

# Biomechanics of Gait



**Odb. As. MUDr. Robert Vyskočil**

Ortopedická klinika LF MU a FN Brno

**Přednosta: Prof. MUDr. Martin Repko, Ph.D.**

## **Objectives:**

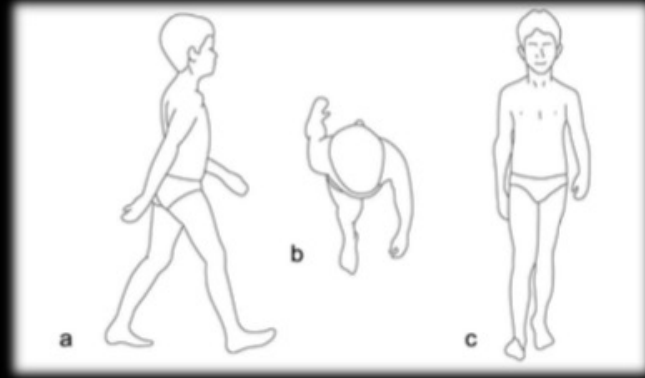
- 1. Define gait.**
- 2. Describe gait cycle.**
- 3. Kinematical parameters of gait.**
- 4. Define the center of gravity (COM).**
- 5. Displacement of COM.**
- 6. Foot functions.**

# What is gait?

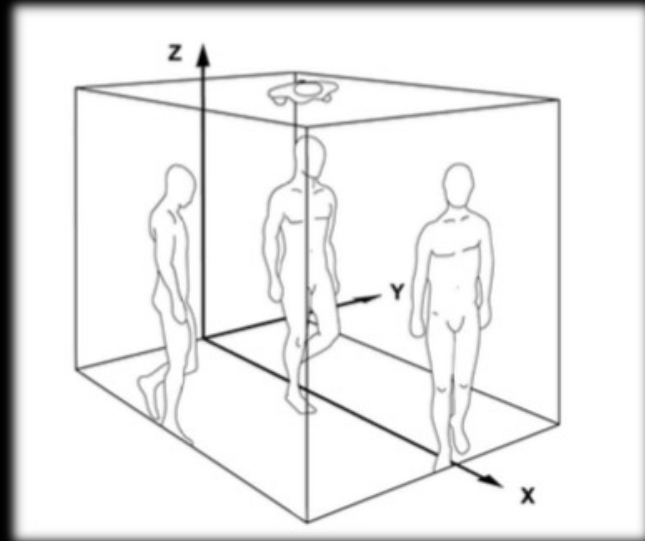
**Translatory progression of the body as a whole,  
Produced by coordinated rotatory movements of  
body segments.**

**Chůze** je lokomoční pohyb využívající dolní končetiny a je vlastní dvounohým (bipedálním) živočichům jako je i člověk. Umožňuje přemístění z jednoho místa na místo druhé. **Chůze** se skládá z jednotlivých kroků, kdy se pravidelně střídá jedna noha za druhou, čímž dochází k pohybu.

The gait in the three principal planes: (a) sagittal; (b) transverse; and (c) frontal.



The three dimensional of movement.



