PHYSICAL THERAPY APPROACH FOR NON-AMBULATORY CP

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1. Proportion of non-ambulatory CP and GMFCS level stability
2. Functional limitation/change in non-ambulatory CP
3. Life expectancy for non-ambulatory CP
4. Various interventions for CP
5. Complications and prevention
6. The concept of physical therapeutic approach

01

PROPORTION
OF NON-AMBULATORY CP AND
GMFCS LEVEL STABILITY

PROPORTION OF NON-AMBULATORY CP

Participants characteristics (연령에 따른 GMFCS level별 비율)

Table I: Participant characteristics

Characteristic	Age (years)[a] 4	15	30	45	60
Sample size	16 440	14 609	11 735	7023	2375
Deaths	1795	1727	1674	1486	940
Mean follow-up years (SD)	11.4 (7.2)	11.1 (7.3)	12.8 (7.7)	10.5 (6.4)	7.9 (5.6)
Mean calendar year at beginning of follow-up	1995	1996	1994	1997	1997
Male (%)	57	55	54	53	53
Gross Motor Function Classification System (%)					
I or II - walks unaided	34	47	55	54	42
III - walks with support	17	15	13	15	21
IV or V - does not walk					
Rolls or sits	32	25	24	25	29
Does not roll or sit, lifts head or chest in the prone position	10)49%	7)38%	4)32%	4)33%	4)37%
Does not lift head or chest in the prone position	7	6	4	4	4
Tube fed (%)	10	8	3	3	4
Fed orally by others (%)	26	17	14	13	12
Self-feeds orally (%)	64	75	83	84	84

[a]Some individuals contributed information at multiple ages.

9) Brooks, J. C., Strauss, D. J., Shavelle, R. M., Tran, L. M., Rosenbloom, L., & Wu, Y. W. (2014). Recent trends in cerebral palsy survival. Part II: individual survival prognosis. Developmental Medicine & Child Neurology, 56(11), 1065-1071.

Proportion of non-ambulatory CP

CP GMFCS Level별 분표

Table II: Distribution of GMFCS levels in study participants

GMFCS level	*n* (%)	
I	108 (44)	66% (I–III)
II	23 (10)	
III	30 (12)	
IV	43 (18)	34% (IV–V)
V	39 (16)	

GMFCS, Gross Motor Function Classification System.

35) Shevell, M. I., Dagenais, L., & Hall, N. (2009). The relationship of cerebral palsy subtype and functional motor impairment: a population-based study. Developmental Medicine & Child Neurology, 51(11), 872-877.

SUBTYPES IN NON-AMBULATORY CP

- Hemiplegia 99~100%, Diplegia 82~98% = GMFCS Lv. I~III
- Dyskinetic 75%~85%, Quadriplegia 76.5~100% = GMFCS Lv. IV~V

- GMFCS Lv. IV 93% = Quadriplegia & Dyskinetic type CP
- GMFCS Lv. V 95% = Quadriplegia & Dyskinetic type CP

- Non-ambulatory
- Hemiplegia & Diplegia: 1.5%
- Quadriplegia & Dyskinetic: 76.4%

≫ Gross motor function과 CP subtype은 높은 상관관계가 있다.

- 약 25%에서 subtype의 변화가 있다는 점을 고려해야 함
  (especially in non-spastic type)

SUBTYPES IN NON-AMBULATORY CP

Table III: Distribution of GMFCS level by neurological subtype

Neurological subtype	GMFCS level I	II	III		IV	V	
Spastic quadriplegia	3	6	11	23.5%	**33**	**32**	76.5%
Spastic hemiplegia	**68**	6	2	99%	0	1	1%
Spastic diplegia	**31**	7	13	98%	1	0	2%
Dyskinetic	1	2	1	25%	**7**	**5**	75%
Ataxic–hypotonic	4	1	2	78%	1	1	22%
Other	1	1	1	75%	1	0	25%

GMFCS, Gross Motor Function Classification System.

35) Shevell, M. I., Dagenais, L., & Hall, N. (2009). The relationship of cerebral palsy subtype and functional motor impairment: a population-based study. Developmental Medicine & Child Neurology, 51(11), 872-877.

Subtypes in non-ambulatory CP

Table 3
GMFCS-levels in relation to CP subtypes

SCPE	SC	GMFCS I	GMFCS II	GMFCS III	GMFCS IV		GMFCS V
Unilateral spastic	Spastic hemiplegia	89	12	3	0	0%	0
Bilateral spastic	Spastic tetraplegia	0	0	0	0	100%	19
	Spastic diplegia	54	26	27	18	17.7%	5
Ataxic	Ataxic diplegia	1	9	4	0	0%	0
	Simple ataxia	13	19	2	0	0%	0
Choreo-athetosis	Choreo-athetosis	8	4	0	6	36.8%	1
Dystonia	Athetosis + dystonia	0	0	1	1	80%	3
	Dystonia	0	0	4	7	85.6%	15
Nonclassifiable	Mixed	0	0	0	0	100%	2
Total		165	60	41	32	22.4%	45

Westbom, L., Hagglund, G., & Nordmark, E. (2007). Cerebral palsy in a total population of 4–11 year olds in southern Sweden. Prevalence and distribution according to different CP classification systems. *BMC pediatrics*, *7*(1), 41.

GMFCS LEVEL STABILITY

GMFCS는 현재의 기능 수준을 Check하는 것
미래의 Function을 예측하는 것이 아니다.

DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

Stability of the Gross Motor Function Classification System in children and adolescents with cerebral palsy: a retrospective cohort registry study

ANN ALRIKSSON-SCHMIDT[1,2] | EVA NORDMARK[3] | TOMASZ CZUBA[4] | LENA WESTBOM[2,5]

- 7세 이전 년 2회, 7세 이후 년 1회 GMFCS 측정

n=736(age 2-24yrs), total assessment=7922(mean 11/person)

- Same level from initial to last assessment : 56%
- Same level at initial and last assessment : 74%
- Median number of level changes: 2

첫평가와 마지막평가의 GMFCS level change

Table I: Comparison between the first (after second birthday) and last (before January 1, 2014) assessment of Gross Motor Function Classification System (GMFCS) level

	Stable GMFCS level, *n* (%)	Lower GMFCS level, more function, *n* (%)	Higher GMFCS level, less function, *n* (%)
GMFCS level at first assessment[a]			
I (*n*=317)	271 (85)	–	46[a] (15)
II (*n*=113)	63 (56)	31 (27)	19[b] (17)
III (*n*=104)	51 (49)	28[c] (27)	25[c] (24)
IV (*n*=90)	62 (69)	8[d] (9)	20 (22)
V (*n*=129)	112 (85)	17 (15)	–
CP subtype			
Unilateral spastic (*n*=221)	178 (80)	22 (10)	21[e] (10)
Bilateral spastic (*n*=297)	218 (73)	33[f] (11)	46[f] (15)
Ataxic (*n*=73)	44 (60)	11 (15)	18 (25)
Dyskinetic (*n*=137)	97 (71)	17[g] (12)	23[g] (17)
Mixed (*n*=8)	5	1	2
Sex			
Female (*n*=309)	224 (72)	39[h] (13)	46[h] (15)
Male (*n*=427)	318 (74)	45[i] (11)	64[i] (15)
Birth cohort			
1990–1993 (*n*=86)	142 (76)	19 (10)	25 (14)
1994–1997 (*n*=152)	116 (76)	13 (9)	23 (15)
1998–2002 (*n*=213)	156 (73)	26 (12)	31 (15)
2003–2007 (*n*=185)	128 (69)	26 (14)	31 (17)
Number of assessments			
Median; interquartile range; total range	11; 7–14; 2–21	11; 8–14; 3–20	12; 8–15; 2–20
Number of assessors			
Median; interquartile range; total range	3; 2–5; 1–10	4; 2–5; 1–10	4; 2–5; 1–9
Total study population (*n*=736)	542 (74)	84 (11)[k]	110 (15)[k]

	Stable GMFCS level, *n* (%)	Lower GMFCS level, more function, *n* (%)	Higher GMFCS level, less function, *n* (%)
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3) Alriksson-Schmidt, A., Nordmark, E., Czuba, T., & Westbom, L. (2017). Stability of the Gross Motor Function Classification System in children and adolescents with cerebral palsy: a retrospective cohort registry study. Developmental Medicine & Child Neurology, 59(6), 641-646.

GMFCS LEVEL STABILITY

GMFCS 변화에 영향 없음	GMFCS 변화에 영향 미침
• CP subtype • Change in assessor • Time between assessments • Sex • Birth cohort	• Initial level • Age at first assessment and all assessments • Number of assessments before first change

- 다른 연구에서는 73%가 Level 변화 없음(CanChild study).
- GMFCS I & V: level change ↓ (d/t end range limitation).
- GMFCS IV, V (Severe CP): musculoskeletal problems with aging등으로 인해 higher function level로 변하는 비율 ↓
- GMFCS II, III가 I,IV, V에 비해 level change 많음.

GMFCS LEVEL STABILITY

2세 미만 아동의 GMFCS level은 타 연령에 비해 변하기 쉽다

DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

Use of the GMFCS in infants with CP: the need for reclassification at age 2 years or older

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- 2세 전 초기평가, 2-4세 때 재평가 실시(n=77)
- Same level at initial and last assessment: 58%
- In children changed level(n=32), level change 있던 32명중 22명(68.7%)은

- functional level ↓: 68.7%
- functional level ↑: 31.3%

2세 미만 아동의 GMFCS level

- More changeable than older child
- Lower inter-rater reliability(k=0.55)

GMFCS LEVEL STABILITY

GMFCS level stability infant(2y미만) vs. childhood(2-4y)

Table III: Stability of GMFCS level of participants as infants (<2y) versus their scores in childhood (2–4y; *n*=77).

GMFCS level 2-4y	GMFCS level of participants as infants (<2y)						
	I	II	III	IV	V	Total	
I	17	4	0	0	0	21	- 4
II	5	2	3	1	0	11	+2
III	3	3	11	1	0	18	- 2
IV	0	0	6	9	1	16	
V	0	0	0	5	6	11	+4
Total	25	9	20	16	7	77	

Linear weighted kappa = 0.70, 95% CI 0.61– 0.79. GMFCS, Gross Motor Function Classification System.

13) Gorter, J. W., Ketelaar, M., Rosenbaum, P., Helders, P. J., & Palisano, R. (2009). Use of the GMFCS in infants with CP: the need for reclassification at age 2 years or older. Developmental Medicine & Child Neurology, 51(1), 46-52.

GMFCS LEVEL STABILITY

1-3 vs 4,5 level change
(2세미만과 2-4세)

Table IV: Calculation of positive predictive value for potential walking or potential wheelchair mobility from infancy to childhood (age 2–4y)

GMFCS level 2–4y	GMFCS level as infants (<2y)		
(a)	I-II-III	IV-V	Total
I-II-III	48 **89 %**	2 **9 %**	50
IV-V	6 **11 %**	21 **91 %**	27
Total	54	23	77

GMFCS level 2-4y

GMFCS level as infants (<2y) Positive predictive value: combination 1 (I-II-III vs IV-V)=0.96, 95% CI 0.85–0.99.

(b)	I-II	III-IV-V	Total
I-II	28	4 **7 %**	32
III-IV-V	6	39 **93 %**	45
Total	34	43	77

Positive predictive value: combination 2 (I-II vs III-V)=0.88, 95% CI 0.70–0.96. GMFCS, Gross Motor Function Classification System.

13) Gorter, J. W., Ketelaar, M., Rosenbaum, P., Helders, P. J., & Palisano, R. (2009). Use of the GMFCS in infants with CP: the need for reclassification at age 2 years or older. Developmental Medicine & Child Neurology, 51(1), 46-52.

02

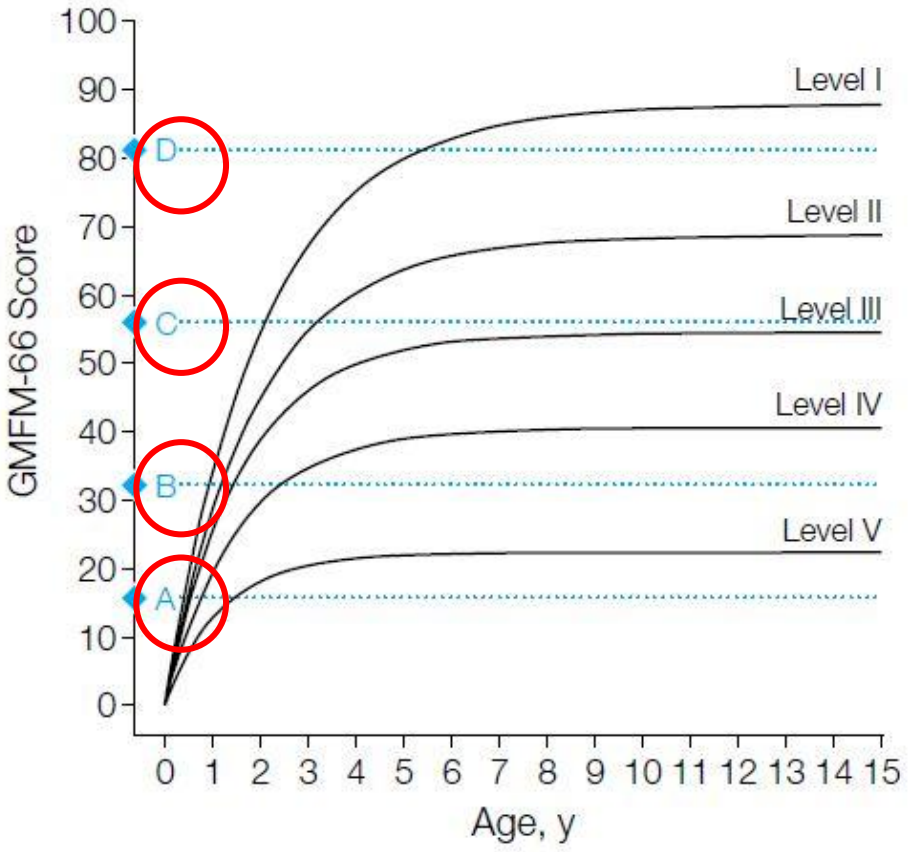
FUNCTIONAL LIMITATION AND CHANGE

IN NON-AMBULATORY CP

FUNCTIONAL LIMITATION

D = walking down 4 alternative steps
C = unsupported 10 steps
B = sitting unsupported 3s
A = lift head & neck

Figure 3. Predicted Average Development by the Gross Motor Function Classification System Levels



The diamonds on the vertical axis identify 4 Gross Motor Function Measure-66 (GMFM-66) items that predict when children are expected to have a 50% chance of completing that item successfully. The GMFM-66 item 21 (diamond A) assesses whether a child can lift and maintain his/her head in a vertical position with trunk support by a therapist while sitting; item 24 (diamond B) assesses whether when in a sitting position on a mat, a child can maintain sitting unsupported by his/her arms for 3 seconds; item 69 (diamond C) measures a child's ability to walk forward 10 steps unsupported; and item 87 (diamond D) assesses the task of walking down 4 steps alternating feet with arms free.

33) Rosenbaum, P. L., Walter, S. D., Hanna, S. E., Palisano, R. J., Russell, D. J., Raina, P., ... & Galuppi, B. E. (2002). Prognosis for gross motor function in cerebral palsy: creation of motor development curves. Jama, 288(11), 1357-1363.

