Physical therapy & Functional gain in Pediatric Spinal Cord Injury / Dysfunction

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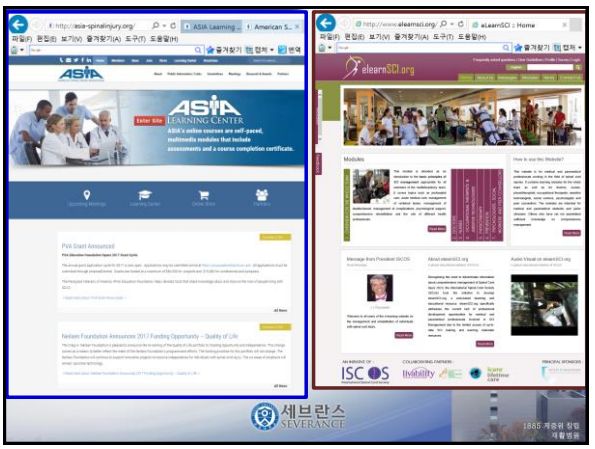
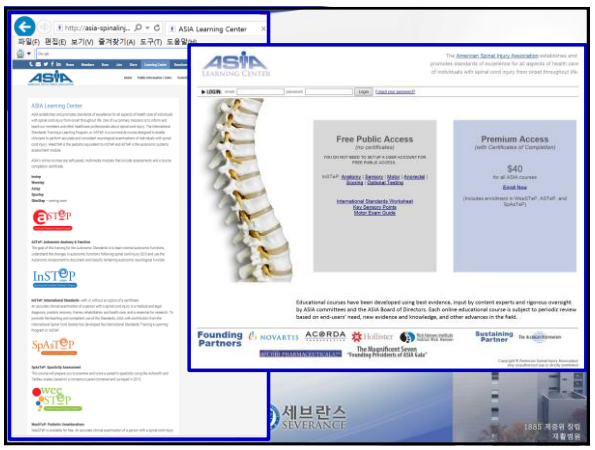
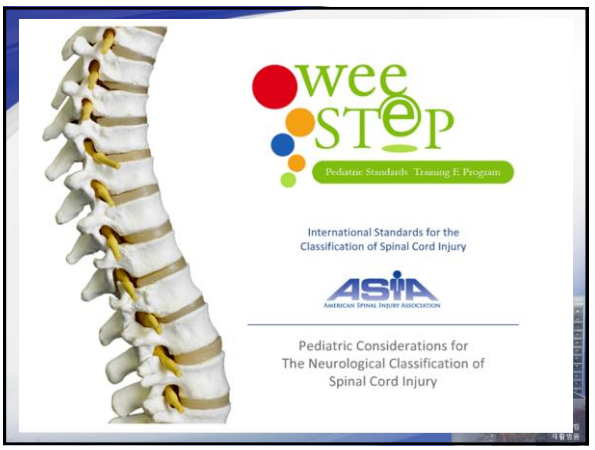






Overview of Pediatric SCI

- Persons with childhood-onset SCI have **higher mortality** as compared with adults with adult-onset SCI
  - **Scoliosis**
  - **Restrictive lung disease** secondary to **scoliosis**
  - **Respiratory development** in infants & very young children
  - **Infants** and **young children** with **tetraplegia are prone to incipient respiratory failure**, manifested as **sleep-disordered breathing**
  - **High incidence of hip dislocation** in children leads to **pelvic obliquity** and **subsequent sores**.

Physical therapy framework: 5 steps

- The process involved in **physical therapy management** of people with SCI can be described in five steps:
  1. **Assessment**
  2. **Setting goals**
  3. **Identifying key impairments**
  4. **Implementing treatments** → **Play ??**
  5. **Re-assessment**
- The **language and framework** of **the International Classification of Functioning, Disability and Health (ICF)** is useful for describing the physical therapy process.