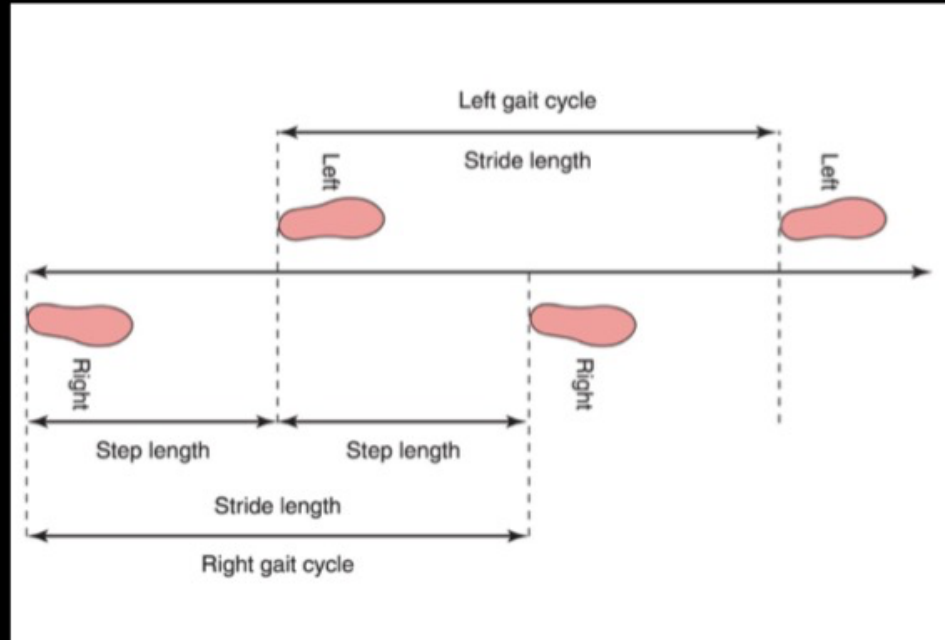
# Kinematics of Gait

## “Gait cycle”

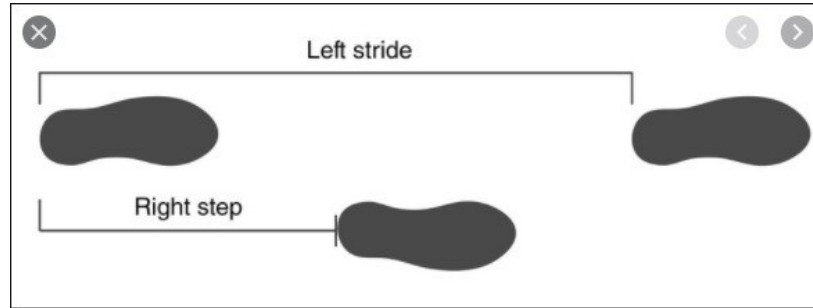
**The stride:** is the activity that occurs between the time one foot touches the floor and the time the same foot touches the floor again.

**Step:** is basically one-half of a stride.

**Step length:** is that distance between heel strike of one foot and heel strike of the other foot.



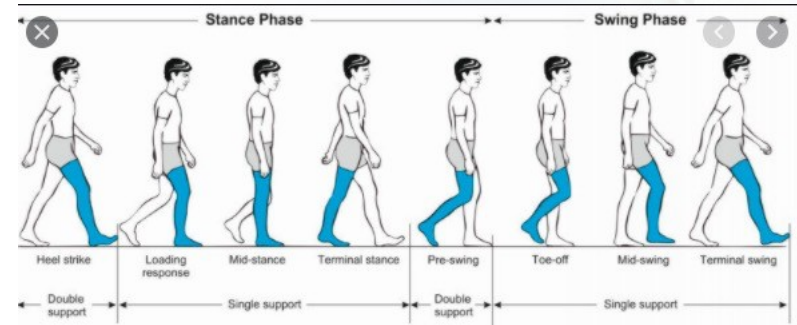
# Stride x Step



## Gait Cycle & Gait Analysis

Structure: Whole Body  
Pathology: Various

### Assessment





# Gait Cycle & Gait Analysis



Přehrát po...



Sdílet



Info...