CHANGES IN FUNCTIONAL ABILITY

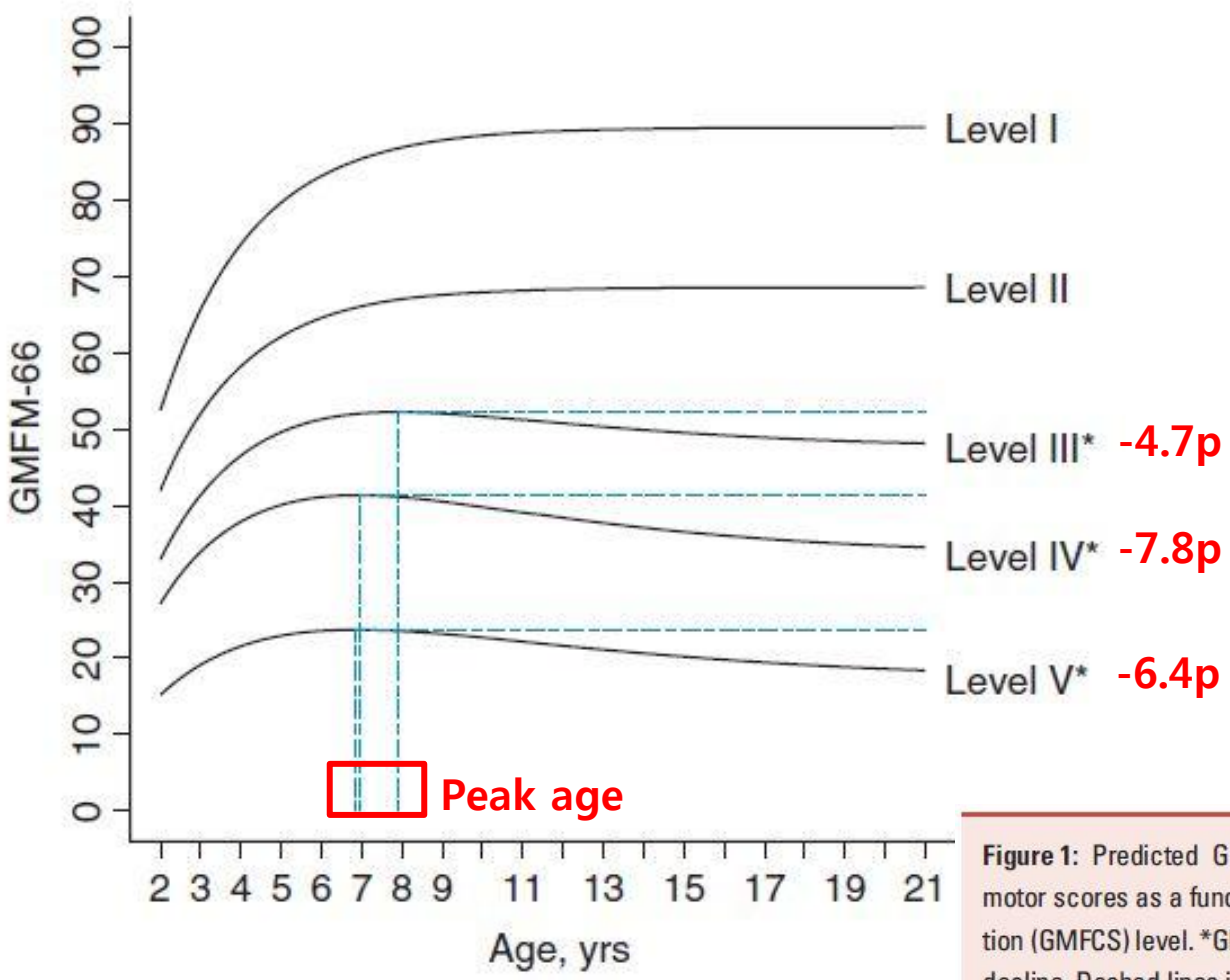


Figure 1: Predicted Gross Motor Function Measure (GMFM-66) motor scores as a function of age by Gross Motor Function Classification (GMFCS) level. *GMFCS levels with significant average peak and decline. Dashed lines illustrate age and score at peak GMFM-66.

15) Hanna, S. E., Rosenbaum, P. L., Bartlett, D. J., Palisano, R. J., Walter, S. D., Avery, L., & Russell, D. J. (2009). Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Developmental Medicine & Child Neurology, 51(4), 295-302.

CHANGES IN FUNCTIONAL ABILITY

GMFCS와 age에 따른 GMFM score

Table I: Mean Gross Motor Function Measure (GMFM-66) by age and Gross Motor Function Classification System (GMFCS)

		Age (y)				
GMFCS		2–6	6–9	9–12	12–16	16–21
Level I (n^a=183)	Mean	72.5	84.0	86.9	87.1	87.6
	95% CI	71.1, 73.9	82.8, 85.2	85.5, 88.4	85.5, 88.7	85.9, 89.3
	SD	11.1	8.7	10.0	10.7	11.2
	n^b	244	201	188	177	166
Level II (n^a=80)	Mean	55.7	60.1	71.0	70.6	70.8
	95% CI	54.3, 57.1	63.2, 66.9	69.1, 72.8	68.7, 72.4	69.1, 72.5
	SD	8.1	8.6	9.1	7.2	7.8
	n^b	139	82	97	63	83
Level III (n^a=122)	Mean	49.7	53.0	52.8	50.8	51.7
	95% CI	48.7, 50.8	52.0, 54.3	51.7, 54.9	49.0, 52.7	50.0, 53.4
	SD	6.6	6.9	7.2	10.0	10.0
	n^b	159	131	153	114	132
Level IV (n^a=137)	Mean	38.8	41.4	39.2	38.6	34.4
	95% CI	37.7, 40.0	40.2, 42.6	38.0, 40.5	36.1, 40.3	32.7, 36.2
	SD	7.6	7.2	7.8	9.0	9.5
	n^b	174	146	154	108	115
Level V (n^a=135)	Mean	23.1	24.8	21.0	21.9	22.7
	95% CI	21.9, 24.2	23.5, 26.0	19.3, 22.6	20.1, 23.7	19.8, 25.6
	SD	7.6	8.4	9.6	8.7	12.5
	n^b	162	171	133	96	75

[a]The number of children. [b]The number of observations, which typically includes multiple observations per child, within and across age categories. CI, confidence interval.

15) Hanna, S. E., Rosenbaum, P. L., Bartlett, D. J., Palisano, R. J., Walter, S. D., Avery, L., & Russell, D. J. (2009). Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Developmental Medicine & Child Neurology, 51(4), 295-302.

CHANGES IN FUNCTIONAL ABILITY

Table III: Peak/Decline estimates and between-child variation in the parameters of change for best fitting models, by Gross Motor Function Classification System (GMFCS)[a]

		GMFCS				
		Stable Limit models		Peak/Decline models		
		I	II	III	IV	V
Average GMFM-66 limit		89.5	68.5	47.4	33.5	17.3
50% range		81.0, 94.4	61.0, 75.2	38.7, 56.1	26.1, 41.0	9.7, 25.0
Average Age_{90}		5y 2mo	4y 11mo			
50% range		4y 1mo, 6y 8mo	3y 7mo, 6y 6mo			
Average predicted GMFM-66 at age 6y				51.2	41.1	23.6
50% range				47.1, 55.2	36.2, 46.0	17.6, 29.6
Peak/Decline	Age at peak (y)			7y 11mo	6y 11mo	6y 11mo
	(95% CI)			(6y 10mo, 9y)	(6y 2mo, 7y 6mo)	(5y 10mo, 7y 11mo)
	50% range			3y 8mo, 12y 1mo	4y 6mo, 9y 2mo	3y 6mo, 10y 4mo
	GMFM-66 loss from peak to limit			4.7	7.8	6.4
	(95% CI)			(1.9, 7.5)	(4.9, 10.6)	(2.8, 10.0)
	50% range[b]			0, 13.1	0, 16.9	0, 16.6

[a]Stable Limit models are used for Levels I to II, and Peak and Decline models are used for Levels III to V. Not all parameters are estimated for both models. Fifty per cent ranges are not reported for the Peak and Decline rate parameter because it has poor interpretability and low between-child variation. [b]Negative peak/loss estimates are undefined for the Peak and Decline model, and so the lower bound of the 50% range has been set to 0. GMFM-66, Gross Motor Function Measure; CI, confidence interval.

15) Hanna, S. E., Rosenbaum, P. L., Bartlett, D. J., Palisano, R. J., Walter, S. D., Avery, L., & Russell, D. J. (2009). Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Developmental Medicine & Child Neurology, 51(4), 295-302.

CHANGES IN FUNCTIONAL ABILITY

Table IV: Probabilities of attainment (scoring 3) for selected Gross Motor Function Measure items, at the average peak and limit score for Gross Motor Function Classification Levels III to V[a]

	Level III		Level IV		Level V	
Item	Peak (52.2)	Limit (47.5)	Peak (41.3)	Limit (33.5)	Peak (23.7)	Limit (17.3)
10. Prone, lifts head	99.5	98.8	96.6	88.0	**52.5**	**17.9**
23. Sitting, arms propping, 5s	99.6	99.1	97.3	89.5	**37.8**	**4.0**
22. Supported at thorax, lifts head to midline, 10s	99.3	98.5	95.6	84.0	**38.4**	**9.1**
34. Sits on bench, 10s	93.6	85.7	**59.3**	**10.0**	<1	<1
41. Prone, attains four-point	94.6	85.7	**48.2**	**3.6**	<1	<1
44. Four-point crawl or hitch, 10f (3.048 m)	97.0	87.0	**31.2**	**1.0**	<1	<1
35. From standing, sits on bench	**74.8**	**35.3**	3.3	<1	<1	<1
68. Walks 10 steps, one hand held	**57.7**	**19.0**	1.4	<1	<1	<1
53. Stand arms-free, 3s	**40.1**	**16.1**	2.3	<1	<1	<1
69. Walks 10 steps, no support	14.6	1.6	<1	<1	<1	<1

[a]Items with moderate probabilities (25–75%) at peak predicted score are in bold.

Peak-limit 차이가 4.7~7.8 point 밖에 안되지만 이 기능을 수행할 수 있는 비율은 현저히 줄어든다.

15) Hanna, S. E., Rosenbaum, P. L., Bartlett, D. J., Palisano, R. J., Walter, S. D., Avery, L., & Russell, D. J. (2009). Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Developmental Medicine & Child Neurology, 51(4), 295-302.

Changes in functional ability

- 아동기와 청소년기는 성인 CP의 기능에 중요
- 할 수 있는 것-> 주로 하는 것
- 기능 손실은 성인 이후에도 발생
- 각 수준별로 성취 가능하지만 잃기 쉬운 활동에 주목
- 같은 GMFCS 수준에서도 개인차가 존재
- 개인적 특성을 고려

03

LIFE EXPECTANCY

FOR NON-AMBULATORY CP

Life Expectancy

severe CP(GMFCS 4&5) in UK

2세	10세	20세	30세	40세
	72%	44%	34%	27%

가장 큰 사망원인: Respiratory problems(61~76%)

- Disability ↑ → survival rate ↓
- Ambulatory CP의 94%가 30세까지 생존(일반인 생존율 98.5%)
- GMFCS level 5 with feeding tube CP의 20세 생존율 41%
- Causes of death in CP

- Cerebral palsy itself
- Respiratory problems(pneumonia)
- Circulatory problems(cardiac arrest, progressive cardiac failure)
- Complications from G-tube)
- Bowel and bladder problem
- Etc.(accident, tumor,

LIFE EXPECTANCY

Feed tube한 GMFCS 5의 생존율의 증가

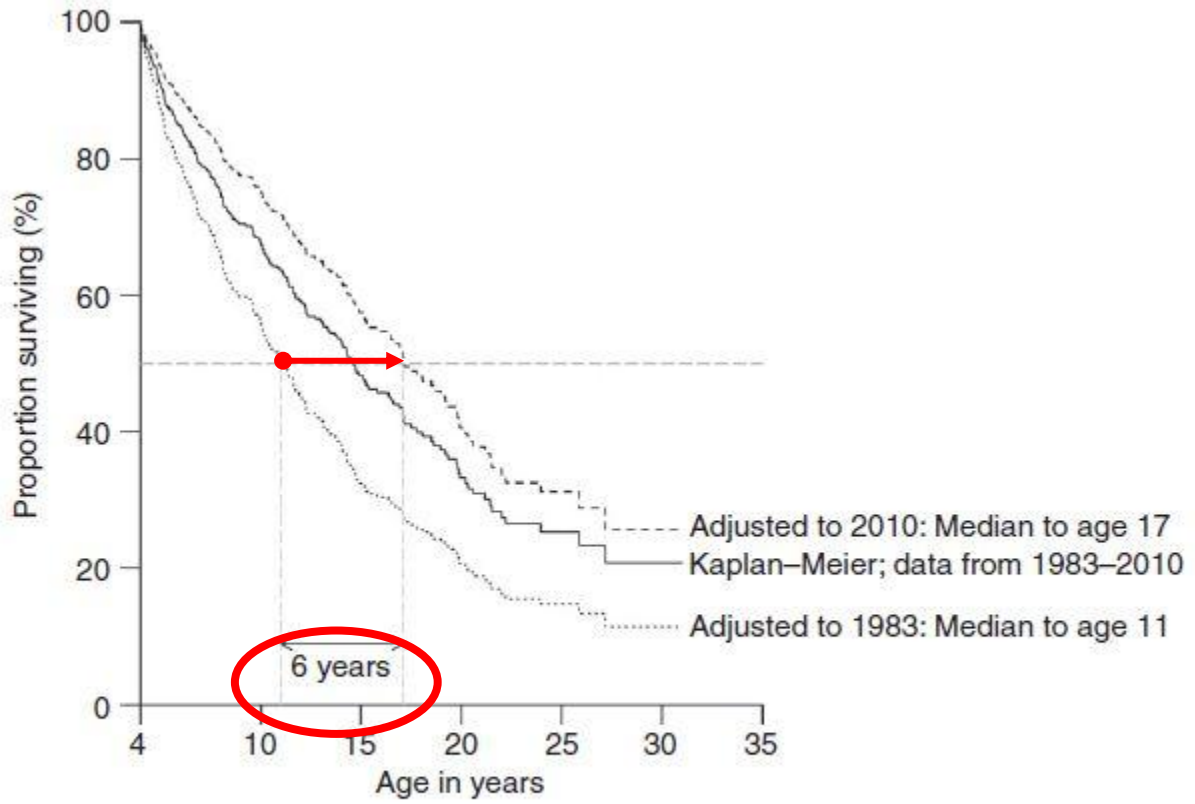
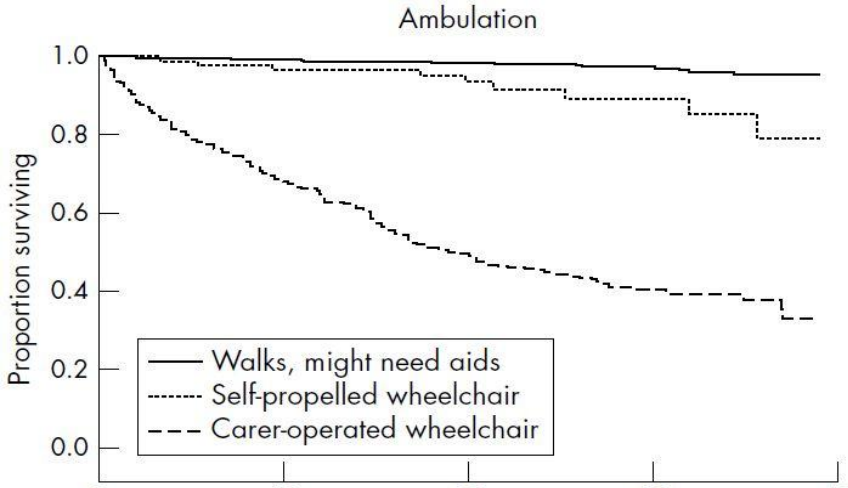


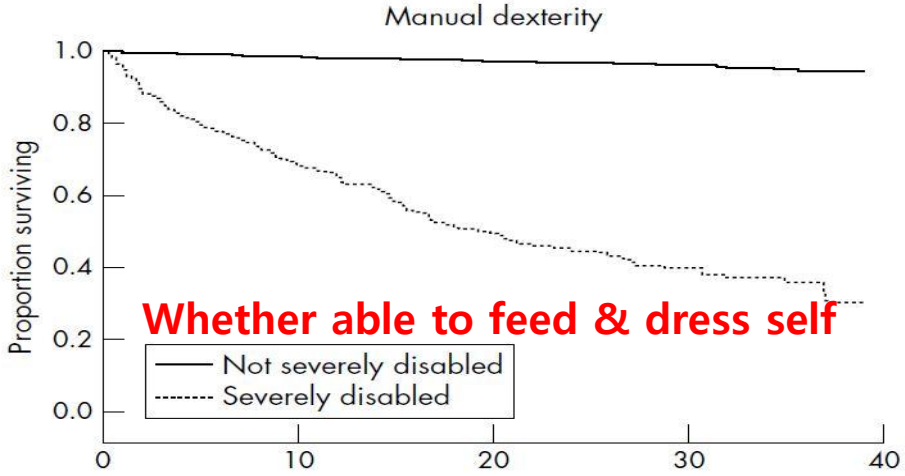
Figure 1: Survival of 4-year-old children who do not lift their heads when in the prone position and are tube fed.

