Orthopedic Physical Examination in Children and Gait

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Approach

• Friendly, and Gentle fashion
• On the Mother’s lap
• Still Nervous-exam parent and sibling
• Carry her to the opposite side of the room
• Examine the painful site last
Two step in Examination

1. Screening test

2. Complete musculoskeletal evaluation
A. Infant screening
- Paralysis: brachial plexus injury
- Pseudoparalysis: clavicle fracture, proximal humeral physeal separation. Septic hip in infant (only symptom).
- LLD, asymmetric gluteal folds: DDH
- General hypermobility related condition: DDH, FFF,
B. Child & adolescent screening

: Underclothing

1. General inspection: anatomic position, front, side, back (typical appearance clue to Dx)

Proteus syndrome
Poland Syndrome

Agenesis of Pectoralis Major

Microdactyly

Neurofibroma (Café-au-lait spot)

Prepuberty: diameter 5mm <
Postpuberty: diameter 15mm <
--More than 6 in number
Screening test

2. Pelvis and Back

- Iliac crest: even-level or not. LLD
- Trendelenburg test: DDH
- Forward bending: Scoliosis
## Screening test

### 3. Assessing Gait

#### Rotational profile

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Normal Values</th>
<th>significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot-progression angle</td>
<td>-5 to +20</td>
<td>Nonspecific</td>
</tr>
<tr>
<td>Medial rotation</td>
<td>20-60</td>
<td>Femoral anteversion</td>
</tr>
<tr>
<td>Lateral rotation</td>
<td>30-60</td>
<td>Femoral anteversion</td>
</tr>
<tr>
<td>Thigh-foot angle</td>
<td>0 to +20</td>
<td>Tibial torsion</td>
</tr>
<tr>
<td>Foot configuration (Foot lateral border)</td>
<td>Straight</td>
<td>Metatarsus adductus</td>
</tr>
</tbody>
</table>
Specific evaluation

A. Joint mobility

- Wynn-Davis test
- Beighton scoring system
Specific evaluation

A. Joint mobility

- Severe in child, decrease with aging
- Personal Variable
- Genetic tendency
- Pathologic: Elher-Danlos, Marfan
- Wynn-Davis 4 or 5 positive in 7% of children
- FFF, patella dislocation, sprain, DDH
Specific evaluation

B. Range of Motion

- Change with growing
- Most wide in infant
- Affected with intrauterine condition
- One muscle can affect to two joint (Hamstring, gastrocnemius)
C. Deformity

- Functional deformity: 2ndary deformity of joint due to muscle contracture: LLD with adducted hip in CP, LCP
- Structural deformity: congenital deformity.
Specific evaluation

D. Altered function

Acute type:
- Trauma, infection
- Well known onset time
- Swelling, pain, tenderness, LOM

Chronic type
- More serious disease
- Not clear onset time; ignored
- Deformity, underlying disease
Specific evaluation

E. Pain

Very important
Real structural problem
Back pain in children:
(Discitis, Histocytosis, leukemia, malignant lymphoma)
Most common cause: trauma.
(Microfracture, overuse syndrome-sport related)
Specific evaluation

D. Point of Maximum Tenderness
Very effective to know cause of pain
(Osgood-Schlatter, Sever, Freiberger)
Easy for X-ray order
Important in X-ray reading:
(DDX between fx and 2\textsuperscript{nd} ON)
A. 1 month old girl : click of hip : (DDH)

• Birth history : Breech (20-30% of DDH), primigravida, oligohydroamniosis, CMT

• Family history

• Physical examination
  < 3m : Barlow provocative test & Ortolani sign
  > 3m : Abduction limitation
**Diagnosis**
*(Physical Examination)*

**Fig. 7.19 Barlow's Sign.** Hip instability is demonstrated by attempting to gently displace the hip out of the socket over the posterior acetabular rim.

**Fig. 7.20 Ortoloni's Sign.** The thigh is first adducted and depressed to subluxate the hip. The thigh is then abducted. The hip reduces with a palpable “clunk.”
B. 2 year-old boy: Bow leg & intoeing: (physiologic or pathologic intoeing)

- Development delay: CP?

