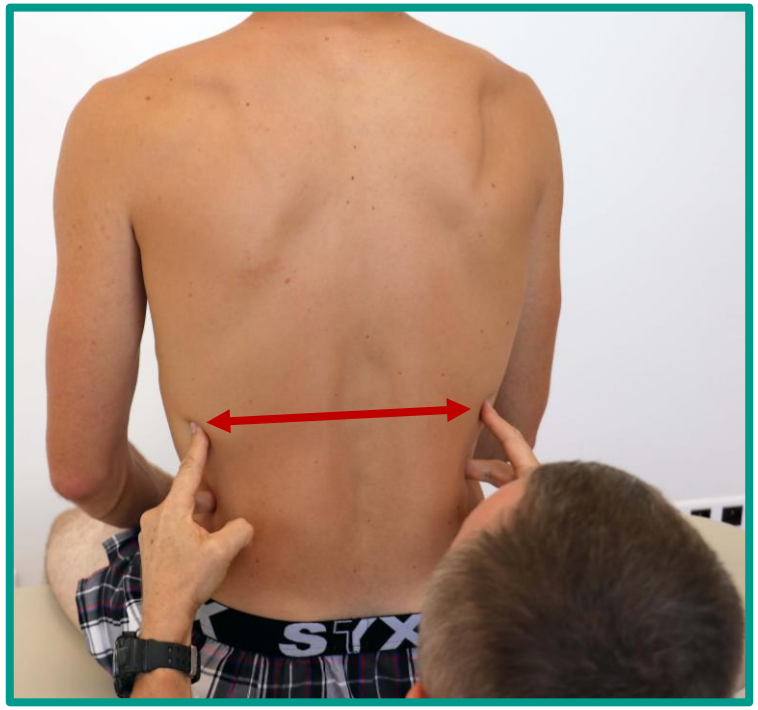
- Scapulas stay centrated
- Spine uprighted