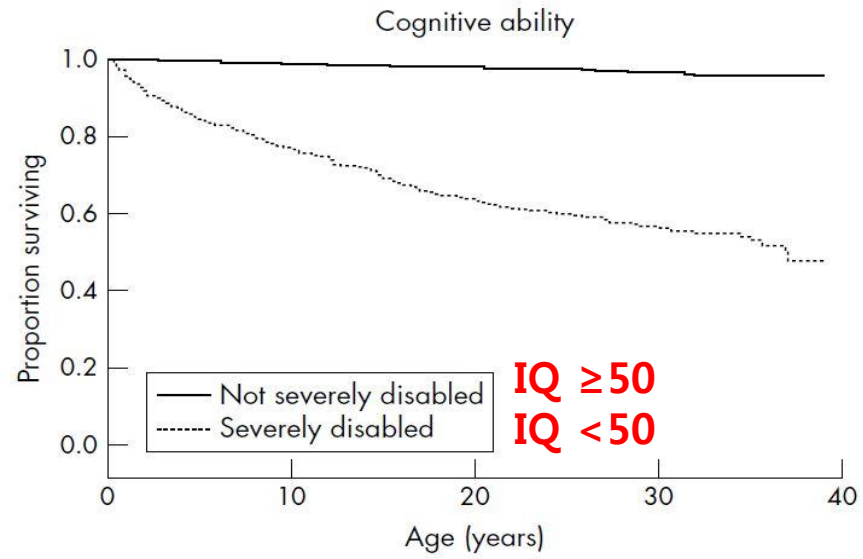
9) Brooks, J. C., Strauss, D. J., Shavelle, R. M., Tran, L. M., Rosenbloom, L., & Wu, Y. W. (2014). Recent trends in cerebral palsy survival. Part II: individual survival prognosis. Developmental Medicine & Child Neurology, 56(11), 1065-1071.

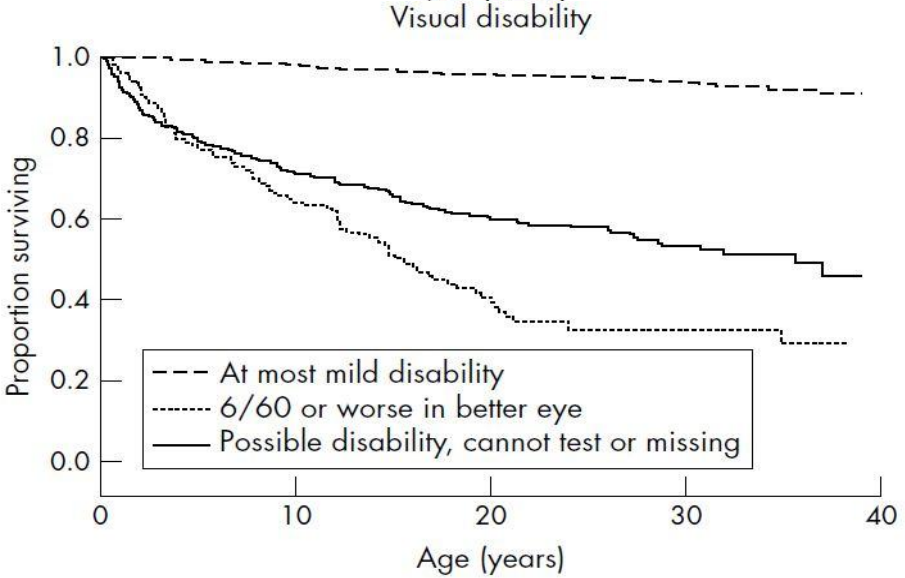
LIFE EXPECTANCY

Survival in cerebral palsy by type of functional disability









19) Hutton, J. L., & Pharoah, P. O. (2006). Life expectancy in severe cerebral palsy. Archives of Disease in Childhood, 91(3), 254-258.

LIFE EXPECTANCY

4가지 factor(ambulation, manual, cognition, vision)
모두 심한손상과 덜 심한 손상의 life expectancy

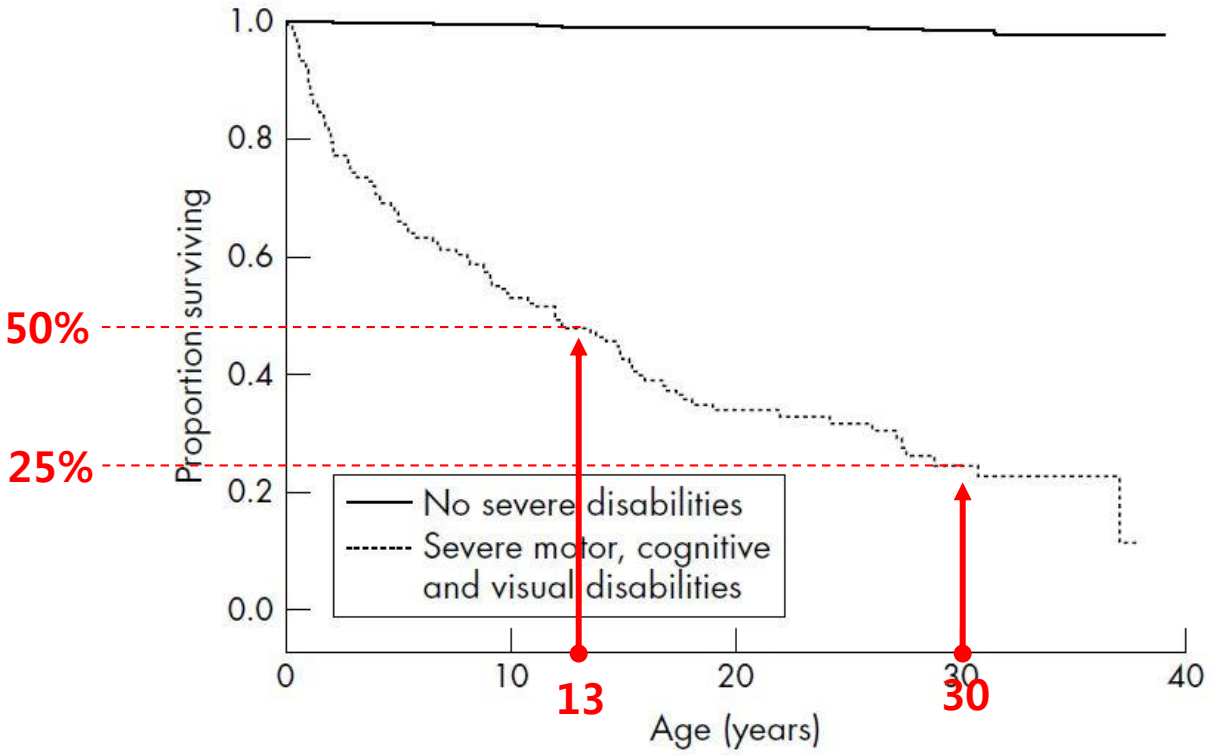


Figure 2 Cerebral palsy survival for mild and severe disabilities.

19) Hutton, J. L., & Pharoah, P. O. (2006). Life expectancy in severe cerebral palsy. Archives of Disease in Childhood, 91(3), 254-258.

LIFE EXPECTANCY

4세 아동의 기능수준별 생존율 예측치

Table II: Probability (%) that a 4-year-old child with cerebral palsy will survive to ages 10, 15, 20, 25, and 30 years

		Adjusted-to-2010					Unadjusted Kaplan–Meier				
	n	10	15	20	25	30	10	15	20	25	30
Does not lift head in the prone position											
Tube fed	482	75	58	41	31	26	68	48	33	25	21
Fed orally by others	615	85	73	56	47	43	80	66	51	43	39
Feeds self orally	50	97	90	90	–	–	95	88	88	–	–
Lifts head but not chest in the prone position											
Tube fed	303	79	66	55	44	34	73	58	48	38	29
Fed orally by others	795	89	80	67	54	48	85	73	61	49	44
Feeds self orally	103	97	92	86	76	76	95	89	84	74	74
Lifts head and chest, partial rolling											
Tube fed	265	82	71	65	54	40	77	65	59	48	35
Fed orally by others	962	93	86	78	66	55	90	81	73	62	52
Feeds self orally	329	97	95	92	87	77	96	93	91	85	75
Full rolling, does not walk unaided											
Tube fed	475	90	85	77	64	56	87	81	73	60	52
Fed orally by others	1643	96	93	88	84	77	95	91	86	82	76
Feeds self orally	4906	99	98	96	94	92	98	97	95	93	91
Walks unaided											
Tube fed	125	96	94	86	81	–	95	93	84	79	–
Fed orally by others	188	97	97	97	97	87	96	95	95	95	86
Feeds self orally	5199	100	99	98	96	94	99	99	98	96	94

Log rank test for the Kaplan–Meier survival curves to test whether survival varies by: motor function (χ^2=2799, df=4, p<0.0001), feeding (χ^2=2365, df=2, p<0.0001), or motor-feeding group (χ^2=3508, df=14, p<0.0001).

9) Brooks, J. C., Strauss, D. J., Shavelle, R. M., Tran, L. M., Rosenbloom, L., & Wu, Y. W. (2014). Recent trends in cerebral palsy survival. Part II: individual survival prognosis. Developmental Medicine & Child Neurology, 56(11), 1065-1071.

Life Expectancy

Life expectancy; additional years(SD) for adolescent to adult

Table III: Life expectancy: additional years (standard error) for adolescents and adults with cerebral palsy[a]

	Cannot lift head			Lifts head or chest			Rolls/sits			Walks unaided[b]	General population
Sex/Age	TF	FBO	SF	TF	FBO	SF	TF	FBO	SF		
Female											
15y	14 (1.0)	18 (1.2)	–	18 (1.5)	23 (1.0)	–	27 (1.8)	37 (1.3)	48 (1.2)	55 (1.0)	66.2
30y	14 (0.9)	19 (1.2)	–	14 (0.8)	23 (1.1)	–	18 (1.8)	32 (1.2)	37 (0.8)	43 (0.7)	51.6
45y	12 (1.0)	14 (1.0)	–	12 (1.0)	17 (1.2)	–	12 (1.5)	21 (1.0)	25 (0.6)	29 (0.6)	37.4
60y	7 (0.8)	10 (1.4)	–	7 (0.8)	10 (1.1)	–	7 (0.8)	10 (0.8)	16 (0.5)	19 (0.7)	24.1
Male											
15y	14 (1.0)	18 (1.2)	–	18 (1.4)	23 (1.0)	–	27 (1.7)	33 (1.1)	45 (1.1)	52 (0.9)	61.4
30y	14 (0.9)	19 (1.2)	–	14 (0.8)	23 (1.1)	–	18 (1.7)	28 (1.1)	33 (0.7)	39 (0.6)	47.4
45y	12 (1.0)	14 (1.0)	–	12 (1.0)	17 (1.1)	–	12 (1.5)	18 (0.9)	22 (0.5)	25 (0.5)	33.5
60y	7 (0.8)	10 (1.4)	–	7 (0.8)	10 (1.1)	–	7 (0.8)	10 (0.8)	12 (0.4)	15 (0.5)	21.1

–, Results not shown because of small sample size. [a]As noted in the text, these life expectancies do not necessarily apply to younger children. [b]Life expectancies for the 'walks unaided' groups assume that individuals in the group will remain ambulatory until at least age 60. FBO, fed orally by others; SF, self-feeds orally; TF, tube fed.

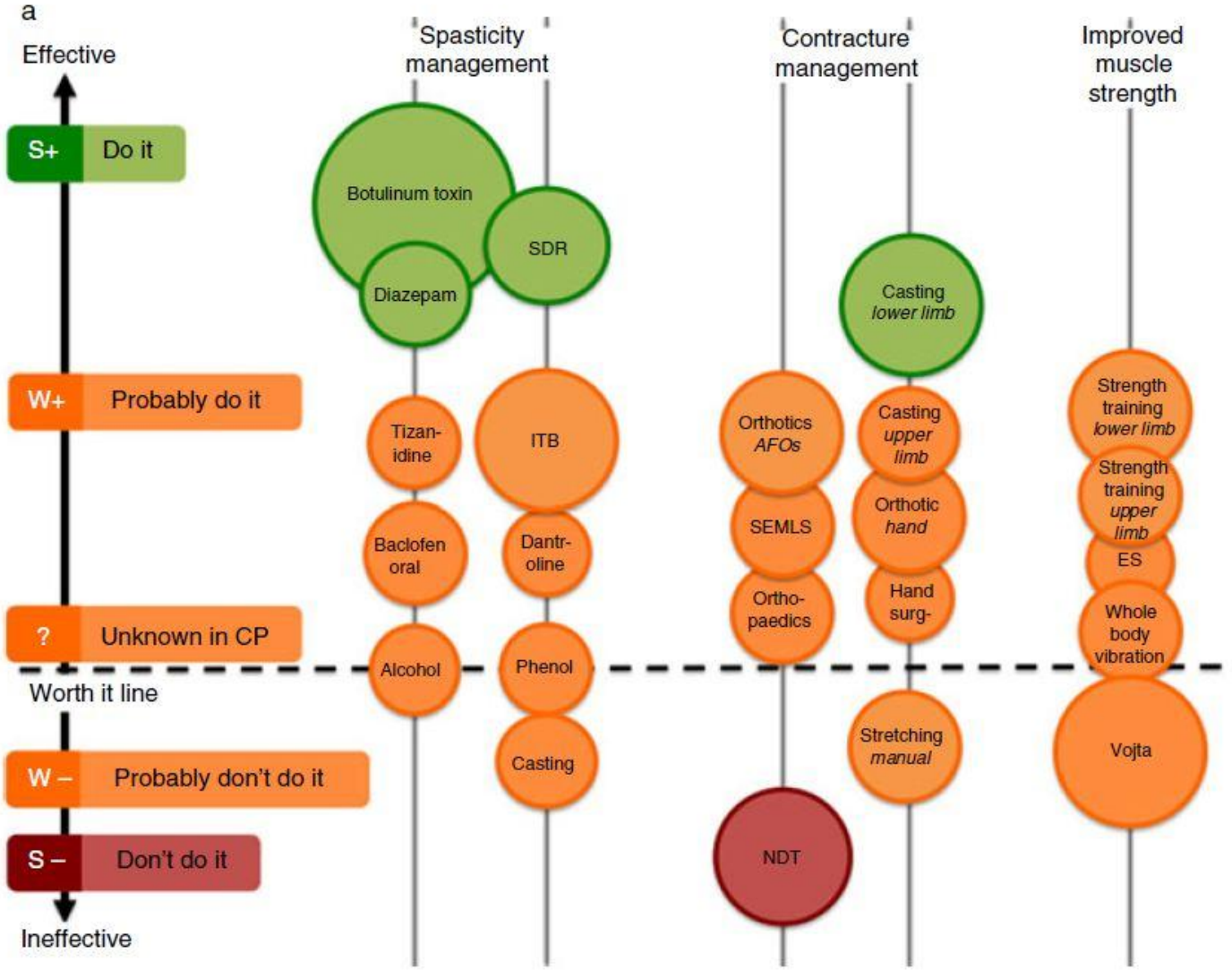
9) Brooks, J. C., Strauss, D. J., Shavelle, R. M., Tran, L. M., Rosenbloom, L., & Wu, Y. W. (2014). Recent trends in cerebral palsy survival. Part II: individual survival prognosis. Developmental Medicine & Child Neurology, 56(11), 1065-1071.