Physical therapy framework
: Implementing treatments

- **Implementing treatments** that are **evidence based** and **address impairments** *directly and indirectly related to SCI* is an ***essential part of physical therapy.***
- **Weakness** ➔ ***vs. bone growth (low m. tone)***
- **pain**
- **contracture**
- **decreased respiratory function**
- **poor fitness**
- **lack of skill**

ASIA E-learning center, WeeSTeP (Pediatric Standards Training E Program)

Orthopedic considerations

- **Children with SCI** are at **unique risk for several orthopedic complications** that do not occur in the skeletally mature adult.
- **Scoliosis**
- **Hip dislocation & Hip Subluxation**
- **Leg length discrepancy**

Lubicky JP, Betz RR: Spinal deformity in children and adolescents after spinal cord injury, in Betz RR, Mulcahey MJ (eds): The Child with a Spinal Cord Injury. Rosemont, IL, American Academy of Orthopedic Surgeons, 2011:363-370

Scoliosis

- Almost every child who sustains an **SCI before skeletal maturity** develops scoliosis, and approximately **two-thirds of these children require surgery**.
  Dearolf W.W., Betz R.R., Vogel L.C., et al: Scoliosis in pediatric spinal cord-injured patients. *J Pediatr Orthop* 1990
- **Thoracolumbar-sacral orthotic bracing** has been shown to significantly **slow the rate of curve progression** and **delay the need for surgery** in children with SCI.
  Mehta S., Betz R.R., Mulcahey M.J., et al: Effect of bracing on paralytic scoliosis secondary to spinal cord injury. *J Spinal Cord Med* 2004
- General indications for spine fusion surgery in children with neurogenic scoliosis secondary to **SCI**
  - **include curves greater than 40° by Cobb angle**,
  - **age greater than 10 years**,
  - **rapid progression of the curve**,
  - **functional problems or pain in a mature patient.**

Lubicky JP, Betz RR: Spinal deformity in children and adolescents after spinal cord injury, in Betz RR, Mulcahey MJ (eds): The Child with a Spinal Cord Injury. Rosemont, IL, American Academy of Orthopedic Surgeons, 2011:363-370

Scoliosis

- **Spinal deformity after SCI** can be caused by several factors,

1. **Muscle weakness/imbalance with superimposed forces of growth**, as in a paralytic or neuromuscular spinal deformity
2. **Vertebral column deformity due to unreduced fracture** and/or **dislocation** or **bony element destruction** caused by the injury
3. **Vertebral column abnormalities resulting from surgical intervention at the time of injury treatment** (eg, laminectomy, improperly instrumented segments, or fall-off kyphosis).

Lubicky JP, Betz RR: Spinal deformity in children and adolescents after spinal cord injury, in Betz RR, Mulcahey MJ (eds): The Child with a Spinal Cord Injury. Rosemont, IL, American Academy of Orthopedic Surgeons, 2011:363-370

Scoliosis : 3 types of childhood scoliosis

1. **Idiopathic scoliosis** — Idiopathic scoliosis represents 80 percent of all scoliosis cases. It usually develops during adolescence, between ages 10 and 16. Scoliosis that develops earlier can be defined as infantile (0-3 years) or juvenile (4-10 years). The younger a scoliosis curve develops, the higher the chance that it progresses or worsens. Idiopathic means "of unknown cause" and scientists have not yet unraveled why scoliosis develops. But because idiopathic scoliosis runs in families, it has a genetic basis.
2. **Congenital scoliosis** — Congenital scoliosis is a fairly rare bone abnormality detected at birth. The vertebral (spine) bones do not form normally and this can lead to scoliosis. Very often, it accompanies other birth defects, such as heart or kidney problems.
3. **Neuromuscular scoliosis** — **CP, spina bifida, SCI, DMD**. Neuromuscular scoliosis is **caused by abnormalities in muscles and nerves that support the spine**. **Neuromuscular scoliosis can become quite severe**. Scoliosis looks different in different people:
   - It may be mild.
   - It may be severe.
   - It may involve a **single, short "C" curve**.
   - It may involve a **long, double or triple "S" curve**.

http://my.clevelandclinic.org/ccf/media/files/ortho/pediatric-scoliosis-guide.pdf

Neuromuscular Scoliosis in Children with SCI

1. **Neuromuscular scoliosis** is **highly prevalent** among persons with **SCI who are injured at a young age**.
2. **Neurological level, motor score, and severity of injury** are **not predictors of neuromuscular scoliosis**, thus altering them will not likely change the outcomes with respect to neuromuscular scoliosis.
3. **Age at injury** is the **only predictor of worst curve** and **spinal fusion in children with SCI**.
4. There is a **need for prospective studies on how to prevent neuromuscular scoliosis** in young children with SCI, because they are at greatest risk for developing it and ultimately requiring surgical spine fusion.