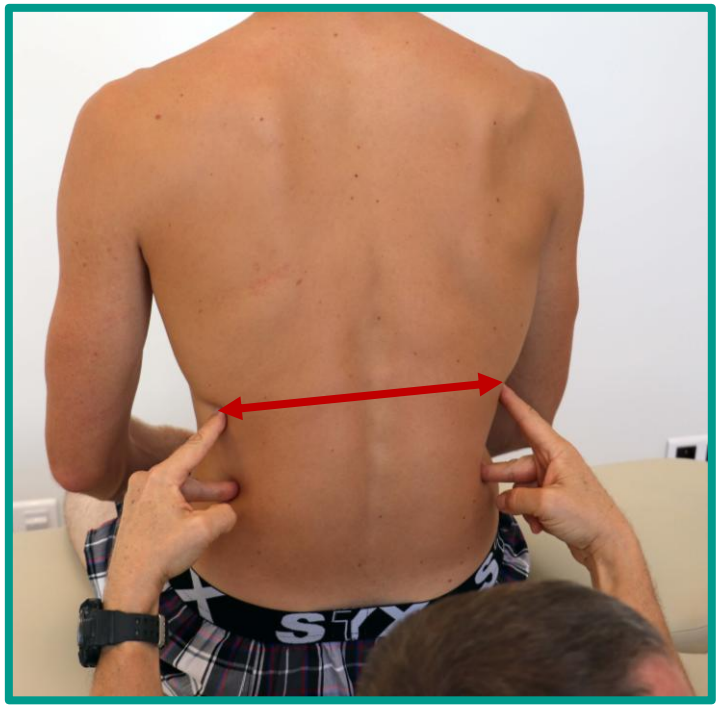


- No palm pressure
- Same loading on both thighs

LONG SIT + DIAPHRAGM FUNCTION

INCORRECT ACTIVATION

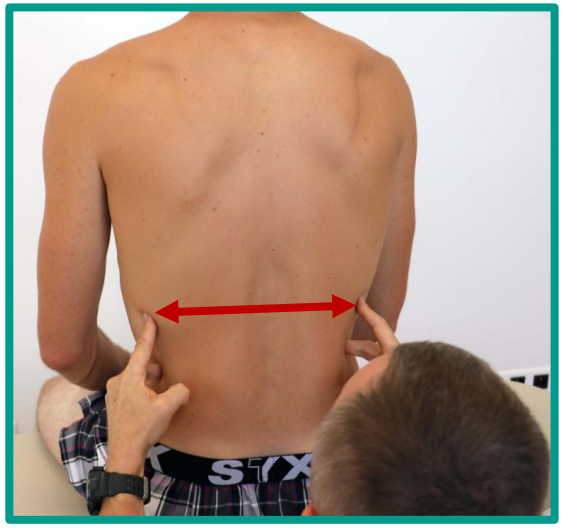


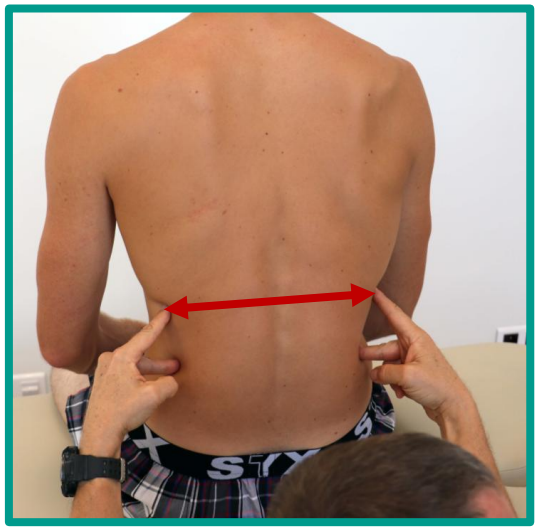


- Lateral expansion of the abdominal wall via an increase of the spinal kyphosis

LONG SIT + DIAPHRAGM FUNCTION

INCORRECT ACTIVATION





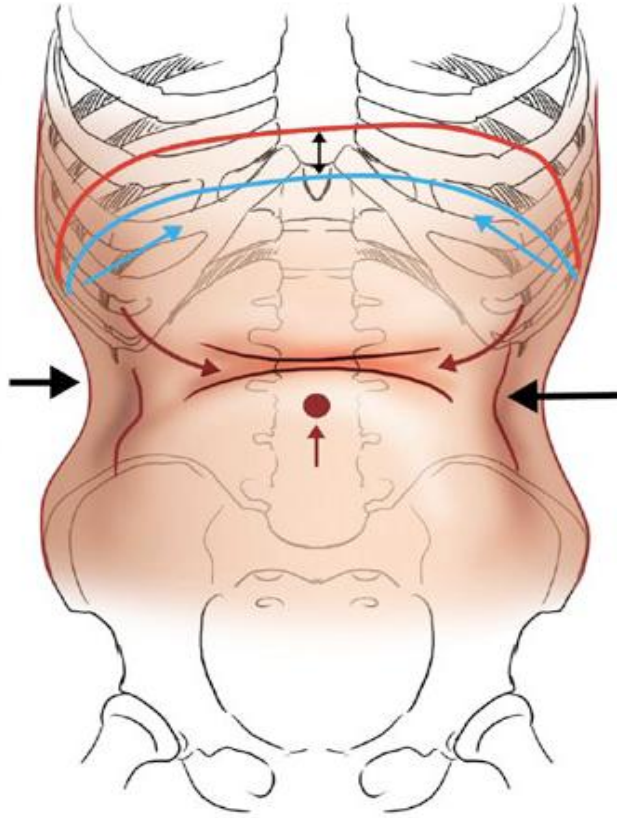


- Asymmetrical pressure against the therapist‘s fingers

- Excessive spinal kyphosis
- Excessive pressure via sucking in of the belly button

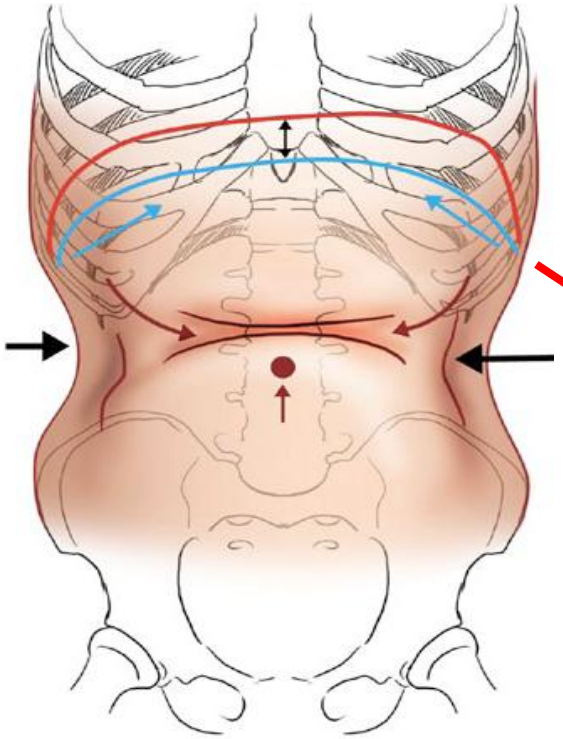
MOST COMMON PATHOLOGIES

1) **HOUR GLASS SYNDROME**
   - Hyperactivation of the m. rectus abdominis
   - Sucking inward of the abdominal wall (belly button goes in and up)
   - Problem with timing of muscle contractions