04

VARIOUS INTERVENTIONS

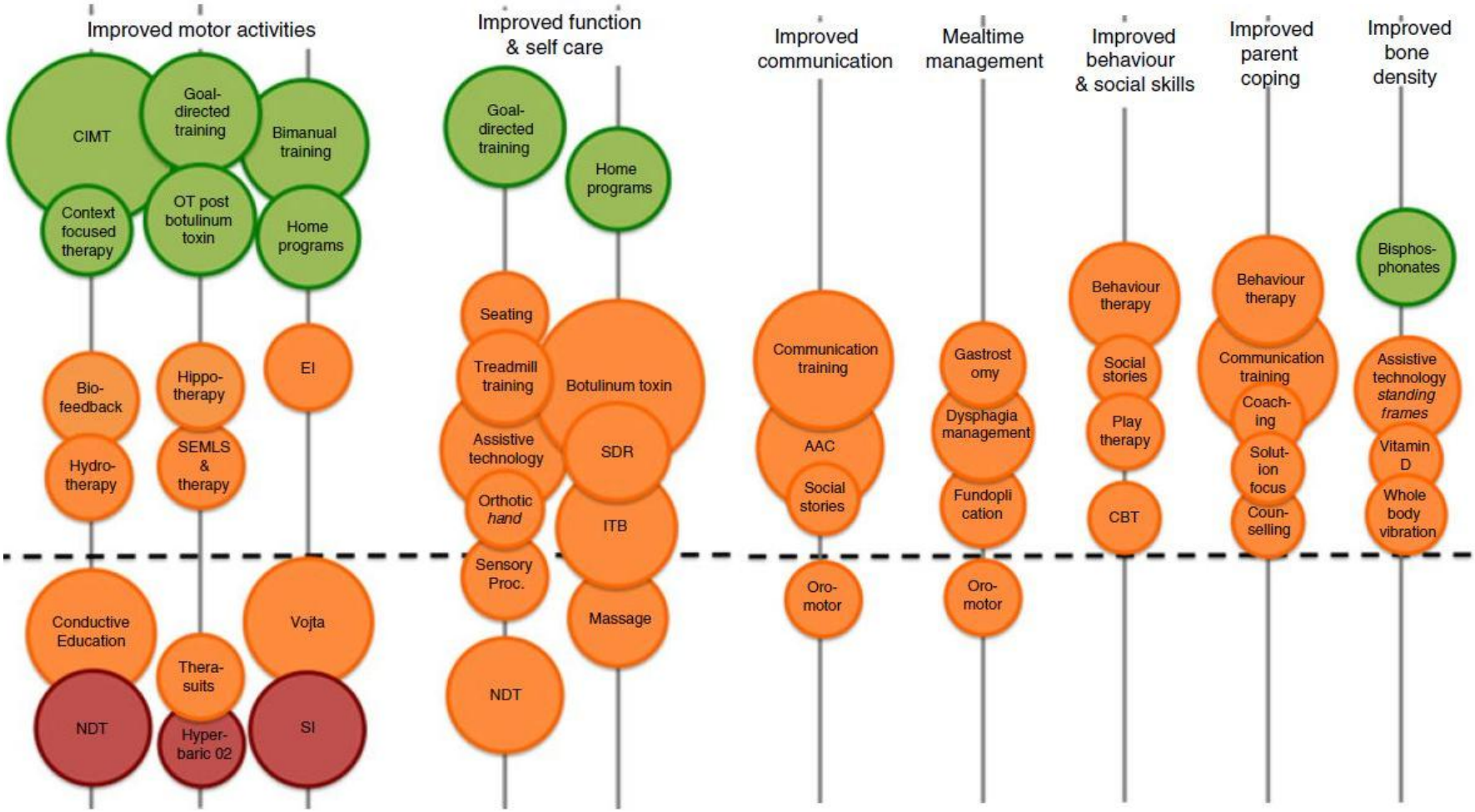
FOR CP

Interventions for CP



29) Novak, I., Mcintyre, S., Morgan, C., Campbell, L., Dark, L., Morton, N., ... & Goldsmith, S. (2013). A systematic review of interventions for children with cerebral palsy: state of the evidence. Developmental Medicine & Child Neurology, 55(10), 885-910.

Interventions for CP



29) Novak, I., Mcintyre, S., Morgan, C., Campbell, L., Dark, L., Morton, N., ... & Goldsmith, S. (2013). A systematic review of interventions for children with cerebral palsy: state of the evidence. Developmental Medicine & Child Neurology, 55(10), 885-910.

05

COMPLICATIONS AND PREVENTION

FOR NON-AMBULATORY CP

COMPLICATIONS
IN NON-AMBULATORY CP

1. **Hip joint dislocation/displacement**
2. **Scoliosis**
3. **Pain**
4. **Contracture**
5. **Bone mineral density(BMD) & Fracture**
6. **General health**
7. **Muscle growth**
8. **Cardiopulmonary problem**
9. **Aging**
10. **Etc. (epilepsy, vision/hearing problem, aspiration, GERD, cognitive problem, swallowing problem)**

01 Hip displacement/dislocation

- **Incidence**

- 7% in ambulatory CP
- 60% of total body involvement(non-ambulatory CP)
- 15~20% in whole CP

- **CP Subtypes in MP >30**

- Spastic quadriplegia: 59~83%
- Dystonic: 40%
- Spastic diplegia: 19%

*GMFCS is simple, stable and early diagnosed

- **Higher risk of displacement/dislocation**

- Severe gross motor limitation(GMFCS V > III, IV)
- Spastic quadriplegia & dyskinetic CP
- Highest at 2-5 years

01 HIP DISPLACEMENT/DISLOCATION

GMFCS level별 hip displacement 발생비율

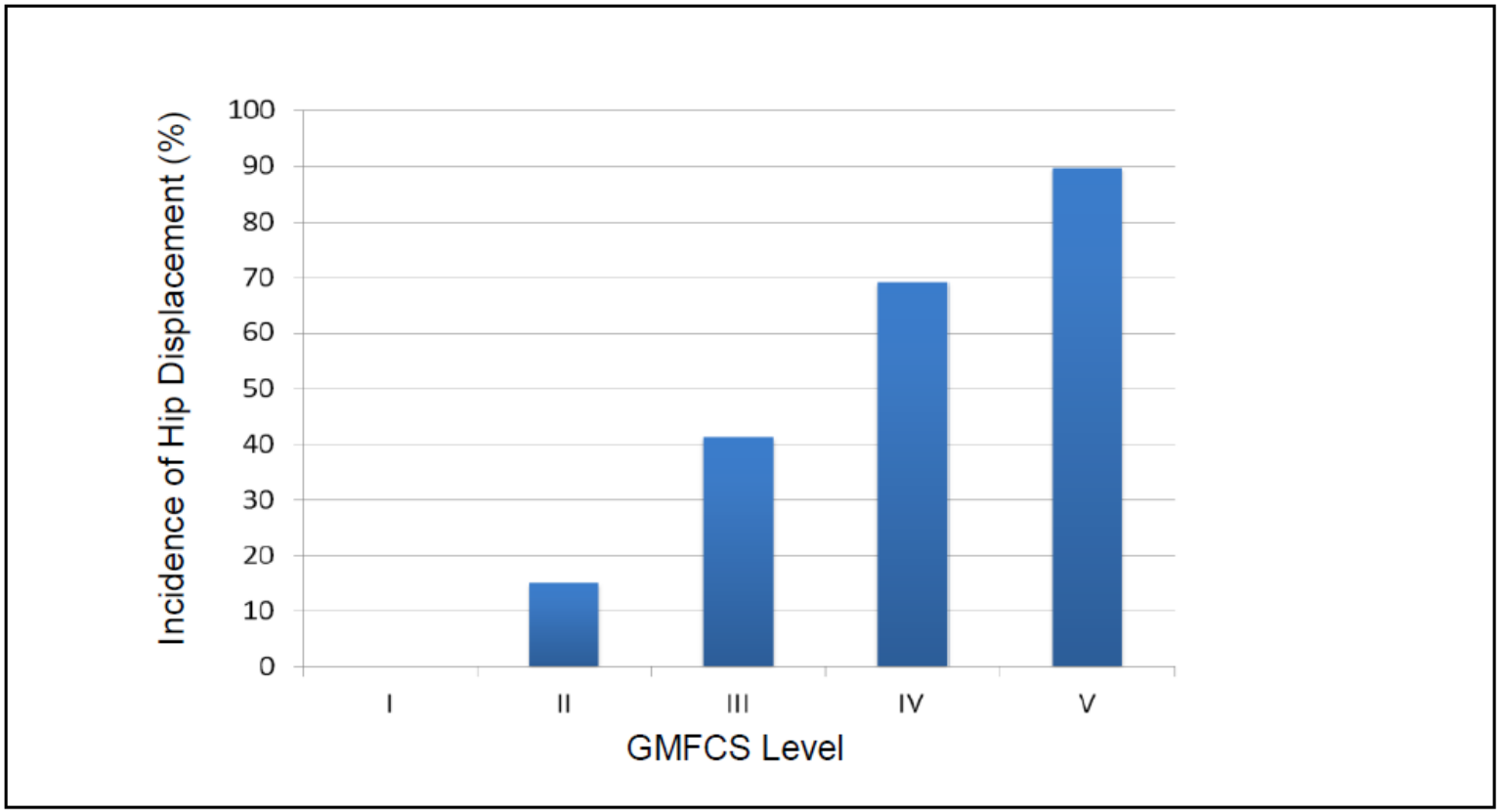


Figure 2: Incidence of hip displacement (Migration Percentage >30%) by GMFCS Level

7) British Columbia Consensus Statement On Hip Surveillance for Children with Cerebral Palsy Information for Health Care Professionals Caring for Children with Cerebral Palsy 2012

01 Hip displacement/dislocation

Normal

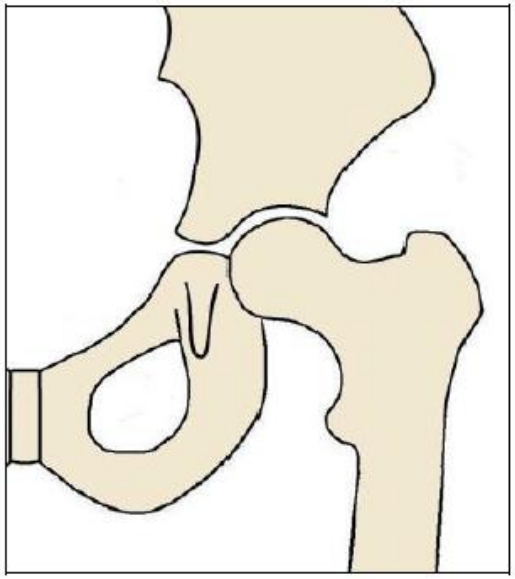


Figure 1a: Normal Hip

Displacement

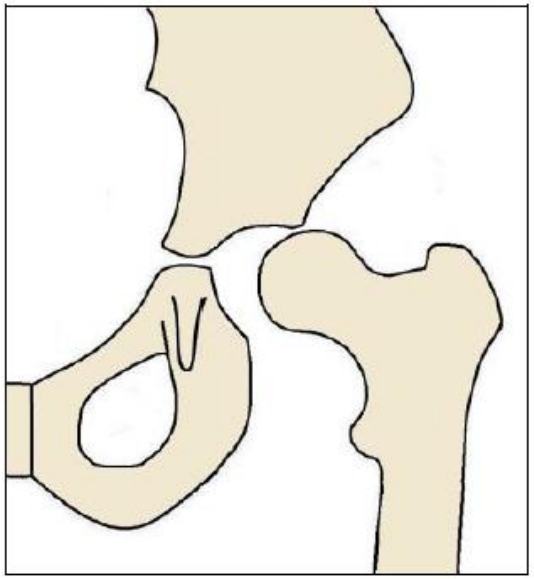


Figure 1b: Displaced Hip

Dislocation

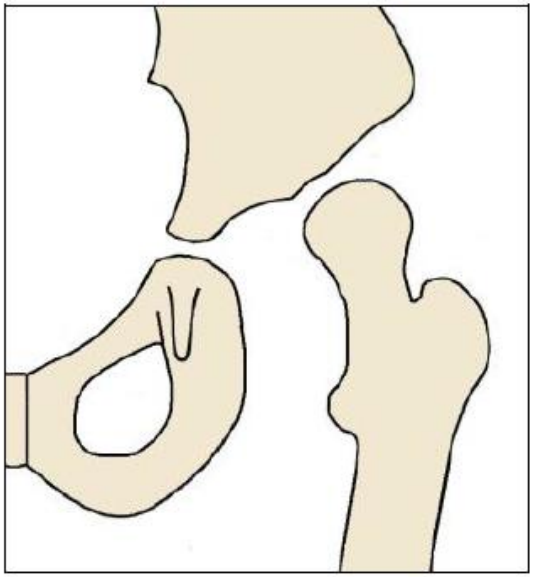


Figure 1c: Dislocated Hip

7) British Columbia Consensus Statement On Hip Surveillance for Children with Cerebral Palsy Information for Health Care Professionals Caring for Children with Cerebral Palsy 2012