Stance



0%

10%

30%

50%

60%

Initial Contact

Load Response

Heel Off

Opposite Initial Contact

Toe off

-Loading Response-----Mid Stance-----Terminal Stance-----Pre Swing-----

Swing



73%

87%

100%

Feet Adjacent

Tibia Vertical

Next Initial Contact

DALŠÍ VIDEA

-Initial Swing-----Mid Swing-----Terminal Swing-----

Subscribe



3:34 / 5:26

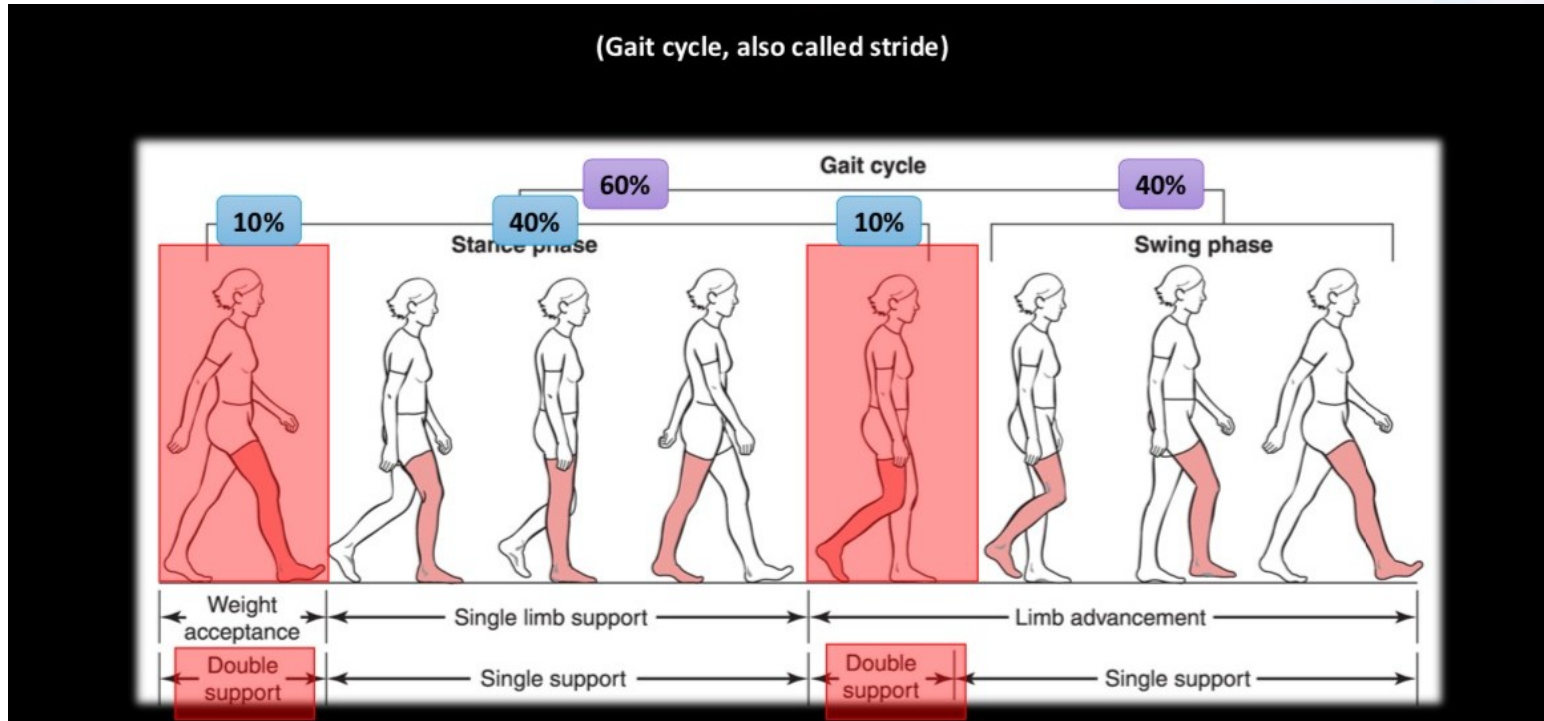


YouTube



# Gait cycle

60% Stance phase, 40% Swing phase



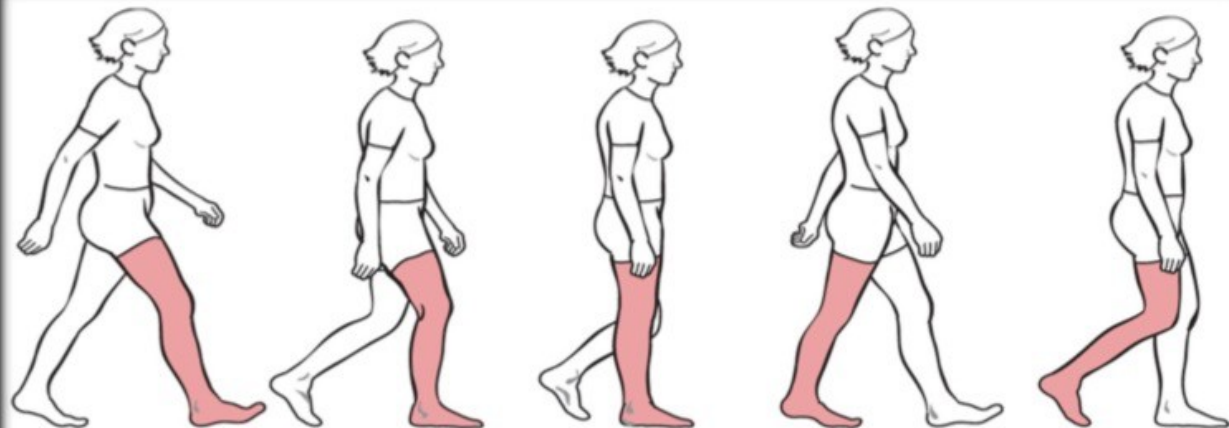


# Analysis of Stance Phase

Foot Initial Contact

Foot leaves the ground

60 % of the gait cycle.



Traditional Term. →

Heel strike

Foot flat

Midstance

Heel-off

Toe-off

Rancho Los Amigos Term. →  
(RLA)

*Initial contact*

*Loading response*

*Midstance*

*Terminal stance*

*Preswing*

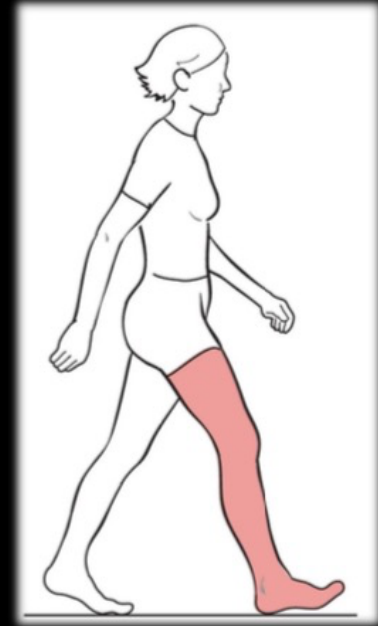


# 1. Stojná fáze

## Stance Phase

### ❖ **Initial Contact (Heel strike)**

- The beginning of the stance phase that occurs when the foot touches the ground.
- Initial Contact is not really a phase, it is an instant in time.
- Double leg support begins.
- Body at lowest point in cycle.