Top Spinal Cord Inj Rehabil 2013;19(2):96–103

Neuromuscular Scoliosis progression in Children with SCI (n=28)

사진출처:
http://hubpages.com/health/The-Schroth-Method

양손잡이 환아 되도록 치료하시면 좋겠죠

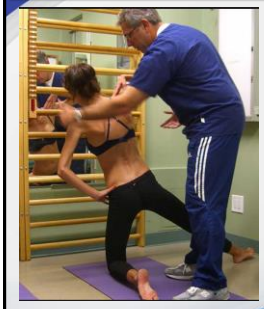
Primary curve (Rt. handed dominant)
- Lt. Convex in lumbar
- W/B in Lt. pelvis during Rt. UE activity
- Repeated come to sit activity using Rt. Handed dominant upper limb with Rt. trunk lateral flexors stretched and then quick contraction

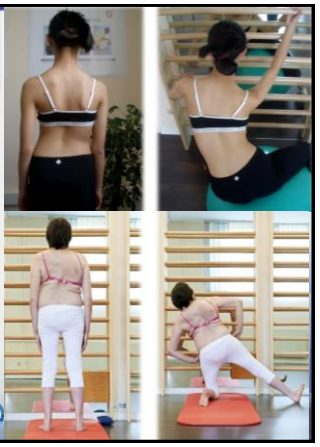
Secondary curve (Rt. handed dominant)
- Rt. Convex in mid-thoracic level (초3~)
- Maintaining the student's chair sitting posture with weight bearing in Lt. elbow
- Lt. concave : Overusing the Lt. scapular depressors

But Lt. handed dominant cases were opposite (n=3)

Data collected by Severance Rehabilitation Hospital IPD since 2010

Scoliosis correction ➔ Schroth method





사진출처:
http://spinecorassociates.net/scoliosis-exercises/
https://schrothbestpractice.com/

Hip dislocation

- **More than 90% of children with SCI** before age 10 years develop hip subluxation or dislocation.
  Dearolf W.W., Betz R.R., Vogel L.C., et al: Scoliosis in pediatric spinal cord-injured patients. *J Pediatr Orthop* 1990
- There is some evidence that this complication occurs whether **spasticity is present or not**.
  McCarthy J.J., Chavetz R.S., Betz R.R., et al: Incidence and degree of hip subluxation/dislocation in children with spinal cord injury. *J Spinal Cord Med* 2004
- **Lack of hip joint integrity** can **inhibit the child's ability to use standing frames or FES bicycles**, in addition to **being a potential pain generator**.
  Rink P., and Miller F.: Hip instability in spinal cord injury patients. *J Pediatr Orthop* 1990
- Therefore, **close surveillance of hips** and an **aggressive approach** to surgical intervention are generally recommended.
  McCarthy J.J., and Betz R.R.: Hip disorders in children who have spinal cord injury. *Orthop Clin North Am* 2006

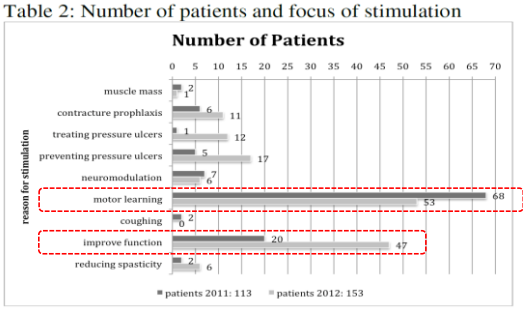
Lubicky JP, Betz RR: Spinal deformity in children and adolescents after spinal cord injury, in Betz RR, Mulcahey MJ (eds): The Child with a Spinal Cord Injury. Rosemont, IL, American Academy of Orthopedic Surgeons, 2011:363-370

Functional electrical stimulation, FES

Type 1(tonic) m. ➔SCI➔ Type 2(phasic) m.
➔FES apply➔➔ Type 1(tonic) m.