<table>
<thead>
<tr>
<th>Age</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mo</td>
<td>Partial head control in prone position</td>
</tr>
<tr>
<td>2 mo</td>
<td>Good head control in prone position; partial head control in supine position</td>
</tr>
<tr>
<td>4 mo</td>
<td>Good head control in supine position; rolls over prone to supine</td>
</tr>
<tr>
<td>5 mo</td>
<td>Rolls over supine to prone</td>
</tr>
<tr>
<td>6 mo</td>
<td>When prone, lifts head and chest putting weight on hands; sits with support</td>
</tr>
<tr>
<td>8 mo</td>
<td>Sits independently; reaches for toys</td>
</tr>
<tr>
<td>10 mo</td>
<td>Crawls; stands holding onto furniture</td>
</tr>
<tr>
<td>12 mo</td>
<td>Walks independently or with hand support</td>
</tr>
<tr>
<td>18 mo</td>
<td>Developing handedness</td>
</tr>
<tr>
<td>2 yr</td>
<td>Jumps; knows full name</td>
</tr>
<tr>
<td>3 yr</td>
<td>Goes upstairs alternating feet; stands momentarily on one foot; knows age and gender</td>
</tr>
<tr>
<td>4 yr</td>
<td>Hops on one foot; throws ball overhand</td>
</tr>
<tr>
<td>5 yr</td>
<td>Skips; dresses independently</td>
</tr>
</tbody>
</table>

- Rotational Profile: physiologic?
C. 18 month old: development delay & inability of walk (C-P?)

- Birth history: LBW, Prematurity, seizure, respiratory
- Reflex test: 5 primitive & 2 postural reflex

<table>
<thead>
<tr>
<th>PRIMITIVE AND POSTURAL REFLEXES</th>
<th>PROGNOSIS FOR WALKING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primitive Reflex</strong></td>
<td><strong>Age When It Disappears</strong></td>
</tr>
<tr>
<td>Moro</td>
<td>6 mo</td>
</tr>
<tr>
<td>Grasp</td>
<td>3 mo</td>
</tr>
<tr>
<td>Neck-righting</td>
<td>10 mo</td>
</tr>
<tr>
<td>Symmetric tonic neck</td>
<td>6 mo</td>
</tr>
<tr>
<td>Asymmetric tonic neck</td>
<td>6 mo</td>
</tr>
<tr>
<td><strong>Postural Reflex</strong></td>
<td><strong>Age When It Appears</strong></td>
</tr>
<tr>
<td>Foot-placement</td>
<td>Early infancy</td>
</tr>
<tr>
<td>Parachute</td>
<td>12 mo</td>
</tr>
</tbody>
</table>

**Reflex**

- Asymmetric tonic neck
- Neck-righting
- Moro
- Symmetric tonic neck
- Extensor thrust

**Points**

- 1

**Prognosis for walking**

- 2 points, poor
- 1 point, guarded (might walk)
- 0 points, good

1 if absent
D. 4 year boy: abrupt onset of limping: (TTS, septic hip, early stage of LCP, Osteomyelitis, SI problem ?)

1. URI history?
2. Knee pain complains: typical referred pain
3. Fever, chilling, walking?
4. Faber test. Compression test
5. CBC, ESR, CRP
E. 3 year-old, out toeing with abduction of forefoot; (Flexible Flatfoot)

1. 3 deformity: forefoot abduction, heel valgus, depression of medial arch
2. General ligament laxity
3. Toe tip test, toe raising test
4. The time of first presentation: congenital Vertical talus?
General ligament laxity
A. 7 year-old boy: limping and growing pain (LCPD)

- Pain pattern:
  Well being with limping
  Intermittent, but longstanding pain
- Hyperactive (ADHD)
- Shorter height than average
- Negative X-ray: early stage
- Positive in Physical examination
  limitation of MR of hip
  Faber test positive
B. 6 year-old boy: elbow swelling and pain after fall from monkey bar

• Gross deformity: sliver-fork, pucker sign
• Neurovascular injury check:
C. 10 year-old boy; heel pain aggravating with playing: (Sever’s disease)

- Bilateral (60%)
- Aggravating with playing
- No resting pain
- Tenderness
- DDx: JRA, Achilles tendinitis, plantar fascitis, children leukemia
D. 5 year-old boy; walking on his toes: (Cerebral Palsy, Spastic)

- Past history: LBW, prematurity, respiratory
- Inspect walking pattern:
  1. short stance phase,
  2. toe to toe walking,
  3. asymmetric gait,
  4. crouch gait
- Physical examination:
E. 5 year-old painless limping. (LLD, Neglected DDH)