# Stance Phase

## ❖ Loading Response (Foot flat)

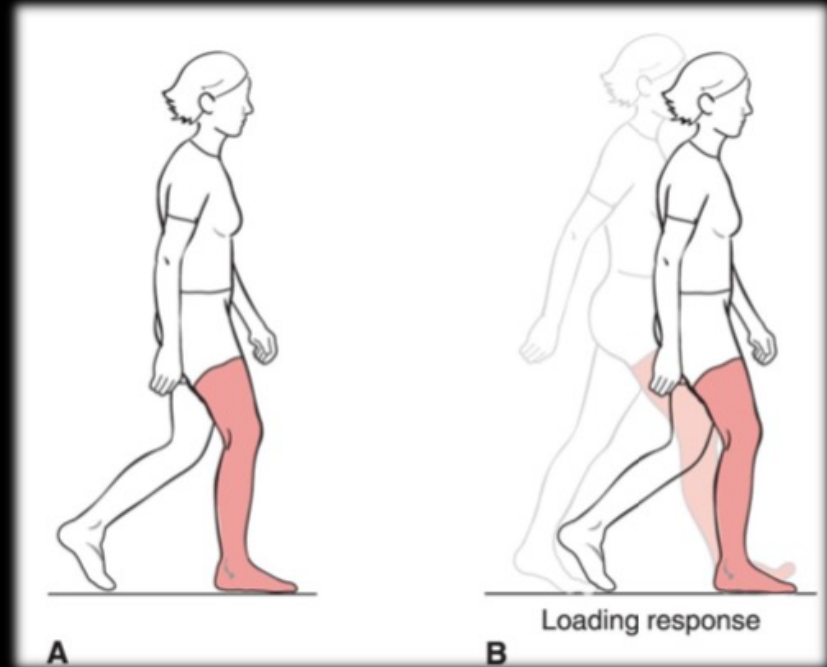
Initial Contact



Foot flat

▪ 0:10% of gait cycle

- Weight shift onto stance leg continues.
- Double leg support ends.



# Stance Phase

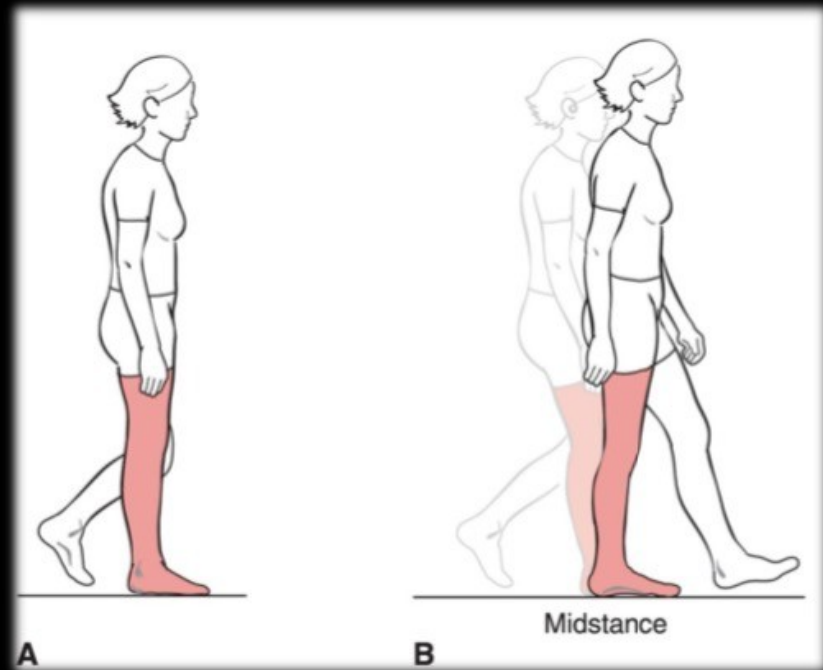
## ❖ Midstance

Foot flat



Midstance

- 10:30% of gait cycle
  - Body at highest point in cycle.
  - Single leg support begins.