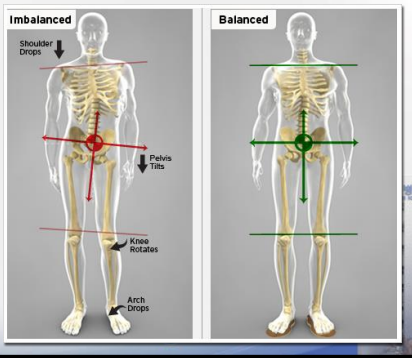
FES in SCI: Clinical Evidence vs Daily Practice

Table 2: Number of patients and focus of stimulation



Bersch I, Frotzler A, Baumberger M; Swiss Paraplegic Centre Nottwil, Switzerland: *Biomed Tech* 2013; 58

Leg length discrepancy



Strength

4 Key recommendations of the ACSM in strengthening
: An effective dosage of progressive resistance training

1. **1~3 sets of 8~12 repetitions with a rest of 1~3 minutes between sets**
2. **A load corresponding to 8~12 repetition maximum(RM) or 60~70% 1RM**
3. **Performed 2~3 times a week**
4. **Constantly progressed**

Current parameters for **progressive resistance training** in people with **SCI** are **based on the able-bodied** literature.

Strength

motor score 1(T)~2(P) < fair (3/5)

1. **In a gravity eliminated plane**
2. **With electrical stimulation. Electrical stimulation can be a useful adjunct to voluntary strength training in people with weak and very weak muscles where progressive strength training is difficult.**
3. **With resistance applied manually by the therapist**

Fitness

4 Key recommendations of the **ACSM in fitness** training

1. **Performed 3 ~5 times a week**
2. **Performed at 50~80% of maximal exercise capacity**
3. **Performed for at least 20 minutes**
4. **Constantly progressed**

Programs that target strength can also **change endurance**, however **specifically targeting endurance** by **increasing repetitions** and **decreasing load** would be more effective.

Cardiovascular training with core stability training in pediatric SCI

http://www.redbalance.com/f_shop/?ff=detail_view&goods_uid=296&category_uid=36

Autonomic cardiovascular dysfunction and Vitamin D deficiency in pediatric SCI

[RESULTS] Among 279 children with SCI
- **Boys had higher systolic BP and girls had higher HR**
  - **but a gender difference in diastolic BP did not emerge.**
  - There were no significant associations of baseline BP or HR as a function of injury level, severity, or duration.
- Among 82 youth with SCI, **79% had vitamin D deficiency or insufficiency**.
  - There were no differences in vitamin D status as a function of gender or level of injury.

- **Adolescents, however, were more likely to exhibit deficiency compared to children.**
- **Baseline BP and HR need to be routinely assessed in youth with SCI.**
  - Because of **the clinical significance** of **autonomic dysreflexia** and **orthostatic hypotension**,
- **In view of the high prevalence of vitamin D insufficiency** in **youth with SCI** and the risk of complications such as **pathological fractures.**

Zebracki, K., et al. (2013). J Pediatr Rehabil Med 6(1): 45-52.

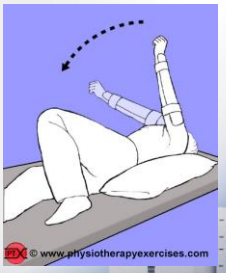
Bed mobility and transfers
: understanding movement

- **Five motor skills** that people with **C6 tetraplegia** and **paraplegia** have the potential to attain are:

1. **rolling**
2. **moving from supine to long sitting**
3. **unsupported sitting**
4. **lifting vertically**
5. **transferring**

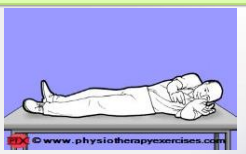
1. Rolling

- **Rolling** is important for **changing position in bed**, **lower limb dressing**, **pressure relief** and **for moving from supine to sitting.**
- People with **C6 tetraplegia** and **thoracic paraplegia** are **unable to use the trunk and legs *to roll*.**
- Instead, they **use their head, neck** and **upper limbs to generate momentum.**



1. Rolling - paraplegia

- Rolling is comprised of **two key sub-tasks**:

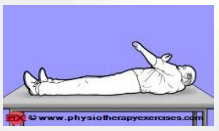


Preparation
: **Lifting** and **rotating the head while swinging the arms away from the direction of the roll.**

Rolling
: **Lifting** and **rotating the head while swinging the arms across the body to generate the momentum to roll.**
This may **need to be repeated to *get sufficient momentum*.**

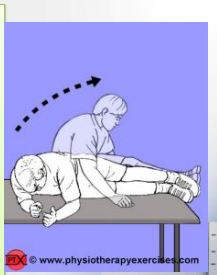
1. Rolling - C6 tetraplegia

- People with **C6 tetraplegia** are **unable to swing extended arms above their head.**
- This is because **paralysis of the triceps** makes it **difficult to keep the elbows extended**.
- Instead, people with **C6 tetraplegia externally rotate their shoulders** and **swing their arms across the body**.