HOUR GLASS SYNDROME



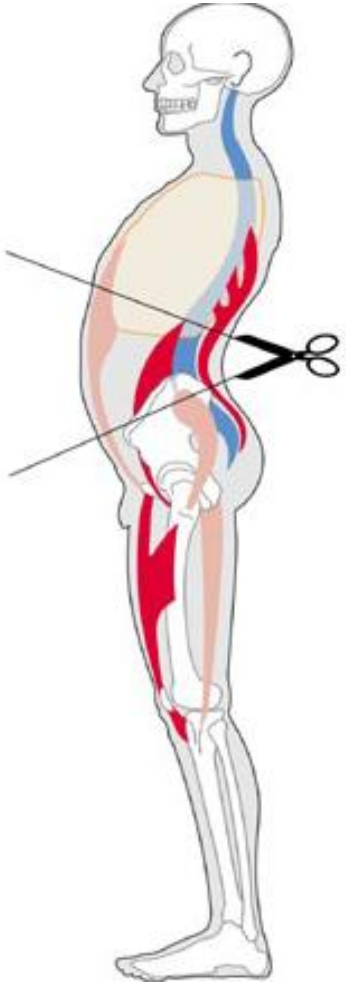




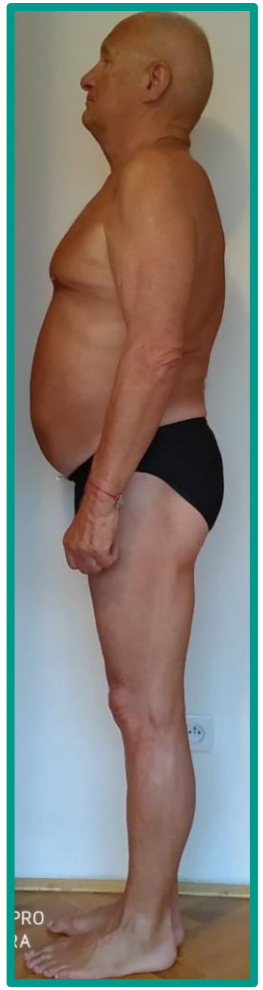
MOST COMMON PATHOLOGIES

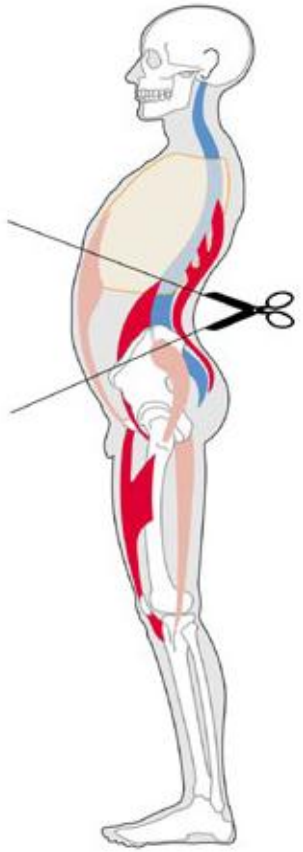
2) OPEN SCISSORS SYNDROME

- Hypoactivation of the abdominal wall
- Bulging (protrusion) of the abdominal wall, especially the lower and lateral section (belly)
- Key body segments are decentrated



OPEN SCISSORS SYNDROME







COMPROMISED STABILIZING SYSTEM



The compensatory movement lacks the efficiency of ideal movement

↓

Overloads the spinal joints and discs (over time), causing muscle overuse and repetitive strain