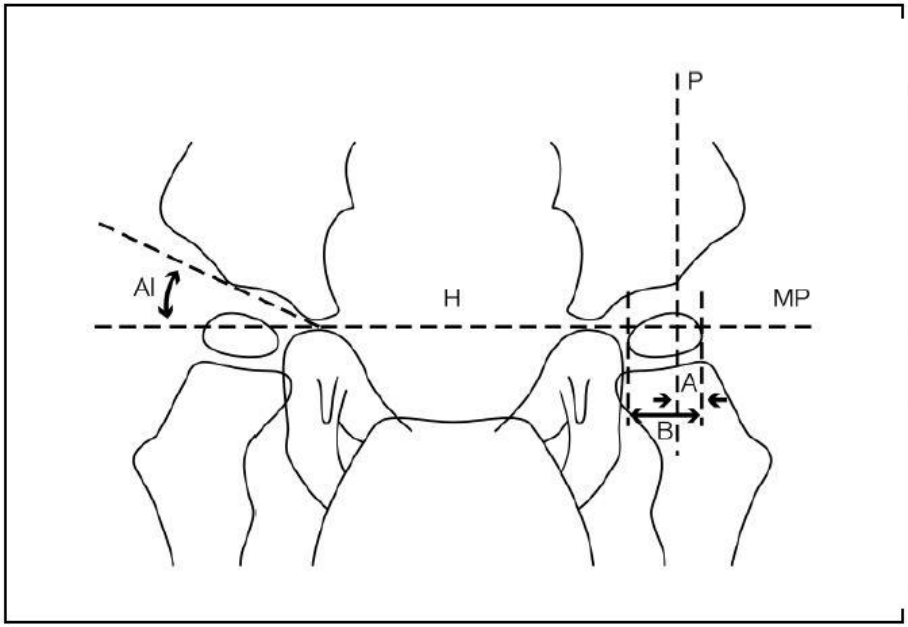
01 HIP DISPLACEMENT/DISLOCATION

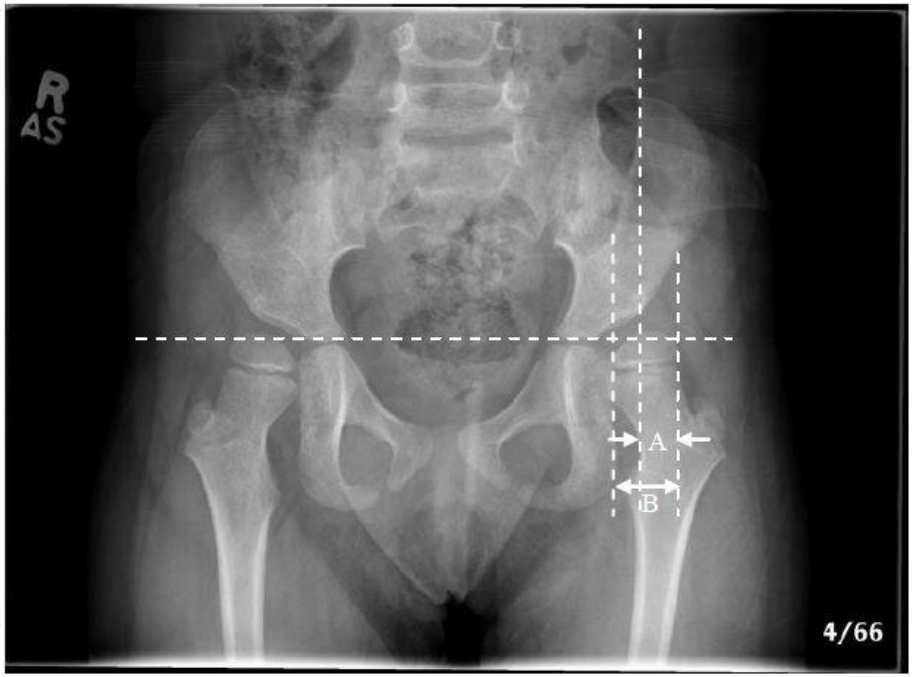
- **Measurement: Reimers' MP**(migration percentage)
- Pelvic AP X-ray에서 femur head가 acetabular margin에서 lateral로 빠진 정도를 측정

- Normal: 0≤MP, (MP<10%, 4yrs)
- **Displacement: MP>30~33**
- **Dislocation: MP=100**

- **Causes of hip displacement/dislocation**
- Decreased weight bearing activity
- Shortening of the psoas and hip adductor
- Increased spasticity

01 Hip displacement/dislocation





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7) British Columbia Consensus Statement On Hip Surveillance for Children with Cerebral Palsy Information for Health Care Professionals Caring for Children with Cerebral Palsy 2012

01 HIP DISPLACEMENT/DISLOCATION

cumulative risk of 40>MP>33

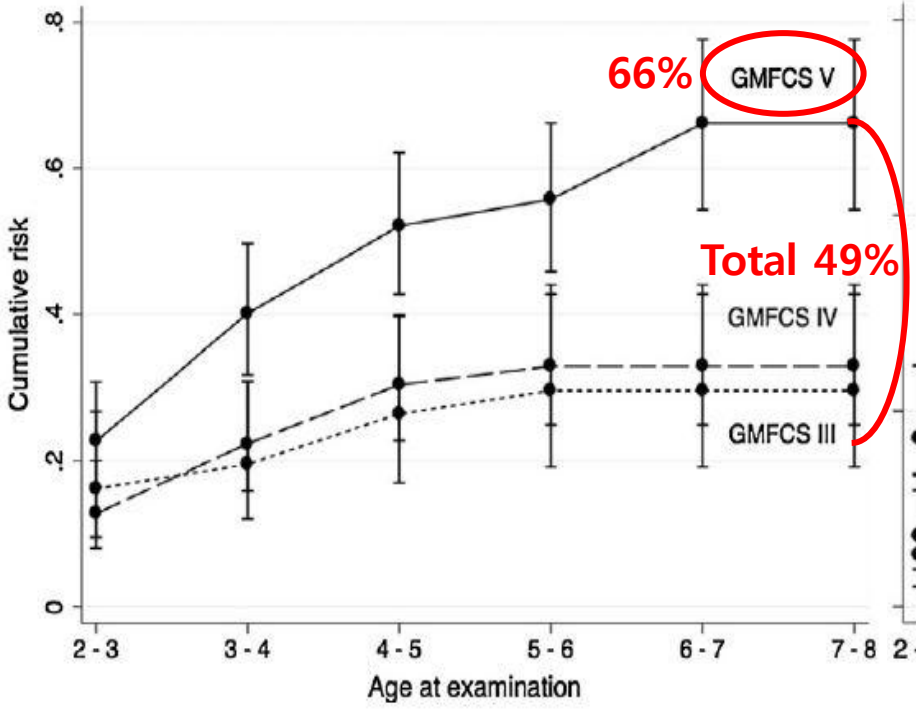
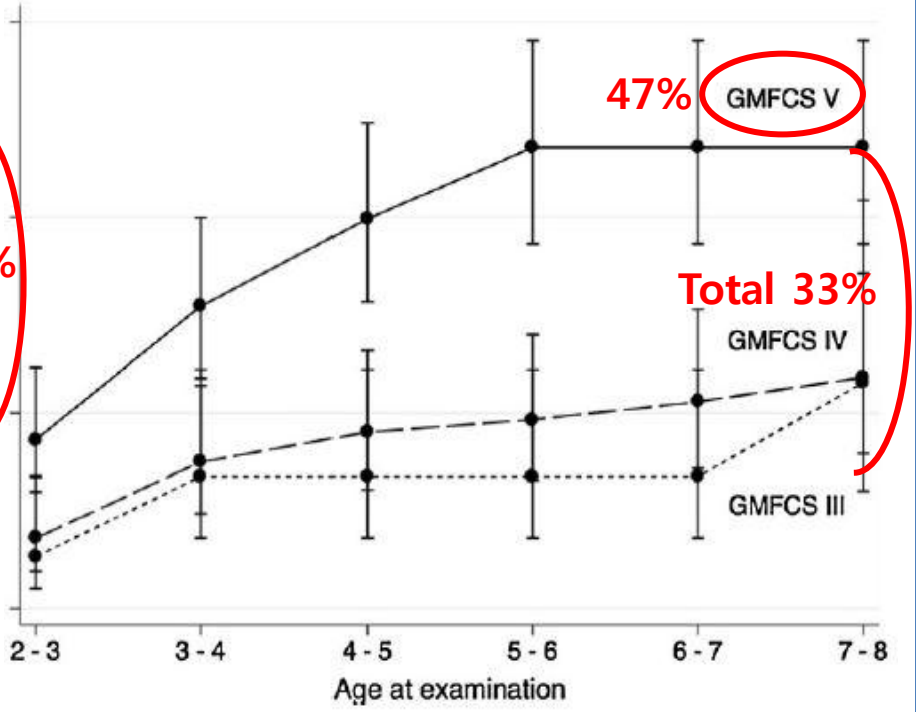


Fig. 2 Cumulative risk of hip displacement MP > 33 %

cumulative risk of MP≥40



3 Cumulative risk of hip displacement MP ≥ 40 %

22) Larnert, P., Risto, O., Hägglund, G., & Wagner, P. (2014). Hip displacement in relation to age and gross motor function in children with cerebral palsy. Journal of children's orthopaedics, 8(2), 129-134.

J Child Orthop (2014) 8:129–134
DOI 10.1007/s11832-014-0570-7

ORIGINAL CLINICAL ARTICLE

Hip displacement in relation to age and gross motor function in children with cerebral palsy

Per Larnert · Olof Risto · Gunnar Hägglund · Philippe Wagner

Table 1 Annual incidence for hip displacement >33 % in relation to GMFCS level

Age (years)	GMFCS III		GMFCS IV		GMFCS V	
	Incidence	95 % CI	Incidence	95 % CI	Incidence	95 % CI
2–3	0.16	0.08–0.27	0.13	0.07–0.20	0.23	0.15–0.32
3–4	0.04	0.00–0.11	0.11	0.05–0.18	0.23	0.13–0.34
4–5	0.09	0.02–0.21	0.10	0.04–0.19	0.20	0.10–0.34
5–6	0.04	0.00–0.16	0.04	0.00–0.10	0.08	0.01–0.21
6–7	0		0		0.24	0.06–0.52
7–8	0		0		0	

1/3이 수술없이 MP 33% ↓

Table 2 Annual incidence for hip displacement >40 % in relation to GMFCS level

Age (years)	GMFCS III		GMFCS IV		GMFCS V	
	Incidence	95 % CI	Incidence	95 % CI	Incidence	95 % CI
2–3	0.05	0.01–0.12	0.07	0.03–0.13	0.17	0.11–0.25
3–4	0.09	0.03–0.18	0.08	0.04–0.15	0.16	0.09–0.25
4–5	0		0.04	0.01–0.09	0.13	0.06–0.23
5–6	0		0.02	0.00–0.06	0.12	0.03–0.27
6–7	0		0.02	0.00–0.08	0	
7–8	0.11	0.01–0.31	0.03	0.00–0.12	0	

1/10만 수술없이 MP 33% ↓

22) Larnert, P., Risto, O., Hägglund, G., & Wagner, P. (2014). Hip displacement in relation to age and gross motor function in children with cerebral palsy. Journal of children's orthopaedics, 8(2), 129-134.

01 Hip displacement/dislocation

- **Influence of hip displacement**
  - Pain
  - ROM ↓
  - Sitting, standing and walking problem
  - Hip dislocation
  - Pelvic obliquity
  - Windswept deformity
  - Scoliosis
  - Challenges in hygiene

01 Hip displacement/dislocation

- **Non-surgical Treatment**

- Preventing contracture
- Appropriate lying, sitting and standing
- Using appropriate orthoses(including customized standing brace)
- Weight bearing in hip abduction and extension position

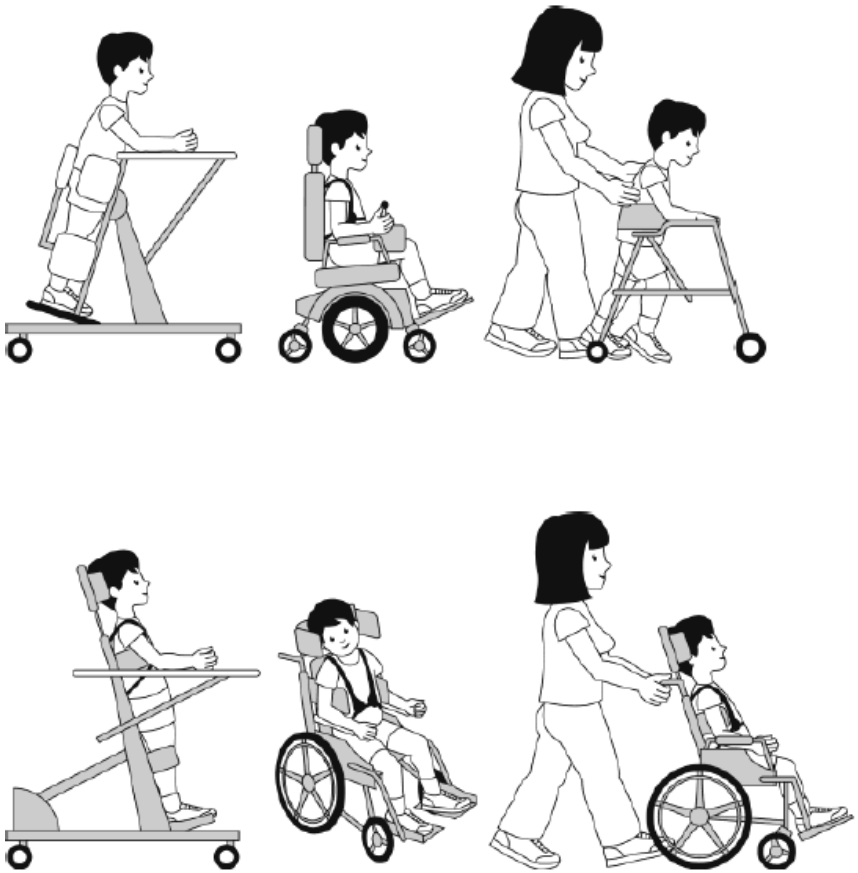
- **Surgical Treatment**

- Indication: MP>40
- Adductor-psoas lengthening, varus osteotomy of the proximal femur (and pelvic reconstruction)
- Soft tissue surgery: Most effective before 4yrs.

- **초기의 올바른 접근 → Hip joint의 안정성 확보**
- **Preventative Intervention: Hip surveillance program**

Hip Surveillance Program

GMFCS IV & V[13, 22]



- At each Clinical Exam, verify GMFCS level; if GMFCS level has changed, ongoing surveillance according to confirmed classification
- Initial Clinical Exam at identification of CP
- Clinical Exam and initial AP radiograph at 24 months of age
- Clinical Exam and AP pelvic radiograph 6 monthly until 6 years of age
- After 6 years of age, continue Clinical Exam and AP pelvic radiograph 12 monthly until skeletal maturity

7) British Columbia Consensus Statement On Hip Surveillance for Children with Cerebral Palsy Information for Health Care Professionals Caring for Children with Cerebral Palsy 2012

Hip Surveillance Program

Table II. Hip operations and radiological outcomes

	Control group: born 1990 to 1991 (n = 103)	First study group: born 1992 to 1997 (n = 258)	Second study group: born 1998 to 2008 (n = 431)
Hip dislocation (MP 100%) at last examination	9	2+2*	0
Hip displacement (MP > 40%) at last examination†	2	2	9
Total number of children operated n (%)	14 (*14*)	39 (*15*)	52 (*12*)
Total number of operations n	23	56	75
Primary surgery			
Adductor–psoas tenotomy	8	24	31
Varus femoral osteotomy	4	15	21
Salvage	2	0	0
Repeat surgery			
Adductor–psoas tenotomy	2	1	0
Varus femoral osteotomy	3	14+2‡	18 + 3‡
Varus femoral osteotomy + Dega	2	0	2
Salvage	2	0	0

* One child with hip dislocation before moving into the area and one child not participating in CPUP
† Dislocated hips not included
‡ Third operation n, number of children; MP, migration percentage

14) Hägglund, G., Alriksson-Schmidt, A., Lauge-Pedersen, H., Rodby-Bousquet, E., Wagner, P., & Westbom, L. (2014). Prevention of dislocation of the hip in children with cerebral palsy. Bone Joint J, 96(11), 1546-1552.