- Limping with equal amount of stance phase
- Allis test
- Trendelenburg test

Trendelenberg test
Neglected DDH
F. 6 year-old girl: Leg ache without limping: (Growing pain)

- Night pain
- Girl
- Not localized
- No limping
- Not alter activity
- Long standing
<table>
<thead>
<tr>
<th>Feature</th>
<th>Growing Pain</th>
<th>Serious Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long duration</td>
<td>Often</td>
<td>Usually not</td>
</tr>
<tr>
<td>Pain localized</td>
<td>No</td>
<td>Often</td>
</tr>
<tr>
<td>Pain bilateral</td>
<td>Often</td>
<td>Unusual</td>
</tr>
<tr>
<td>Alters activity</td>
<td>No</td>
<td>Often</td>
</tr>
<tr>
<td>Causes limp</td>
<td>No</td>
<td>Sometimes</td>
</tr>
<tr>
<td>General health</td>
<td>Good</td>
<td>May be ill</td>
</tr>
<tr>
<td>Physical Examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenderness</td>
<td>No</td>
<td>May show</td>
</tr>
<tr>
<td>Guarding</td>
<td>No</td>
<td>May show</td>
</tr>
<tr>
<td>Reduced range of motion</td>
<td>No</td>
<td>May show</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBC</td>
<td>Normal</td>
<td>± Abnormal</td>
</tr>
<tr>
<td>ESR</td>
<td>Normal</td>
<td>± Abnormal</td>
</tr>
</tbody>
</table>

**Fig. 4.3 Differentiating Growing Pains from More Serious Problems.**
The features of growing pains are usually so characteristic that special studies are seldom required.
GAIT ANALYSIS
보행(Gait)

: 몸의 중심을 전방으로 이전시키면서 하지와 몸체의 율동적이며 교대로 일어나는 일련의 운동

보행분석(Gait analysis)

: 보행 주기상의 각 시기에 따라 각 관절과 근육의 역할 및 이로 인하여 지면에서 생기는 반향력 및 보행의 양상을 분석

Sagittal plane: pelvic tilting, hip & knee & ankle motion

Coronal plane: pelvic obliquity
Terminology
보행 주기 (Gait Cycle)

<table>
<thead>
<tr>
<th>PHASE</th>
<th>STANCE</th>
<th>SWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>TASK</td>
<td>Weight Acceptance</td>
<td>Single Limb Support</td>
</tr>
<tr>
<td>SUB-PHASE</td>
<td>Initial Contact (IC)</td>
<td>Loading Response (LR)</td>
</tr>
</tbody>
</table>

[Diagram showing the stages of the gait cycle with illustrations of different phases]
입각기 (stance phase)

: initial contact ~ toe off (preswing)

보행주기의 60% 차지

1. 초기 접지기 (initial contact)
2. 하중반응기 (loading response)
   : 보행주기의 처음 10%에 해당
     착지시의 충격을 완화하는 감속기 (1st ankle rocker)
3. 중간 입각기 (midstance phase)
   : 10% ~ 30%
     발이 지면에 닿아 있는 상태에서 족관절을 축으로 하퇴부가 전방으로 이동하는 시기 (2nd ankle rocker)
4. 말기 입각기 (terminal stance)
   : 30% ~ 50%
   중족지 골두를 축으로 후족부가 들리기 시작하여 반대 측 발이 지면에 닿는 시기 (3rd ankle rocker)

5. 전유각기 (pre-swing phase)
   : 50% ~ 60%
   유각기의 준비 단계

--- Double support : 0% ~ 10%, 50% ~ 60%
--- Single support : 10% ~ 50%
유각기 (swing phase)

: 발이 지면에서 떨어져 몸을 앞으로 추진하는 시기
  보행주기의 40% 차지

1. 초기 유각기 (initial swing) : foot clearance
2. 중간 유각기 (mid swing)
    : limb advances in front of body
3. 말기 유각기 (terminal swing)
    : limb deceleration, preparation for weight transfer
보행 선형 지표
(Temporal Gait Measurement)

1. 보장 (step length) : 두발사이의 거리
   보행속도가 빠를수록 길어진다.
2. 활보장 (stride length) : 보행 주기의 전체거리
   정상 보행 시 보장의 2배
3. 보폭 (step width) : 발뒤축의 중심간 거리
4. 분속수 (cadence)
   단위 시간 (1분) 동안의 보장 수
   성인 평균 분속수 100 - 110회/분