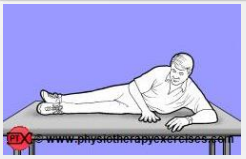
2. Moving from supine to long sitting

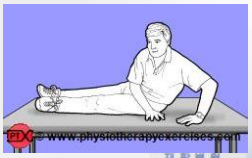
- The ability **to move from supine to long sitting** is **important for activities of daily living** such as **dressing**.
- **Supine to long sitting** is commonly **achieved by rolling on to the side** and then **moving into long sitting**.
- People with SCI **move from supine into long sitting rather than short sitting** because it is a more stable position.



2. Moving from supine to long sitting

- For people with **paraplegia moving into long sitting** is comprised of **2 key sub-tasks**:





Pushing up through one or both arms **to lift the trunk off** the bed.

Extending the elbows and **bringing the centre of mass of the trunk over the hips** to move into sitting.

2. Moving from supine to long sitting

- Moving from supine to long sitting is **more complex** for people with **C6 tetraplegia than** it is for people with **paraplegia**.
- People with **C6 tetraplegia** are **not able to push through their hands to lift the weight of their body** because they have ***paralysis of the triceps***.
- Instead, they **bear weight through the elbows, move on the elbows towards the legs** and **pull into long sitting**.

3. Unsupported sitting
1) exaggerated use of arms, shoulders and head

- In the absence of trunk and leg muscles people with SCI need to use exaggerated arm, shoulder and head movements to sit unsupported.
- For example, to maintain an upright position when reaching forwards they commonly abduct and extend the opposing arm to bring the trunk forward.

3. Unsupported sitting
2) use of the upper limbs to stabilize the trunk and prevent a fall

- It is **more difficult** for people with C6 tetraplegia to use their upper limbs to prevent a fall because they have *upper limb weakness* and paralysis of the triceps.
- Instead people with C6 tetraplegia externally rotate their shoulders and lock the elbows into extension.

3. Unsupported sitting
3) using long sitting to improve stability

- It is easier to maintain an upright position in long sitting than it is **in short sitting**.
- This is because when the knees are extended the hamstring muscles generate a passive tension which **prevents the trunk falling forwards.**
- However, the centre of mass of the trunk *must be positioned* anterior to the hips.

3. Unsupported sitting
3) using long sitting to improve stability

- Maintaining long sitting is *dependent on* appropriate extensibility in the hamstring muscles.
- If the **hamstring muscles** are too extensible they do not prevent a forwards fall.

- If the **hamstring muscles** are **inextensible** the centre of mass of the trunk will be positioned posterior to the hip joint **resulting in a backwards fall.**

4. Lifting vertically

- People with SCI need to be able to lift vertically.
- **Lifting vertically** is important for moving in bed, transferring and pressure relief.
- People with SCI can learn to lift vertically in:
  1) **short sitting**
  2) **long sitting**

5. Transferring - horizontal transfer

- Transferring is an important skill for people with SCI and **many different strategies** are used.
- A **horizontal transfer from the wheelchair to bed** for people with **paraplegia** and **C6 tetraplegia** commonly involves important **key sub-tasks:**
  1) **Positioning the wheelchair** and **moving to the front edge.**
  2) **Positioning the feet.**
  3) **Positioning the hands.**
  4) **Lifting** and **shifting across the bed.**