Hip Surveillance Program

- 주기적인 방사선촬영과 임상평가 실시
- 조기 발견과 시기 적절한 중재가 중요
- Hip surveillance program 시행 이후 hip dislocation 발생↓ (10%→0.4%)
- 조기 수술은 acetabular dysplasia와 complex surgery 예방 가능
- 대다수의 CP는 태어날 때는 hip joint가 정상아동과 차이가 없음
- 적절한 중재가 없을 경우 평균적으로 1년에 MP 5.5%씩 증가됨
- 첫 수술 시 평균나이는 4.8세, gross motor impairment 심할수록 수술증가
  : GMFCS level III(16%), IV(28%), V(50%)

✓ **전 생애적 관점에서 QoL을 위한 preventative surgery 고려**

✓ **정기적 검진과 진료의뢰 제공**

02 Scoliosis

- **Scoliosis criteria: Cobb's angle ≥10'**

- **Occur**

- Before 10yrs. (88% in scoliosis)
- CP의 scoliosis 발병률: 15-80%
- Adult CP (19-65yrs) scoliosis 발생비율: 20.3%
- Spastic quadriplegic group had the highest rate of scoliosis
- The incidence directly paralleled the severity of the neurologic deficit

- **Progression**

- Postural problem→ progress rapidly→ increasingly stiff
- Rapid in growth years up to 60-90'⇒ monitoring 필수!
- Curve increase 2-4'/month in growth years in GMFCS IV, V
- Ambulator: 0.9'/year, Non-ambulator: 2.4'/year
- Cobb's angle<50': 0.8'/year, Cobb's angle≥50': 1.4'/year
- After skeletal maturity 73% scoliosis progressed, 1-4'/year

02 Scoliosis

- **Location**

- Thraco-lumbar > lumbar > thoracic region

: most common at T4-L1 (T10)

- **Cause**

- Gravity
- Asymmetrical spasticity
- Poor posture
- Severe CP due to limited movement, poor postural control

- **Relevant factors**

- Strong: CP severity
- Weak: CP subtype, hip dislocation, pelvic obliquity, age, daytime position, spasticity

02 Scoliosis

- **Problems**

- Continuously increase after skeletal maturity
- Pelvic obliquity ↑
- Spend more time and effort to care
- Arm function ↓
- Pain

- **Intervention**

- Bracing in growth years
- **Symmetrical sitting and appropriate positioning**
- Early surgical intervention: Cobb's angle>40 before 15yrs., total body involvement, bedridden, thoraco-lumbar region curve
- Spinal fusion surgery (만족도 ↑, 위험성 ↑)

02 Scoliosis

15세전 40도 기준으로 aging에따른 spine 각도변화추이

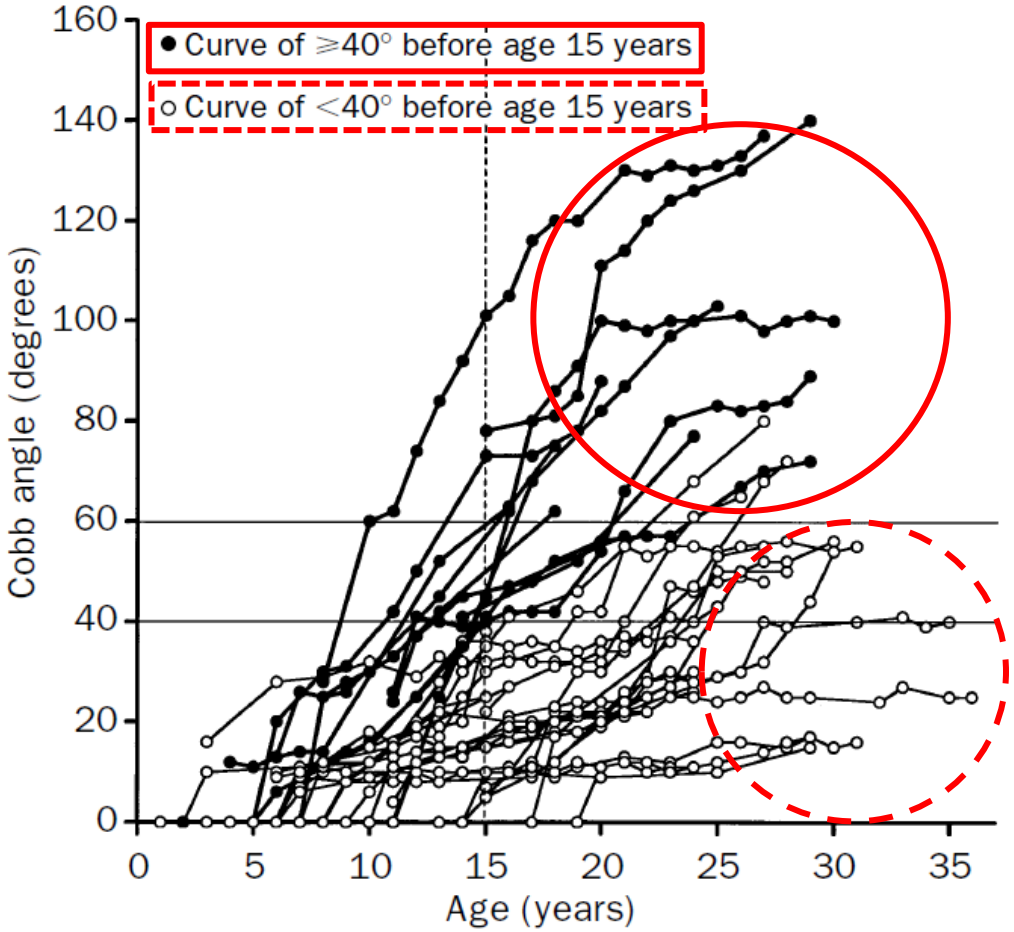


Figure 1: **Curve progression in 37 patients with spastic cerebral palsy**

34) Saito, N., Ebara, S., Ohotsuka, K., Kumeta, H., & Takaoka, K. (1998). Natural history of scoliosis in spastic cerebral palsy. The Lancet, 351(9117), 1687-1692.

02 Scoliosis

With Total body involvement

Without Total body involvement

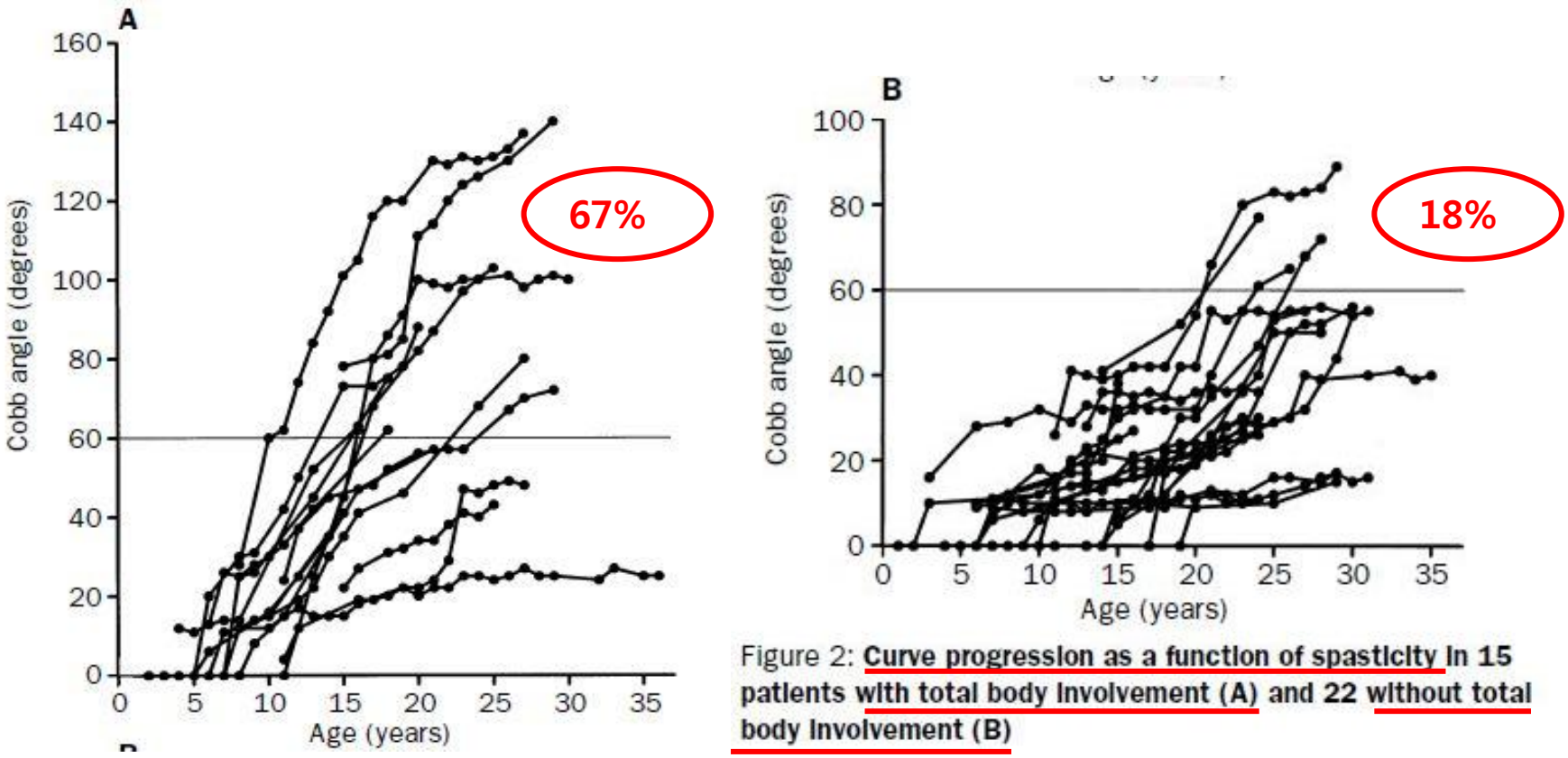


Figure 2: **Curve progression as a function of spasticity in 15 patients with total body involvement (A) and 22 without total body involvement (B)**

34) Saito, N., Ebara, S., Ohotsuka, K., Kumeta, H., & Takaoka, K. (1998). Natural history of scoliosis in spastic cerebral palsy. The Lancet, 351(9117), 1687-1692.

02 Scoliosis

Ambulation의 영향 in scoliosis

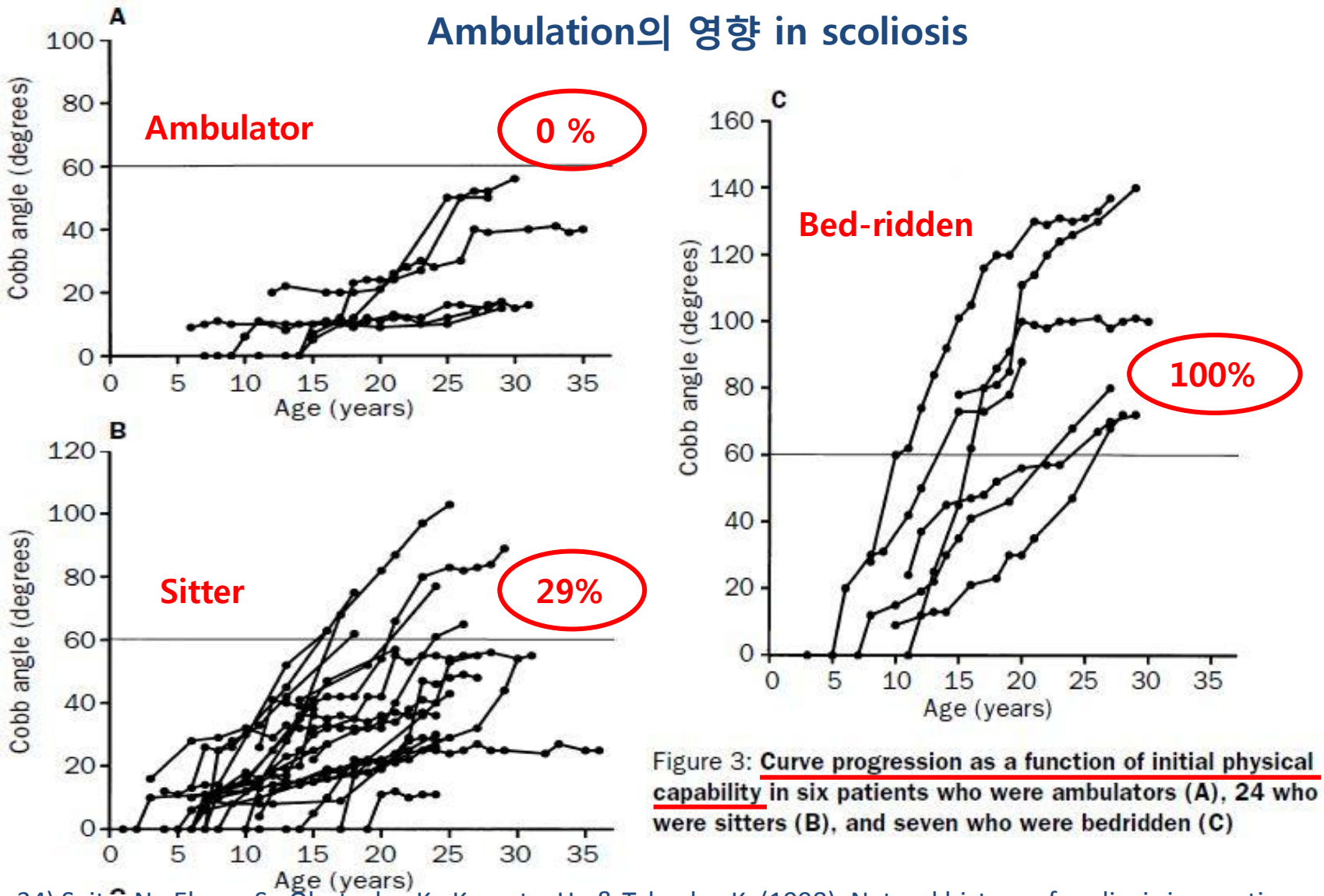


Figure 3: **Curve progression as a function of initial physical capability in six patients who were ambulators (A), 24 who were sitters (B), and seven who were bedridden (C)**

34) Saitō, N., Ebara, S., Ohotsuka, K., Kumeta, H., & Takaoka, K. (1998). Natural history of scoliosis in spastic cerebral palsy. The Lancet, 351(9117), 1687-1692.

03 Pain

- **Incidence**
  - 54% adult CP in Europe→ QoL↓
  - 47.2% in non-ambulatory adolescent CP(only 13.6% managed)
  - 32.4% in 1-14 age CP(2y-17%→ 14y-50%)
  - Female > Male
  - Variable among studies
- **Location**
  - Feet > hip > knee > abdomen > back > head and neck> arm and hand
  - GMFSC level에 따른 통증 호소부위의 차이 있음
- **Relevant factors**
  - Strong: Inactivity, deformity
  - Weak: GMFCS level
  - Unclear: cognitive level, obesity

03 PAIN

- **Causes**

- Spasm and spasticity
- Contracture
- Hip displacement/dislocation
- Constipation
- Gastric reflux
- Hypersensitivity around operative scars
- Therapy itself
- Etc(muscle strain, skin problem, Gastrostomy tube, undetected dental caries)

03 Pain

- **Problems**

- Stop walking (funtional loss, QoL ↓)
- Compensatory posture (leads to postural asymmetry)
- Inactivity (leads to contracture and functional loss)

- **Pain management**

- Commonly ignored in complex medical condition
- Exercise and activity
- Medication
- Adjust the causes of pain

03 PAIN

REGULAR ARTICLE

Pain in children and adolescents with cerebral palsy: a population-based registry study

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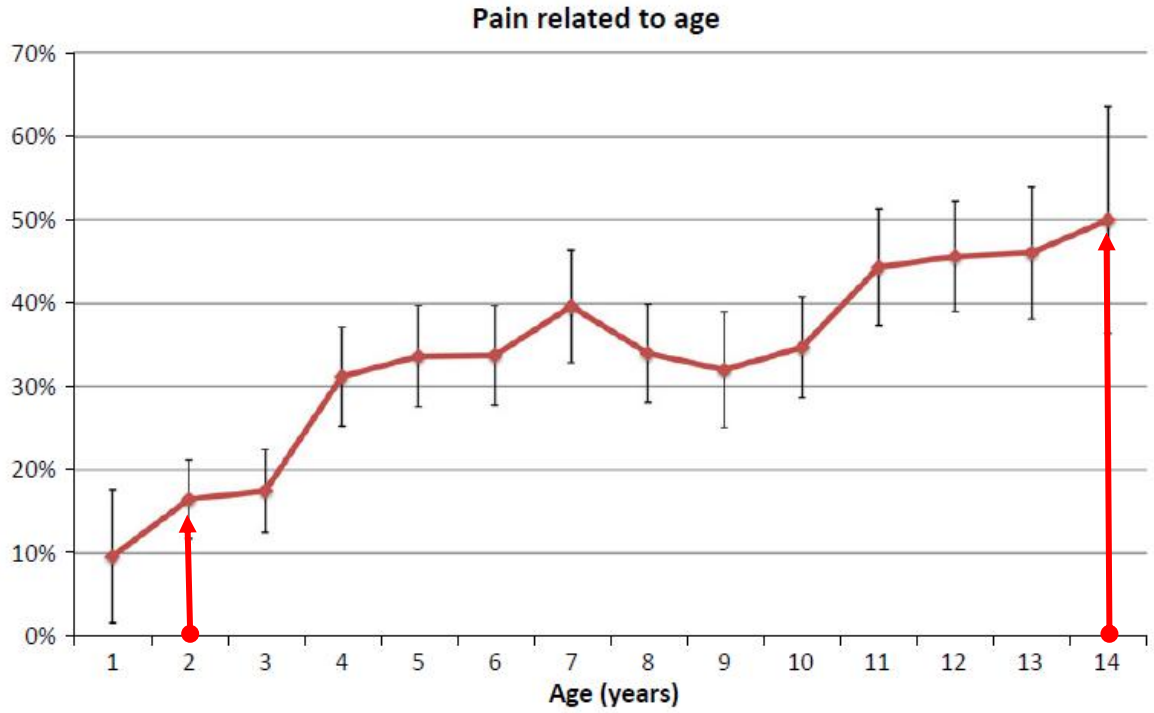

Figure 1 Proportion of children and adolescents with cerebral palsy reporting pain based on age. (The line segments represent the upper and lower bounds of the 95% confidence interval).