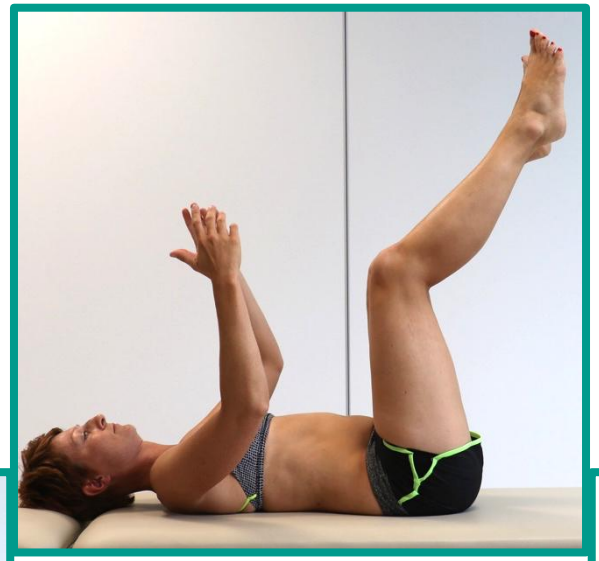
↓

Perpetuates imbalance in the locomotor system and decreased spinal stability

4.5MM TURNING

INITIAL POSITION

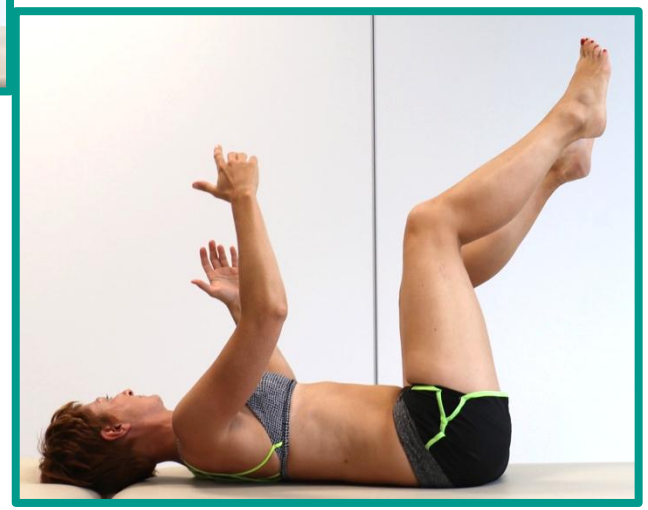
- 3MM supine



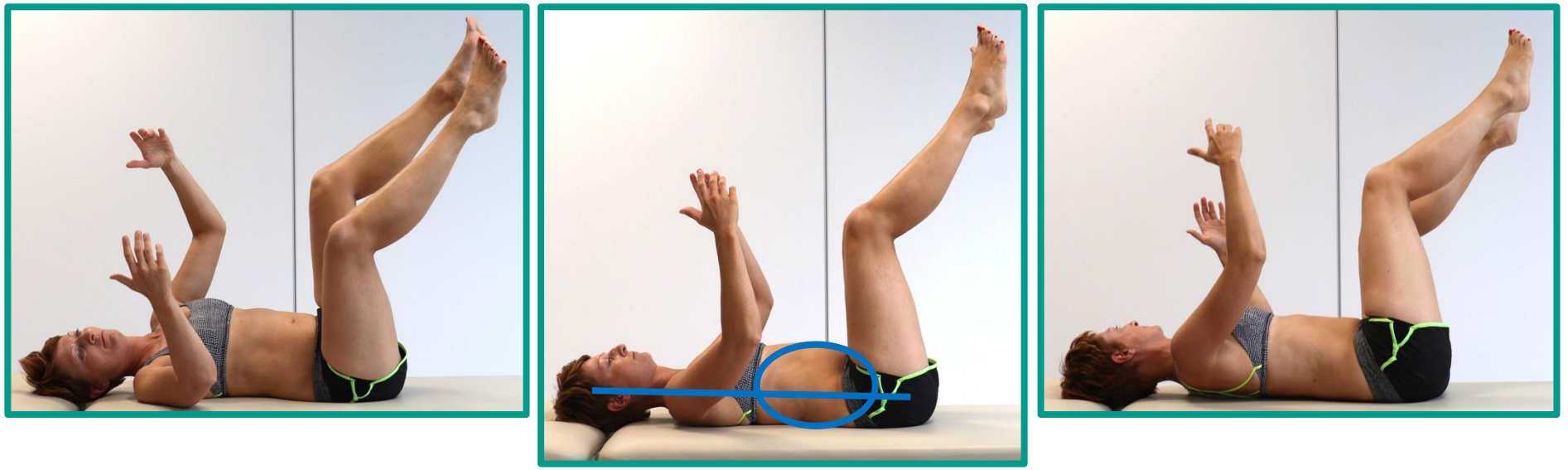
INSTRUCTIONS

- Turn to one side at a time





TURNING
CORRECT ACTIVATION

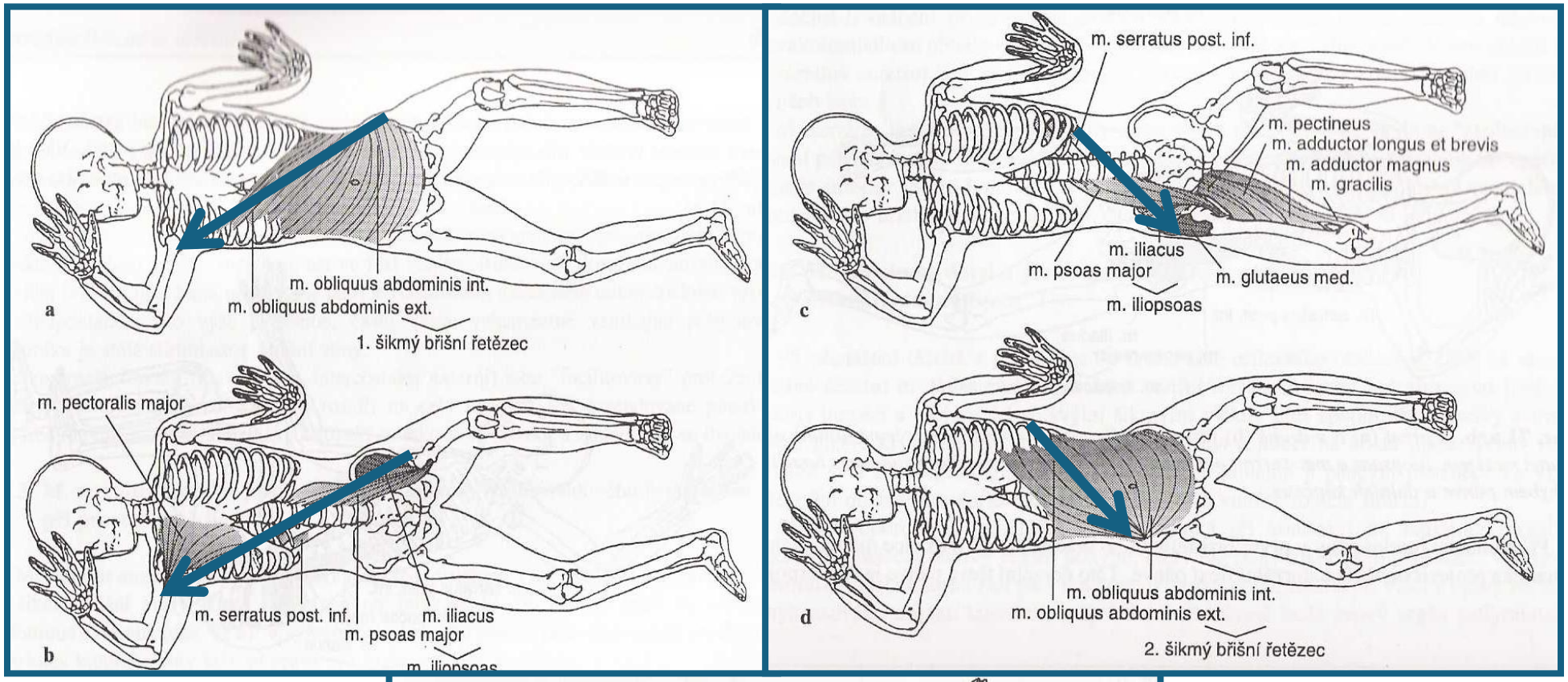


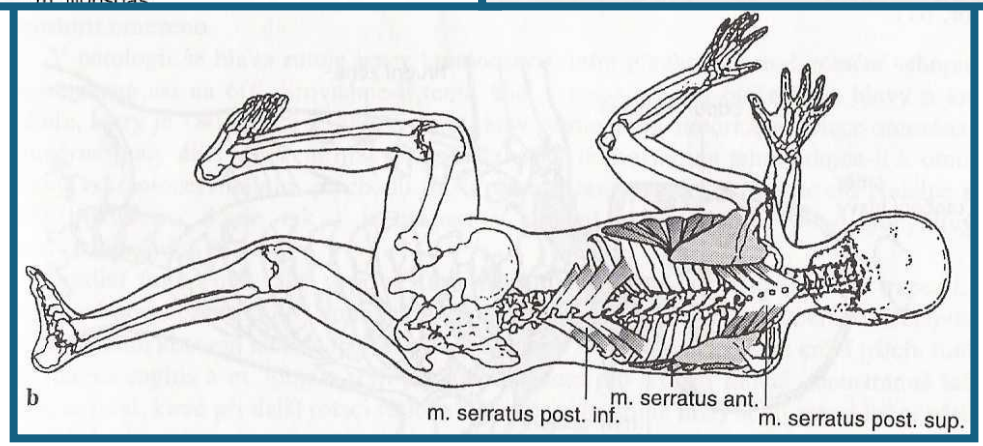
- Head in the line with the spine
- Ribcage connected to the pelvis via abdominal wall