# Stance Phase

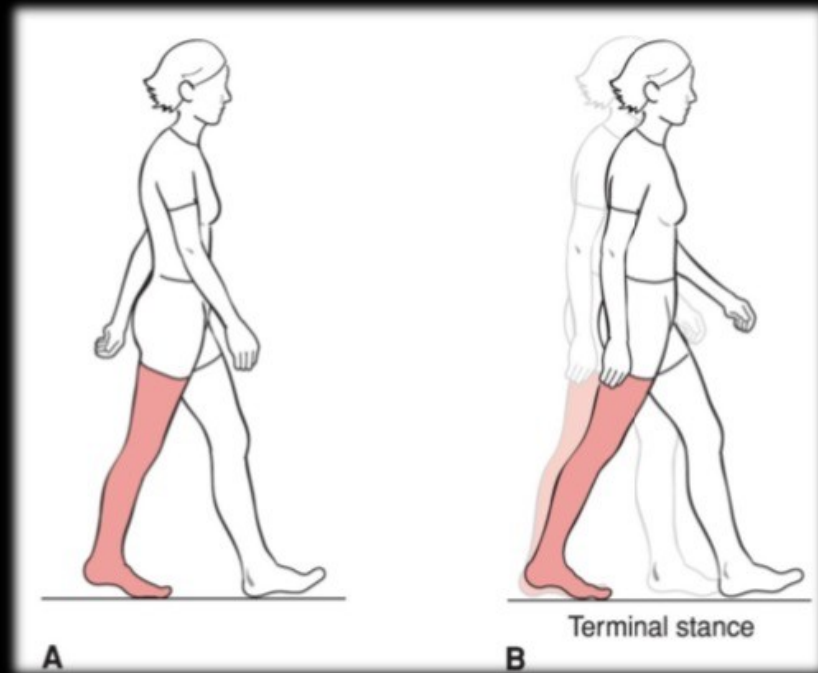
## ❖ Terminal Stance (Heel-off)

Midstance



Heel-off

- 30:50% of gait cycle
  - Body moves ahead of foot.
  - Single leg support ends.



# Stance Phase

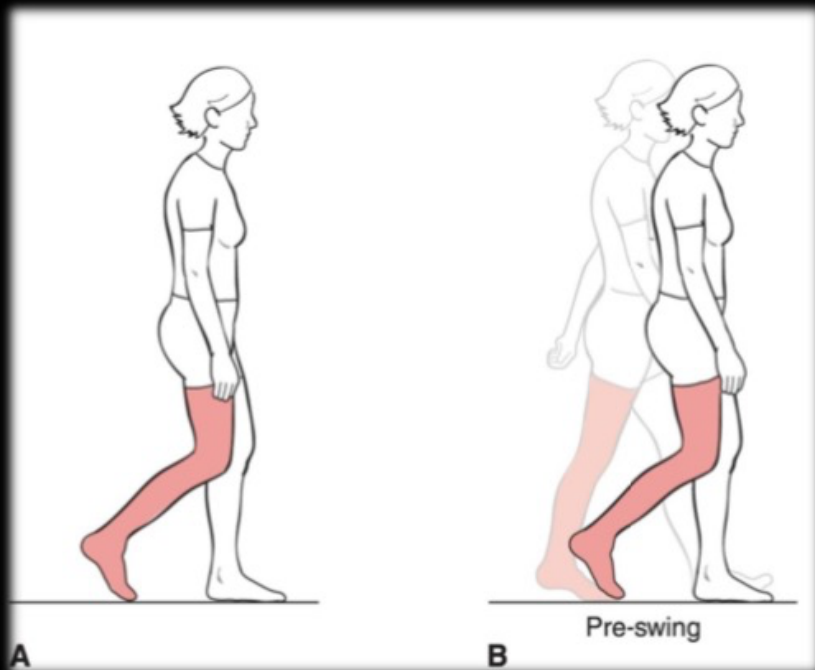
## ❖ Pre-swing (Toe-off)

Heel-off



Toe-off

- 50:60% of gait cycle
- Task of leg advancement begins.
- Double leg support begins and ends.



# Analysis of Swing Phase

Foot leaves the ground



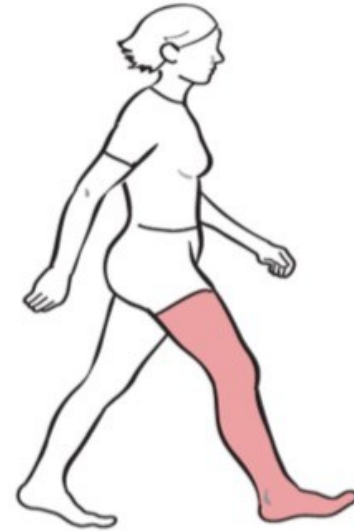
Foot Initial Contact



*Initial swing*



*Midswing*



*Terminal swing*

40 % of the gait cycle.