2) Alriksson-Schmidt, A., & Hägglund, G. (2016). Pain in children and adolescents with cerebral palsy: a population-based registry study. Acta Paediatrica, 105(6), 665-670.

03 Pain

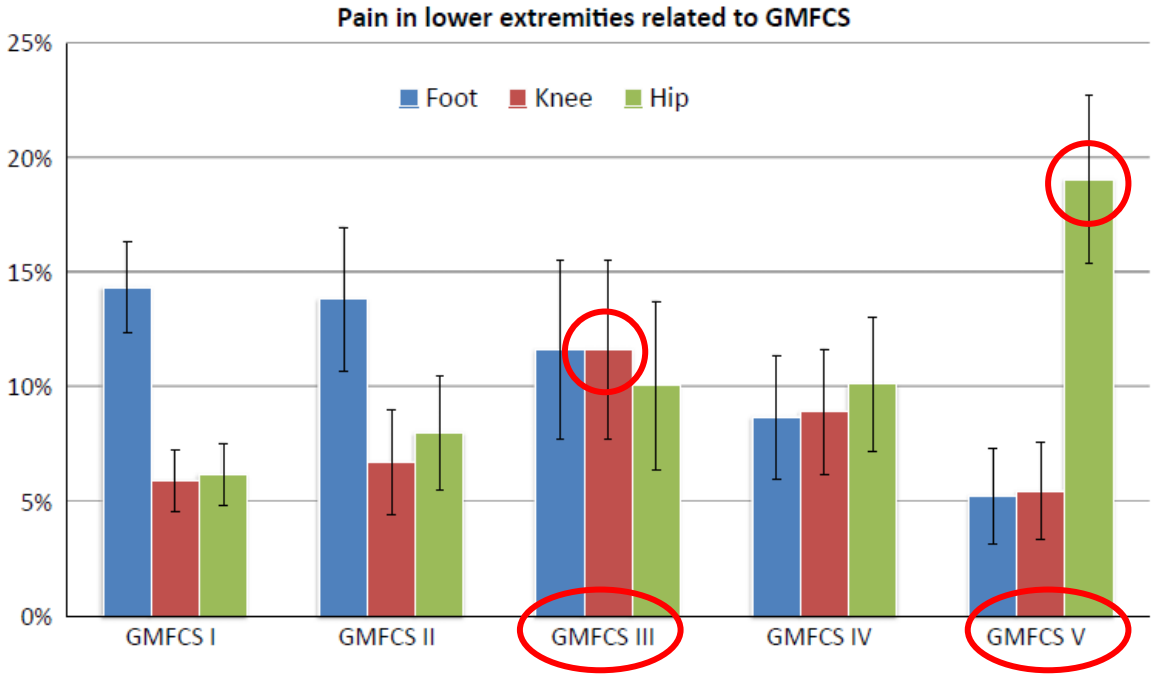

Figure 2 Proportion of pain reported in the lower extremities – feet and or lower leg, knee, hips and or thigh – in children and adolescents with cerebral palsy based on the gross motor function classification system levels. The line segments represent the upper and lower bounds of the 95% confidence interval.

2) Alriksson-Schmidt, A., & Hägglund, G. (2016). Pain in children and adolescents with cerebral palsy: a population-based registry study. Acta Paediatrica, 105(6), 665-670.

03 Pain

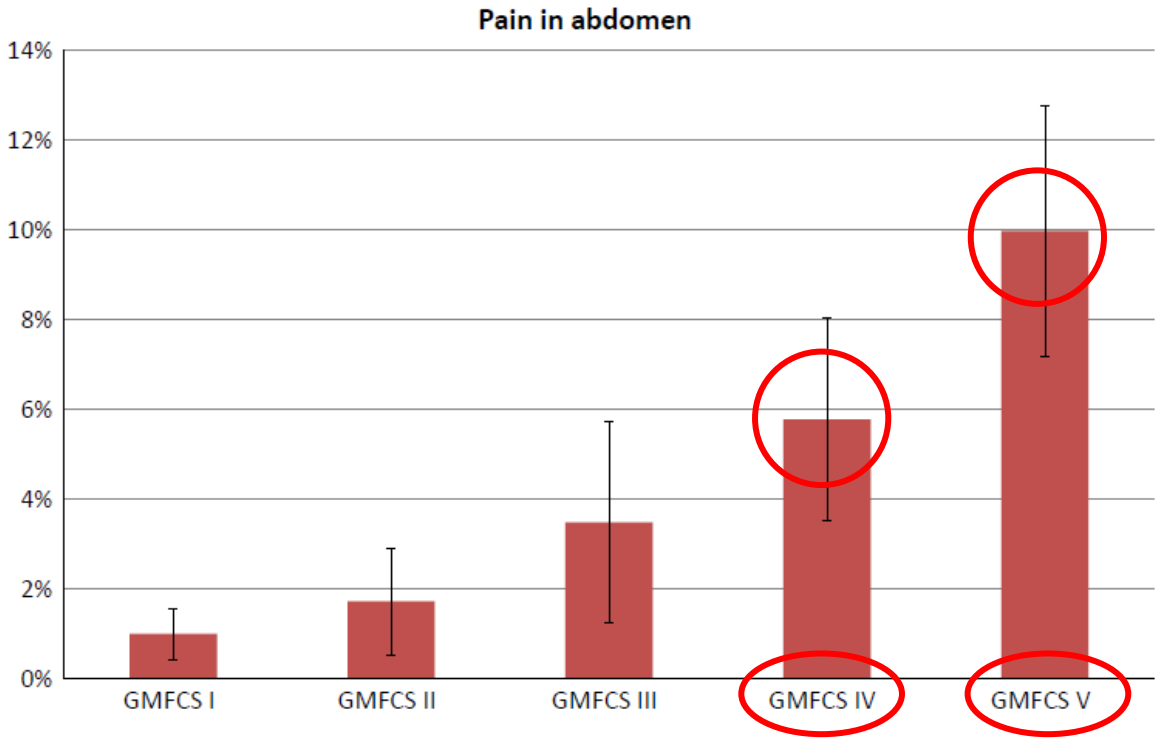

Figure 3 Proportion of pain reported in the abdomen in children and adolescents with cerebral palsy based on the gross motor function classification system. The line segments represent the upper and lower bounds of the 95% confidence interval.

2) Alriksson-Schmidt, A., & Hägglund, G. (2016). Pain in children and adolescents with cerebral palsy: a population-based registry study. Acta Paediatrica, 105(6), 665-670.

04 Contracture

- Characteristics
- Ankle Contracture: 3세 전에 발생
- Ankle Stiffness in CP 51% higher than typical development population

- **Causes**
- Immobility
- Muscle over-activation
- Increased intrinsic passive stiffness of the tissue
- Effect on extracellular matrix in bundle level
  : collagen content ↑
  : abnormal organization in ECM
- Spasticity(?)

04 Contracture

- Location
- Mostly in L/E (GCM, hamstring, psoas, hip adductor)
- Some in U/E (elbow flexor, wrist flexor, finger flexor)

- **Mechanism**
- As the child grows older and the bones elongate

→ **Insufficient neural activation of the muscle**

→ **Lack of muscle growth** with fewer sarcomeres in parallel

→ Gradually **increase the tension on the muscle fibers**

→ **stretch the sarcomeres** + **structural changes** in connective tissue in ECM

→ **Tissue stiffness** ⇒ **Contracture**

- **PT intervention**

05 Bone density

- **In non-ambulatory CP** (GMFCS IV, V)

- Low BMD(Bone mineral density) in childern and adult
- High risk of Osteopenia, Osteoporosis in spastic quadriplegia
- Low BMD, small bone and thin cortex in spastic quadriplegia
- Decreased BMD (femur>spine)

- **Femur osteopenia (BMD Z score<-2.0)**

- 97% of GMFCS V (age>9)
- Factors of femur low BMD

: severity of neurologic impairment (GMFCS)

: difficulty in feeding

: Use of anticonvulsants

: Lower triceps skinfold z-score

: Age(?)

05 Fracture

- **Femur fracture of CP**
- Most common in femur
- 20%~28% of non-ambulatory CP experience up to adolescent
- 23%는 sustained fracture
- High risk in children with greater body fat, prior history of fracture and feeding gastrostomy in GMFCS Ⅲ-V

- **Causes**
- Low bone density
- Stiff joints
- Poor balance
- Violent seizure

- **PT intervention**

- Mechanical stress
  : weight bearing, muscle use
- Sitting balance training

- 골다공증 치료제를 18개월 동안 복용한 quadriplegia CP
- Femur BMD 89%↑ (RCT study)

05 Bone density & Fracture

Age와 low BMD 연관성

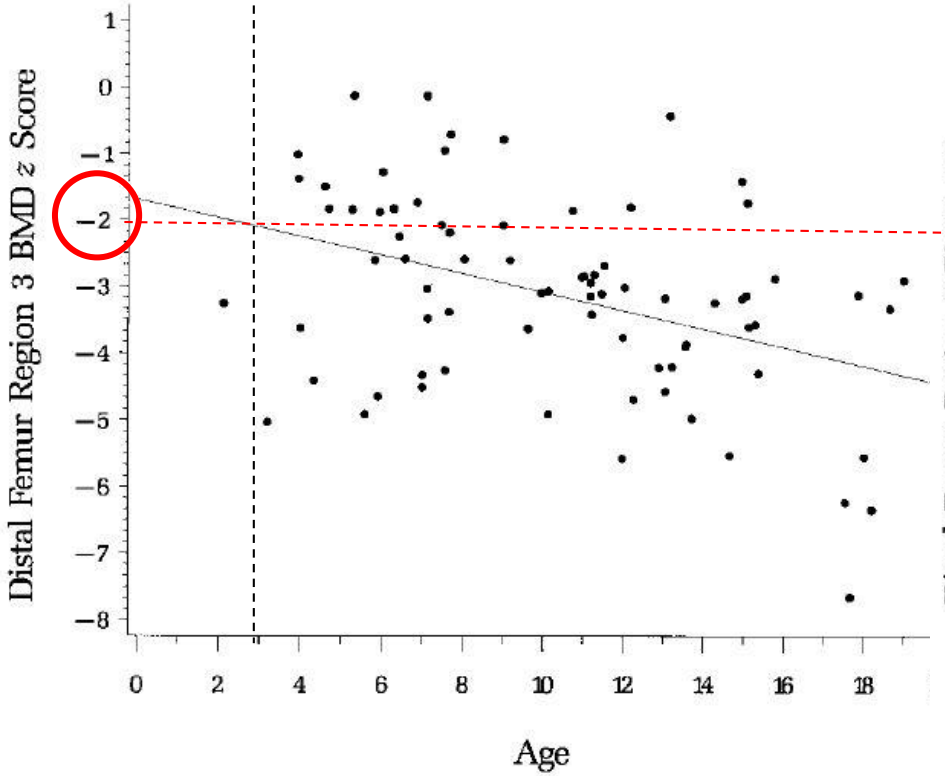

Fig 1. BMD z scores in region 3 of the distal femur as a functic of age (years). Best fit linear regression line shown.

GMFCS level과 low BMD 연관성

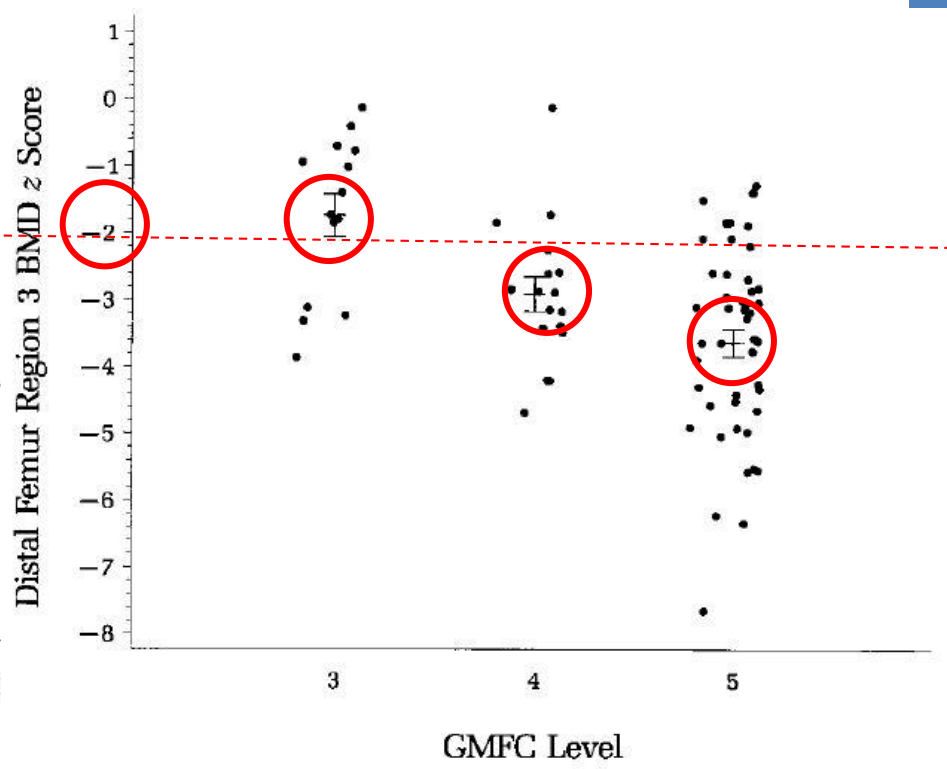

Fig 2. BMD z scores in region 3 of the distal femur as a function of severity of CP as defined by the GMFC scale. Mean ± SE bars shown.