Case presentation –교육정보제공 환자와 보호자 동의 "명의" 공중파 방송에 나왔던 케이스

- PI : 상기 14세 여환 내원 3년 전부터 **저신장증** 주소, KS 병원 OPD에서 주사제 투여하는 것 이외에 특이 과거력 없는 분으로 **이전부터 등이 휘었다고 생각했으나 병원 내원하지 않고 지내던 중 증상 점점 aggravation** 되는 것 같아 2010.2 P 병원 내원하여 교정기 착용함.
- 2010.9 KS병원 내원, **보조기** 새로 맞춤
- 2010. 12 KS OS 내원, 점차 **develop된 Lt. side leg weakness**를 주소, 걸음걸이가 왼쪽으로 기우뚱함, Lt. leg 힘 빠짐, 신발을 잘 못 신음. 보행은 겨우 가능. **척추뼈 중 자라다 만 뼈가 있어(T7) 신경이 눌리고 있다고 들음**
- 2011.2.8 **Mechanical correction Op. 시행** // **intra op에서 Lower leg SEP 나오지 않아 수술 중단**, ICU로 옮김 >> 당시에는 발가락 움직일 수 있었음
- POD #4부터 **L/Ex weakness develop**되어
- 2011.2.13(POD #5) post-op paraplegia evaluation 위해 MRI f/u 하였고 **hematoma 발견되어 emergency Op. 시행**
- 2011.2.25 f/u study 상 수술 부위 cage 빠져있어 **Op. 재시행**
- **2011.3.14 포괄적 재활치료 위해 신지철 선생님 앞으로 first admission**

LE Motor change(AMS, AMI)

평가일	2011 05-18 home D/C	2011 07-12 2nd adm.	2011 09-09 2nd D/C	2012 12-26 3rd adm	2012 01-18 Case Study
AMS LE (Rt./Lt.)	0/0	14 (7/7)	18 (9/9)	32 (16/16)	**36 (18/18)**
AMI (Rt./Lt.)	0/0	10 (5/5)	12 (6/6)	22 (12/10)	**26 (13/13)**

Range Of Motion, Spasticity

평가일	2011 05-18 home D/C	2011 07-12 2nd adm.	2011 09-09 2nd D/C	2012 12-26 3rd adm	2012 01-18 Case Study
ROM LE	full/full except ankle DF 0/0	full/full except ankle DF 0/0	full/full except ankle **DF 10/0**	full/full except ankle **DF 20/10**	**full/full**
Spasticity LE (Rt./Lt.)	G 1+ /G 1+ ankle G2/G2	G 3 /G3 ankle G4/G4	G 2 /G 2 ankle G3/G3	G 1+ /G 1+ ankle G2/G2	G 1 /G 1 **ankle G1+/G1+**

Tibialis posterior, GCM(medial) ➔ PF with inversion

Ambulation

평가일	2011 05-18 home D/C	2011 07-12 2nd adm.	2011 09-09 2nd D/C	2012 12-26 3rd adm	2012 01-18 Case Study
Transfer	2 men transfer	One man pivot tf.	Rt. leg pivot with min assist	independent	independent
이유	**간호사 +어머니**	**어머니**	Fear & U/Ex 약해 잘 안됨		

Vital Capacity

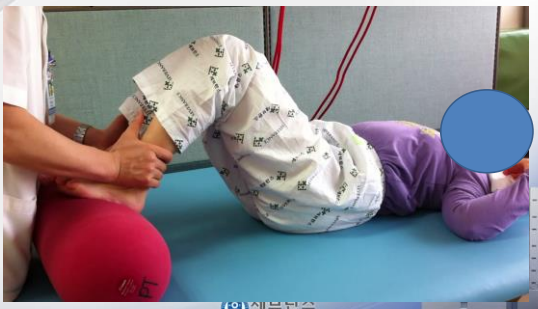
평가일	2011 05-18 home D/C	2011 07-12 2nd adm.	2011 09-09 2nd D/C	2012 12-26 3rd adm	2012 01-18 Case Study
FVC	930cc➔ 1000cc	**1100**	**1250**	**1080**	**1320**

Problem List

- 양쪽 발바닥 통증: NPIS Rt.(3) < **Lt.(5)**
- **Scoliosis로 trunk muscle imbalance**
  (Tx.➔ Both scapular depressors strengthening 시행)
- **LE spasticity – mixed type**
  – Both knee flexors dominant 감소(motor 향상으로)
  – **But, both plantarflexor with invertor (G1+/G2)**
- **LE motor imbalance**
  – **Hip : Rt. < Lt. (특히 hip extensor, hip abductor)**
  – **Knee & ankle : Rt. > Lt. (1/2 grade)**

치료1. Sling Ex. ➔ Scoliosis correction & Rt. hip abd. with Trunk lat. flexors strengthening ex.

치료 2 : Both hip extensors & ankle PF strengthening using multi-roll



치료 3
: Both ankle PF eccentric lengthening in standing

치료 4
: Push off training, ankle PF *concentric contraction* & *eccentric lengthening* in standing