## 2. Fáze švihová

### Swing Phase

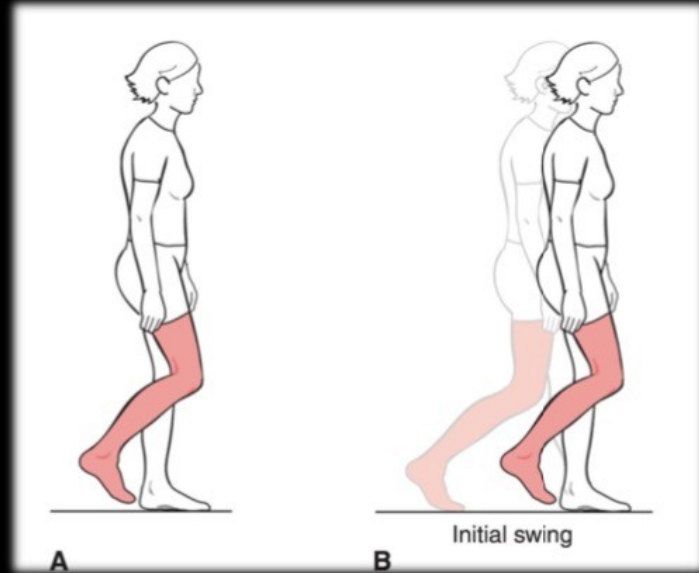
#### ❖ Initial Swing (Acceleration)

Toe-off



Initial Swing

- 60:73% of gait cycle
- Swing phase (non-weight-bearing) begins.
- Single leg support begins on contralateral side.





# Swing Phase

## ❖ Midswing

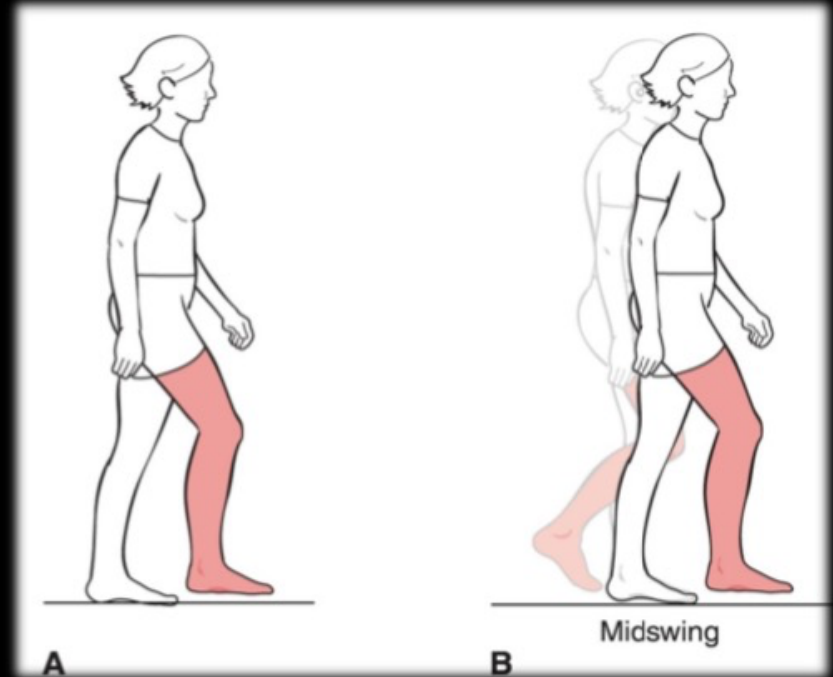
Initial Swing



Midswing

▪ 73:87% of gait cycle

- Leg shortens to clear floor.
- Single leg support on contralateral side continues.



# Swing Phase

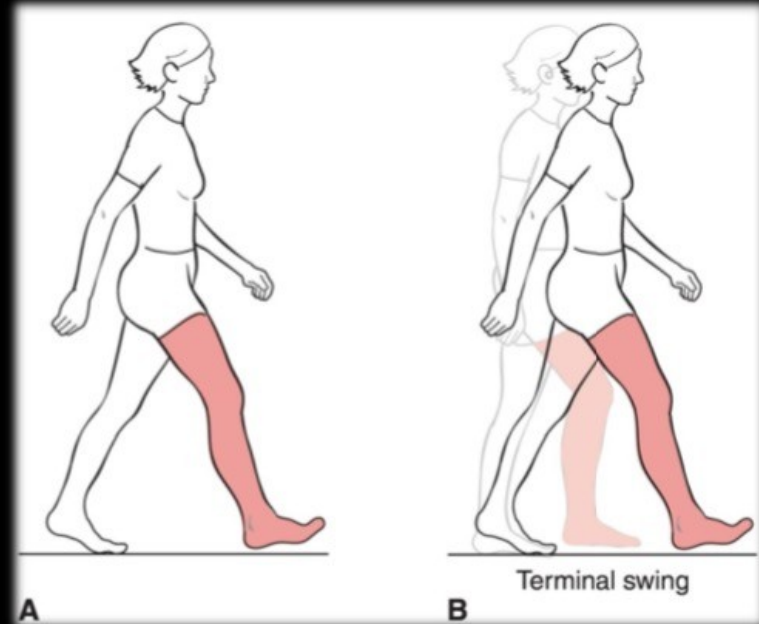
## ❖ Terminal Swing (Deceleration)