- Spine uprighted and maintained all the way through
- Cylindrical shape of the abdominal wall

TURNING
CORRECT ACTIVATION



- Upper and lower extremities move simultaneously in the same direction
- Fluid motion from side to side
- Equal range of motion on both sides

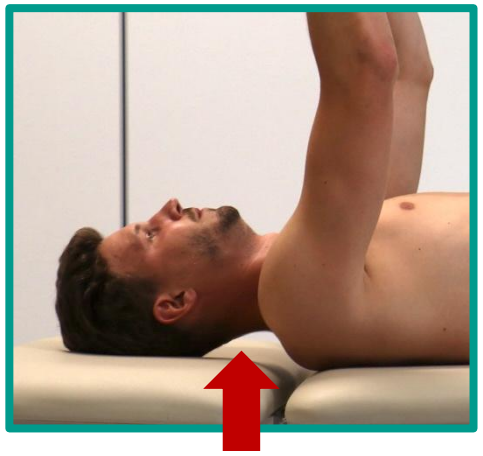

a
m. obliquus abdominis int.
m. obliquus abdominis ext.
1. šikmý břišní řetězec
b
m. pectoralis major
m. serratus post. inf.
m. iliacus
m. psoas major
c
m. serratus post. inf.
m. pectineus
m. adductor longus et brevis
m. adductor magnus
m. gracilis
m. iliacus
m. psoas major
m. glutaeus med.
m. iliopsoas
d
m. obliquus abdominis int.
m. obliquus abdominis ext.
2. šikmý břišní řetězec

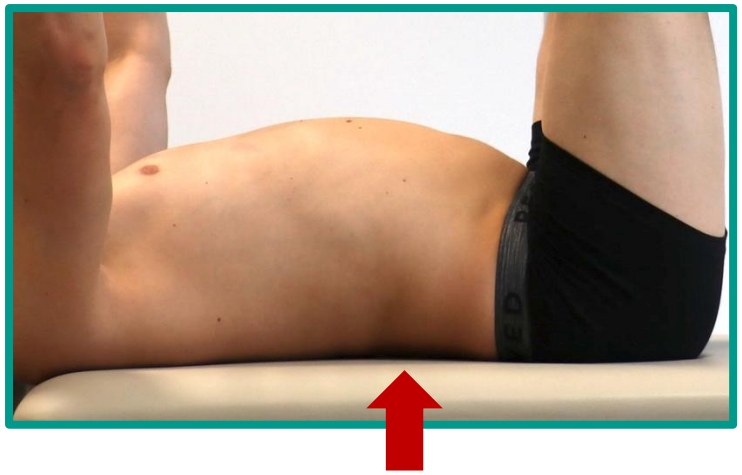

b
m. serratus post. inf.
m. serratus ant.
m. serratus post. sup.

TURNING
INCORRECT ACTIVATION



- Head in forward position
- Ribcage disconnected from pelvis
- Spine in hyperextension
- Cylindrical shape compromised
- Diastasis