5. 보행 속도 (walking velocity)
   단위 시간 동안의 보행 거리
   cm/sec, m/min
운동형상학 (Kinematics)

관절의 운동 각도, 속도, 가속도 등의 운동을 형상화
운동학 (Kinetics)

지면 반발력, 근육 및 인대의 힘, 관절 모멘트, 관절 움직임 등의 운동을 일으키는 지표를 포함

: 운동을 일으키는 기전을 이해하게 함
1. **외적 모멘트 (External moment)**

GRF가 인체에 대해 외적인 힘으로 작용하여 관절을 회전시키는 모멘트를 발생시킴

2. **내적 모멘트 (Internal moment)**

외적 모멘트에 대해 이를 상쇄하거나 극복하기 위해 나타나는 관절 및 근육의 운동

![Diagram of external and internal joint moments](image)
보행 시 신체에 일어나는 근육운동

1. Concentric muscle action
   근육이 단축되면서 수축이 일어나는 것으로 가속을 일으키게 된다. (*power generation*)
   ex) gastrocnemius in terminal stance
       iliopsoas in preswing & initial

2. Eccentric muscle action
   근육이 연장되면서 수축이 일어나는 것으로 감속 및 충격 완화 효과 (*power absorption*)
   ex) soleus in midstance

3. Isometric contraction
   근육의 길이가 변하지 않으면서 수축이 일어나는 것
   ex) gluteus medius (postural stabilizer) in midstance
보행 분석 방법

1. Observational gait analysis

2. Quantitative gait analysis
   i) optical tracking system: kinematics
   ii) dynamic electromyelogram
   iii) force plate: kinetics
   iv) 에너지 소모 측정기
정상 보행 (Normal gait)

보행의 발달

어른의 정상적 heel-toe gait 생후 3Y 6mo에 가능

보행이 발달함에 따라

I) single limb stance ↑
II) walking velocity ↑
III) cadence ↓
IV) step length, stride length ↑
정상 보행의 조건

1. 입각기의 안정성
2. 보행추진력의 발생
   - Preswing:
     plantar flexion power by triceps surae
     hip flexion power by hip flexors
   - Initial stance phase:
     hip extensor power
     by hamstrings & hip extensors
   - Midstance: 위치에너지(PE)가
     운동에너지(KE)로 전환
3. 에너지 보존
   무게 중심 이동의 극소화
   지면 반발력의 외적 모멘트 이용
정상 보행의 5가지 속성

1. Stability in stance phase
2. Foot clearance on swing phase
3. Prepositioning of the foot for initial contact
4. Adequate step length
5. Energy conservation
보행의 결정 요소

1. Pelvic rotation
   : 4 degree forward on the swing limb
   : 4 degree backward on the stance limb
2. Pelvic tilt
   : average 5 degree
3. Knee flexion after heel strike in stance phase
4. Foot & ankle motion
5. Ankle & Knee motion
6. Lat. Displacement of pelvis
   : total 2 inch
보행 속도와 에너지 소모

4 - 5 km/hr로 보행할 때 에너지 소모가 가장 적다.
⇒ 이보다 속도가 빠르거나 느리면, 에너지 소모가 증가

최적 보행속도에서의 에너지 소모량

: 0.8cal/ m/kg or 59cal/ min/kg
Running cycle

A
- 작동주기
  (Double Support)
- 입각기
  (Stance 60%)
- 유각기
  (Swing 40%)
- 하중반응
  (Loading Response)
- 중간입각기
  (Midstance)
- 발기입각기
  (Terminal stance)
- 신부각기
  (Preswing)
- 초기유각기
  (Initial Swing)
- 중간유각기
  (Midswing)
- 발기유각기
  (Terminal Swing)

B
- 작동주기
  (Stride 100%)
  - 초기 접촉
    (Initial Contact)
  - 발BST
    (DF)
  - 유각기
    (Swing > 50%)
  - 발BST
    (DF)
- 힘흡수
  (Power Absorption)
- 힘생성
  (Power Generation)
- 중간입각기
  (Midstance)
- 초기유각기
  (Initial Swing)
- 중간유각기
  (Midswing)
- 발기유각기
  (Terminal Swing)

- 달리기 주기 -
1. Double floating: 20% swing phase

2. velocity ↑
cadence ↑
step length ↑
stride length ↑

3. Kinetics
ankle: major power generator
2nd power absorber
knee: primary power absorber
hip: 2nd power generator
Thank you very much for your attention!!