Midswing



Terminal Swing

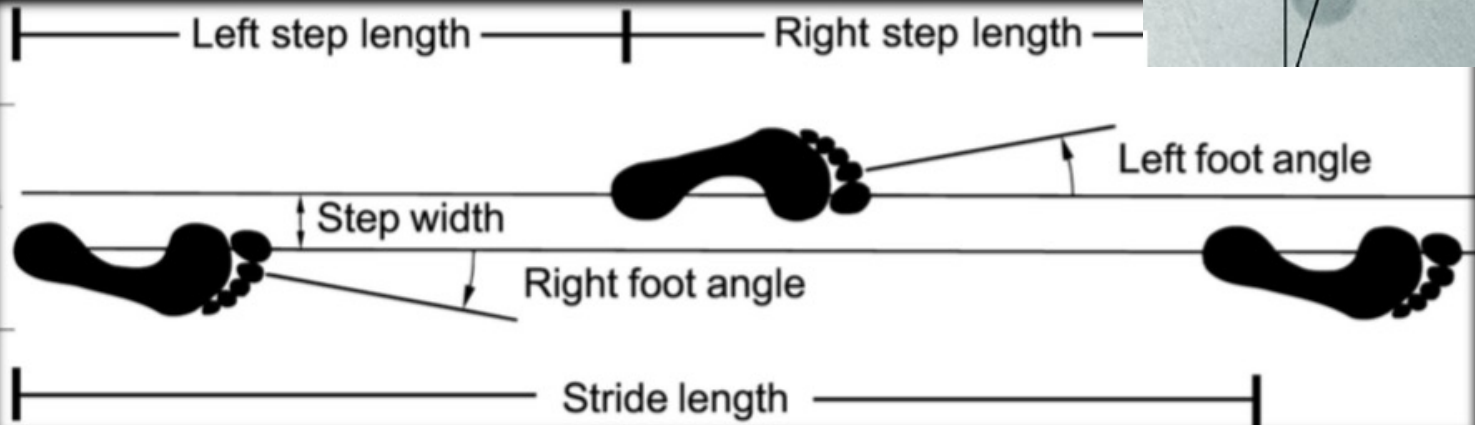
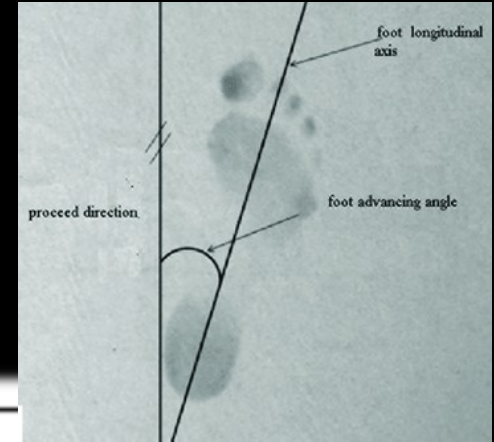
- 87:100% of gait cycle
- Leg advancement task ends.
- Single support ends.



# Kinematické parametry

## A) Distance parameters:

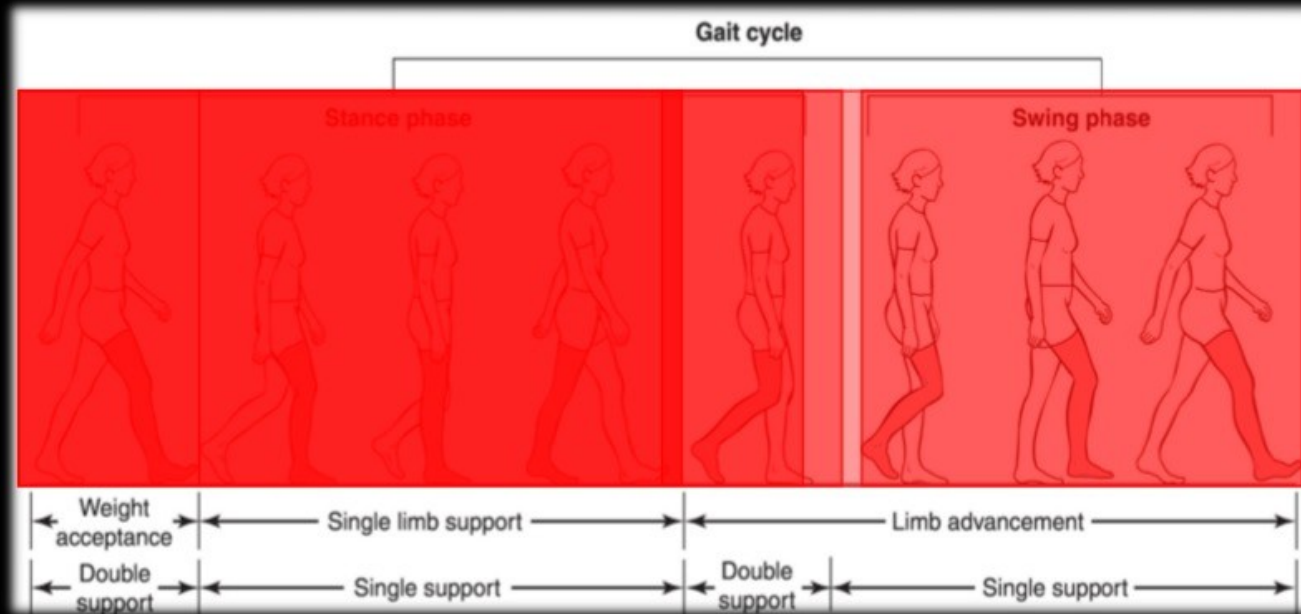
- Stride length.
- Step length.
- Width of walking base “stride width”: ( $\approx 5-10\text{ cm}$ ).
- Foot angle (degree of toe out or angle of gait):  $\approx 7^\circ$ .