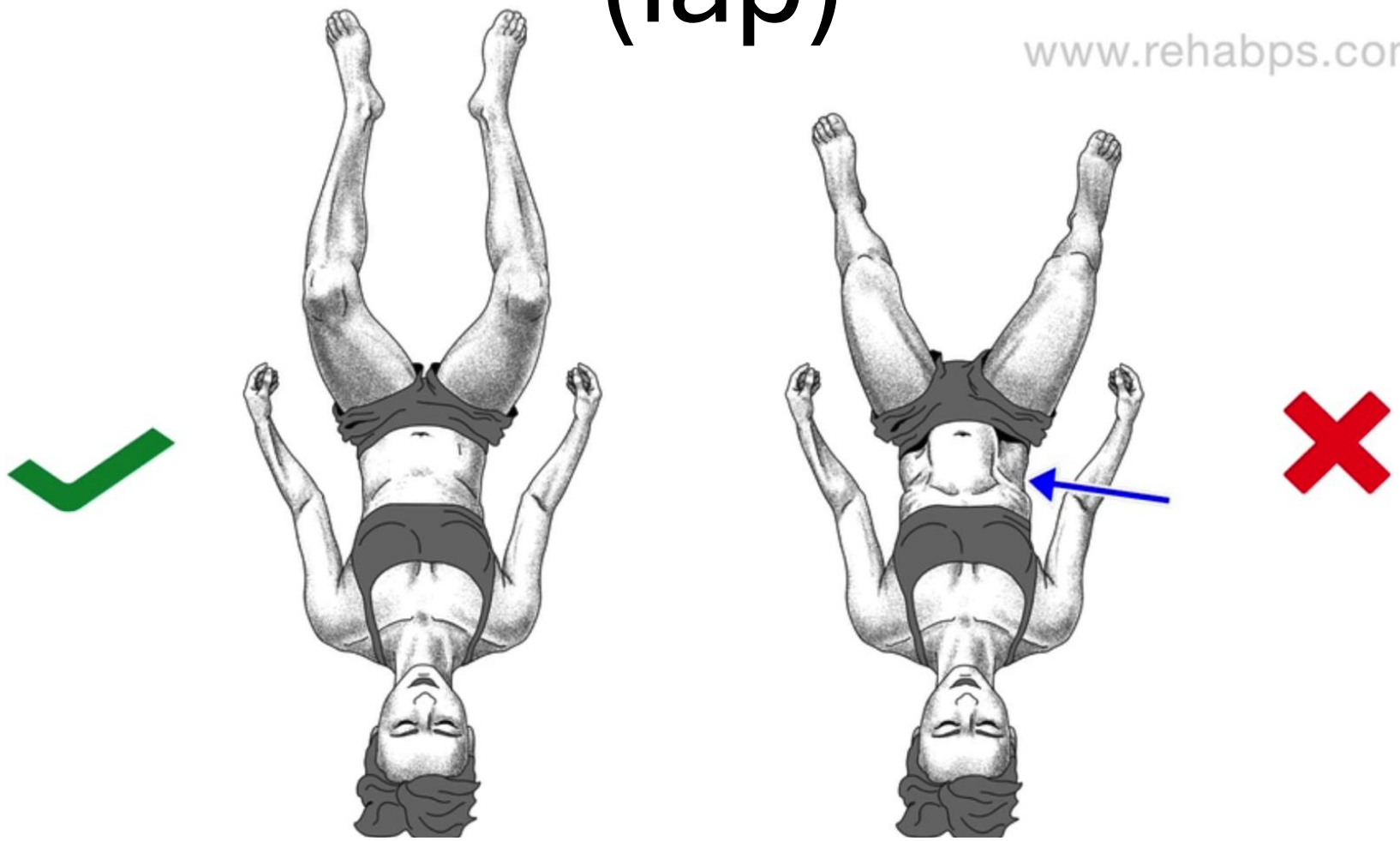




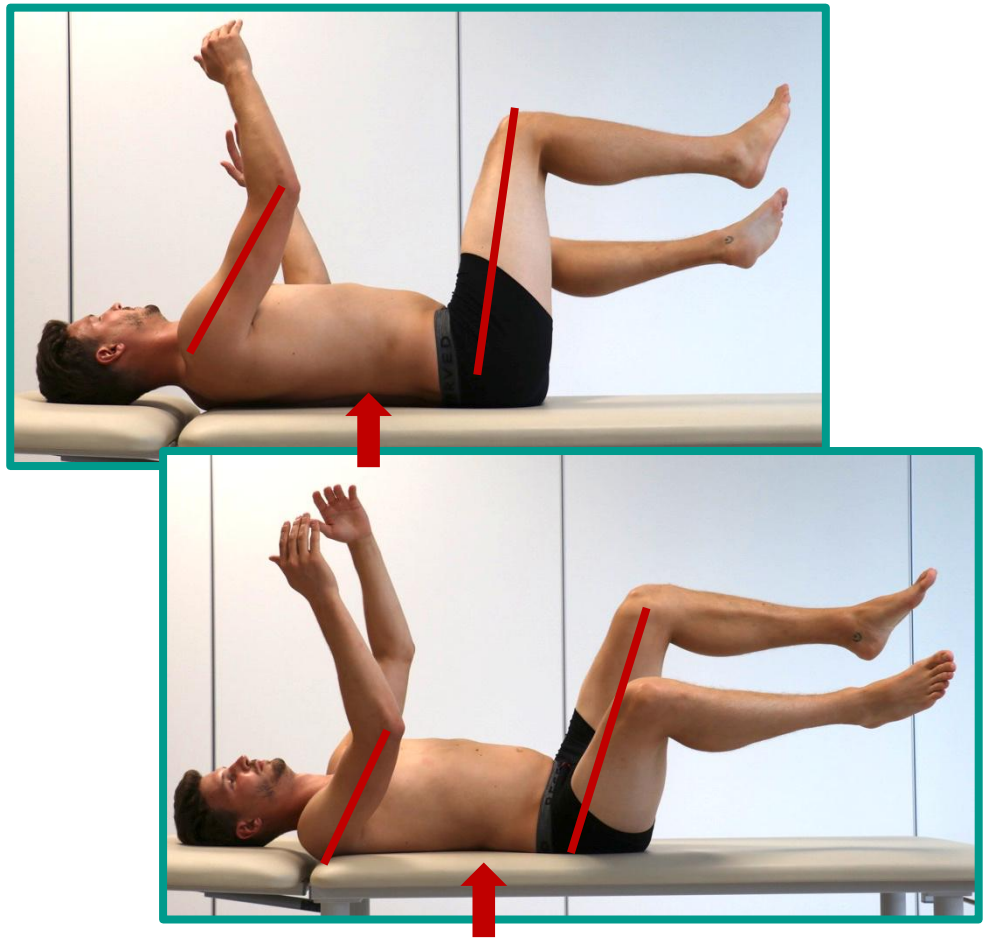


Intra-abdominal pressure (iap)

www.rehabps.com



TURNING
INCORRECT ACTIVATION



- Spine hyperextended at the end of motion
- Upper and lower extremities seem to go in opposite directions, especially when turning to the left

HOW TO APPLY DNS PRINCIPLES

- **ANALYSIS OF BODY SEGMENT ALIGNMENT** in static positions and during movements, and compare with optimal movement pattern from development kinesiology

- **ANALYSIS OF SPORT TECHNIQUE** – compare the technique according to global movement pattern – trunk stabilization, ipsilateral and contralateral pattern

RULES FOR TRAINING

1. **CENTRATION OF KEY SEGMENTS**

2. **ACTIVATION OF OPTIMAL STABILIZATION FUNCTION**

3. **ADEQUATE PROGRESSION OF LOAD, SPEED AND ENDURANCE**

1. KEY SEGMENTS CENTRATION

a) **Spine, ribcage, pelvis**

b) **Supporting segments**

c) **Girdles joints**



2. OPTIMAL STABILIZATION FUNCTION ACTIVATION

A) Utilization of respiratory phases

B) Pressure (approximation) of supporting segments

C) Resistance applied against movement of stepping forward extremities







3. APPROPRIATE LOADING PROGRESSION

1) **Holding /static position**
2) **Initiation of isolated movement**
3) **Isolated movement in full range**
4) **Initiation of transition into next position –** forward/reverse movement
5) **Locomotor phase** – whole course of movement



3. APPROPRIATE LOADING PROGRESSION

- **OKC = strengthening via pulling**
  - Phasic movement against resistance
  - Pulleys, Thera-Band etc.

- **CKC = strengthening via pushing in supporting function**
  - Joint loading = approximation
  - Kettlebell, lifting bar, body weight

OKC=open kinematic chain, CKC=closed kinematic chain

TIME FRAME FOR IMPROVEMENT WHEN DNS IS APPLIED

- In approximately 6 -12 weeks changes in stabilization quality can be observed
- It takes 3 to 6 months for integration of new stabilization - **can cause temporary decrease in performance!**
- 7-9 (12) month - **gradual increase in performance, injury free training**

DNS PRINCIPLES INCLUSION IN TRAINING

- Start in preparatory phase
- Can be implemented into “warm up“ and/or “cool down“
- Combine exercises with body weight and with external load – elevate threshold of optimal stabilization during loading
- Tied up with technique training in specific components (trunk stabilization, pelvis rotation, isolated hip flexion or hip hinge, foot position, scapular position etc.)

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