# Kinematical parameters

## B) Time parameters:

- Step time
- Stride time
- Stance time
- Single limb time
- Double limb time
- Swing time



# Kinematical parameters

## C) Cadence and Speed:

### ▪ Cadence :

- Number of steps per unit time
- Normal: 100 – 115 steps/min.

### ▪ Speed:

- Distance covered by the body in unit time
- Average speed (m/min) = step length (m) x cadence (steps/min).
- Average walking speed= 80m/minute (1.33 m/sec).

# Normal range of parameters

## Female

Approximate range (95% limits) for general gait parameters in free-speed walking by normal FEMALE subjects of different ages

Age (years)	Cadence (steps/min)	Cycle time (s)	Stride length (m)	Speed (m/s)
13-14	103-150	0.80-1.17	0.99-1.55	0.90-1.62
15-17	100-144	0.83-1.20	1.03-1.57	0.92-1.64
18-49	98-138	0.87-1.22	1.06-1.58	0.94-1.66
50-64	97-137	0.88-1.24	1.04-1.56	0.91-1.63
65-80	96-136	0.88-1.25	0.94-1.46	0.80-1.52

## Male

Approximate range (95% limits) for general gait parameters in free-speed walking by normal MALE subjects of different ages

Age (years)	Cadence (steps/min)	Cycle time (s)	Stride length (m)	Speed (m/s)
13-14	100-149	0.81-1.20	1.06-1.64	0.95-1.67
15-17	96-142	0.85-1.25	1.15-1.75	1.03-1.75
18-49	91-135	0.89-1.32	1.25-1.85	1.10-1.82
50-64	82-126	0.95-1.46	1.22-1.82	0.96-1.68
65-80	81-125	0.96-1.48	1.11-1.71	0.81-1.61

# Foot functions

The foot given several unique functions to fulfill during the time it is in contact with the ground.

- Absorb shock at heel strike.
- Adapt to the ground surface.
- Provide a stable platform for the body.
- Become a rigid lever for propulsion.



- „Orthopaedic point“ –
  - Limping – sign of painful ...
  - hip joint
  - trochanteric bursa
  - SI joint
  - lumbar spine pathology
- Shortening of the stance phase of the gait





- „Orthopaedic point“ -
- Trendelenburg gait / limping

### Definition/Description:

The trendelenburg gait is caused by a unilateral weakness of the hip abductors, mostly the gluteal musculature. This weakness could be due to [superior gluteal nerve](#) damage or in 5th lumbar spine lesion. This condition makes it difficult to support the body's weight on the affected side. During normal [gait](#), both lower limbs bear half of the body weight in some part of stance phase. When one lower limb is lifted in swing phase, the other takes the entire weight. **During the stance phase of gait**, the pelvis tilts downwards on the weight-bearing extremity and hikes up on the non-weight bearing extremity. But when there is a hip abductor weakness, the pelvis tilts downwards instead of upwards on the non-weight bearing extremity. In an attempt to lessen this effect, the person compensates by lateral tilt of the trunk away from the affected hip, thus center of gravity is mostly on the stance limb causing a reduction of the pelvic drop.

[1] [2] [3][4][5]



- Trendelenburg gait / limping
  - Weakness of abductors -  
m.gluteus minimus et medius
  - Paresis of n. gluteus superior
  - Pathology - radiculopathy of L5 nerve



Positive sign

*Děkuji za pozornost.*