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06 General health & Growth

- **Motor impairment ↑ →** Poor growth
- **Swallowing difficulty in 99% of GMFCS IV, V**
- **Poor nutrition** d/t GERD, delay in gastric emptying, constipation, unsafe swallowing and aspiration **leads to Poor growth** (immune dysfunction and immobility)
- Growth in **GMFCS V with Feeding tube is better** than GMFCS IV **without tube**
- **CP in severe gross motor impairment** (GMFCS IV, V)

: overall growth index ↓ including height, weight, mid arm circumference,

: poor body composition (tricep skinfold thickness ↓)

- **Ambulatory CP** compared with typical development population

: Total energy expenditure ↓

: Physical activity level ↓

⇨ "Negative effect on growth"

06 General health & Growth

- **Causes** of Poor growth

①**Nutritional factor-** inadequate dietary intake, secondary to impaired oral motor and swallowing competence and poor nutritional status

②**Physical factor-** decreased mechanical stress on bones due to immobility or lack of weight bearing

③**Brain lesion itself-** directly via a negative neurotrophic effect on linear growth or indirectly via the endocrine system

- **Severity of feeding dysfunction**

= Indicators of poor health and nutritional status

- **PT intervention**

- Weight bearing activity
- Muscle activation
- Improve mobility
- Sitting training

07 Muscle Growth

- **Muscle characteristic of CP**

- **Volume reduction**

: 28% ↓ in GCM compared to unaffected side (Hemiplegia)

: 50% ↓ in GCM compared to normal children

- **Numbers of satellite cells ↓**

: muscle growth & regeneration에 관여

- **Lengthened sarcomere**

: in U/E & L/E flexors

- **One fiber type 비율 ↑**

- **Gene expression**

: oxidative metabolism ↓, collagen contents ↑ → bundle stiffness

- **Decreased neural activation**

- **Lipid content ↑**

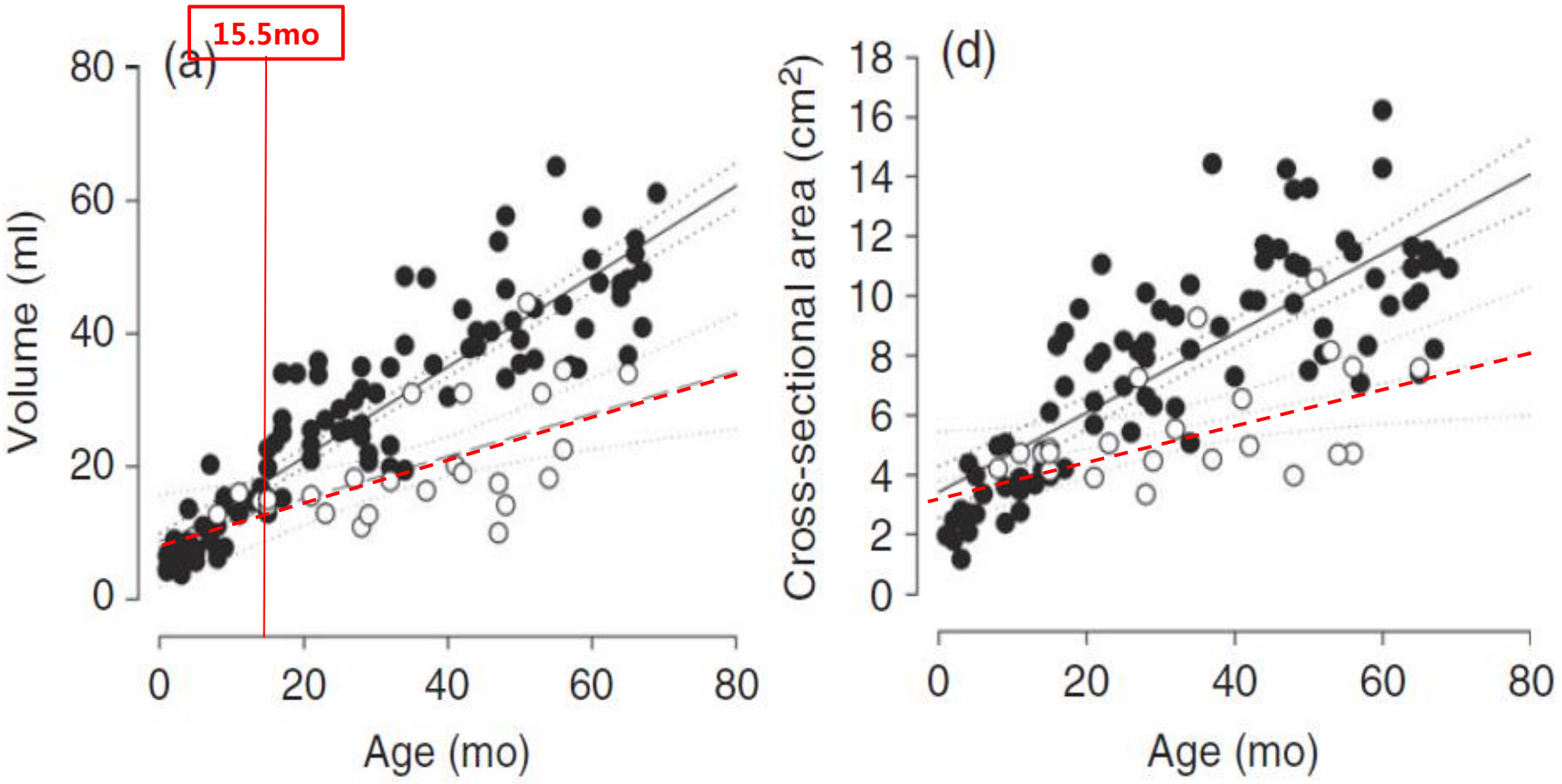
- **Capillary density ↓**

07 Muscle Growth

- **Muscle volume reduction** in GCM
  - Gross motor impairment가 심할수록(I→III) 감소폭↑
  - Non-ambulation에서 감소폭↑

- **Muscle volume Gap between CP & normal** in GCM
  - From 15 month.
  - 15개월 전부터 Ankle m. 사용 촉진 ⇒ 근감소↓, 구축↓
- Different in muscle volume, cross-sectional area, thickness
- No difference in height, weight, fibula length, muscle fiber length

07 Muscle Growth



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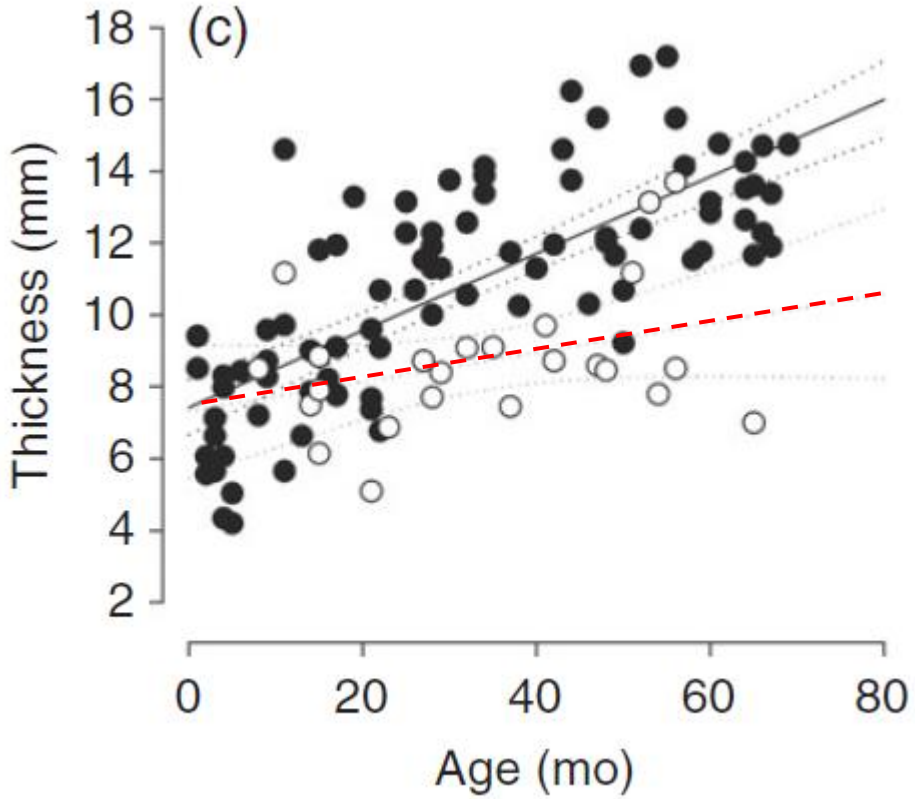
07 Muscle Growth



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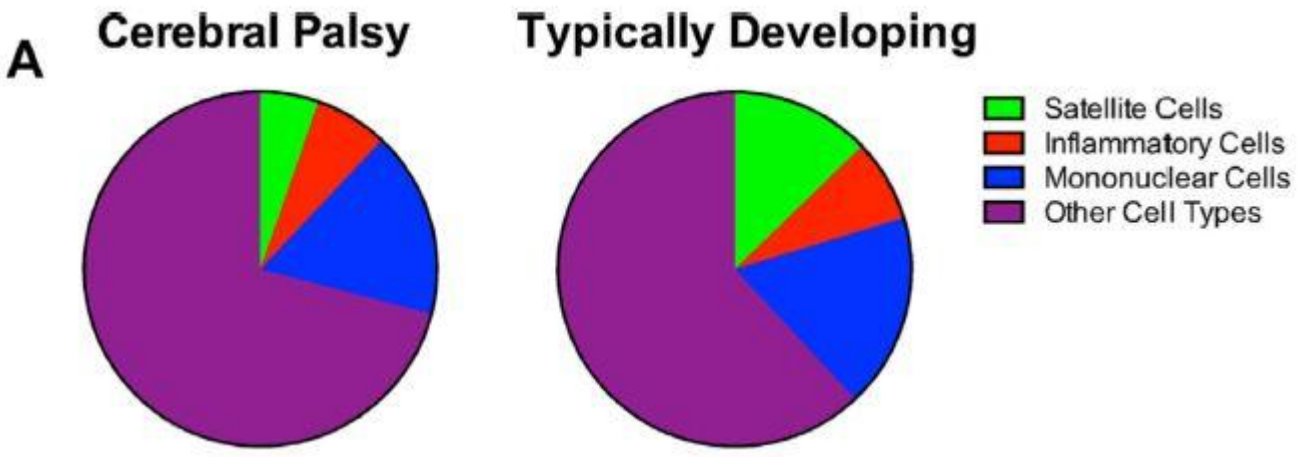
07 Muscle Growth

- **Decreased intrinsic stem cell (Satellite cell)**
- Found below the basal lamina of myofibers
- Associated with muscle growth and regeneration
- Less than half of normal population

Ratio of Satellite in CP compared to normal



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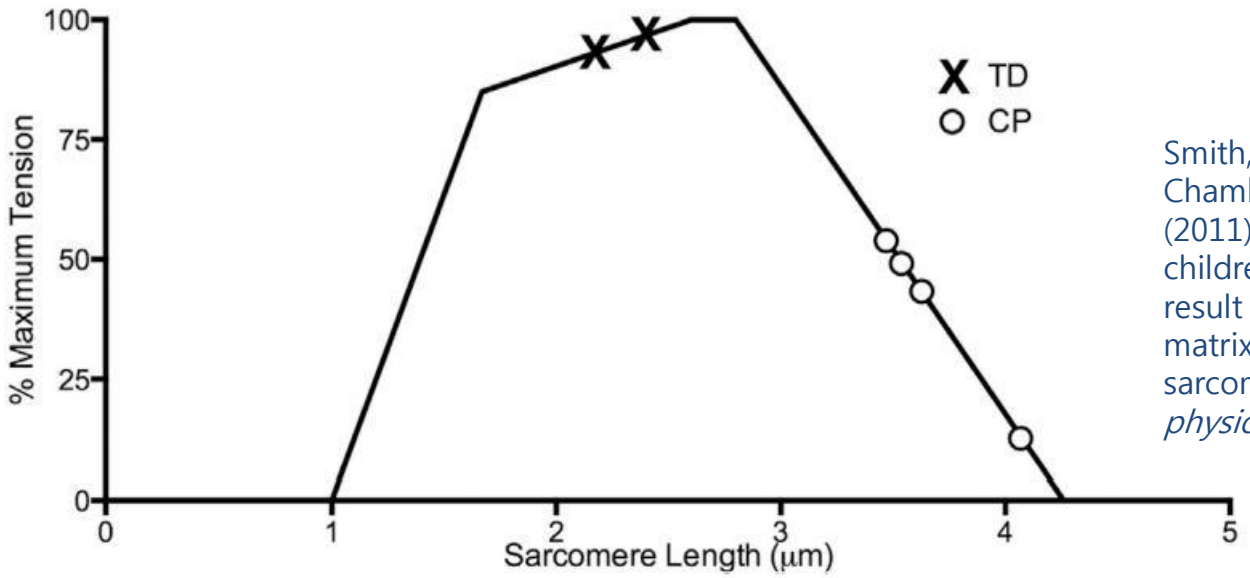
07 Muscle Growth

- **Lengthened sarcomere**
- **Force production**은 muscle velocity와 sarcomere length 또는 2 proteins(actin & myosin)의 overlap되는 양에 영향을 받음

Difference of length of sarcomere in CP compared to normal



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"Lengthened sarcomere→ normal length"

08 Cardiopulmonary Problem

- **Compared to the typical development population**
- Maximum oxygen consumption ↓
- Endurance ↓
- Peak anaerobic power ↓
- **Severe scoliosis** → Respiratory function restriction
- **Poor oral motor function** → posterior saliva drooling and aspiration → **pneumonia ↑**
- **Physical activity level ↓** → aerobic capacity ↓ → cardiorespiratory function ↓ → **CVD risk ↑**
- Cardiopulmonary function of GMFCS IV, V: 연구 부족
- Blood sample between Ambulatory & Non-ambulatory CP
- different in HBP, Low HDL, high total cholesterol, high triglyceride

08 Cardiopulmonary Problem

Table 1
Prevalence of obesity and cardiovascular and metabolic risk factors among participants.

Risk factor	Total ($n=42$)	Ambulatory ($n=14$)	Non-ambulatory ($n=28$)
BMI ≥ 30 kg/m^2	9 (21.4)	3 (21.4)	6 (21.4)
Central obesity	12 (28.6)	4 (28.6)	8 (28.6)
Hypertensive BP	6 (14.3)	0	6 (21.4)
Hypercholesterolemia	13 (39.4)	5 (38.5)	8 (40.0)
Smoker	3 (7.14)	2 (14.3)	1 (3.57)
Low HDL-C	8 (24.2)	2 (15.4)	6 (30.0)
High LDL-C	13 (39.4)	6 (46.2)	7 (35.0)
TC/HDL-C	4 (12.1)	1 (7.7)	3 (15.0)
Hypertriglyceridemia	8 (24.2)	2 (15.4)	6 (30.0)
Hyperglycemia	17 (51.5)	6 (46.1)	11 (55.0)

Values are n (%).
All metabolic markers (ambulatory $n=13$; non-ambulatory $n=20$).

McPhee, P. G., Gorter, J. W., Cotie, L. M., Timmons, B. W., Bentley, T., & MacDonald, M. J. (2015). Descriptive data on cardiovascular and metabolic risk factors in ambulatory and non-ambulatory adults with cerebral palsy. *Data in brief*, *5*, 967-970.

09 AGING

- **Physical aging occurs more rapidly in CP**

- 일반적인 노화의 결과인 muscle strength↓, elasticity↓, bone density↓ 을 저항할만한 상태까지 도달하지 못한 상태에서 노화과정이 진행

- Early-onset type 2 DM and dyslipidemia

- **Early-onset osteoarthritis** of the spine, hip and knee

- Gait deviations
- Postural abnormality
- Joint misalignment
- Focal overuse

- Sedentary lifestyle

- 신체성장을 따라가지 못하는 기능 발달 수준

06

THE CONCEPT OF PHYSICAL THERAPEUTIC APPROACH FOR NON-AMBULATORY CP

The concept of physical therapeutic approach for non- ambulatory CP

- Consider the whole life for patient

  - using equipment, refer to surgeon

- Facilitate physical activities

  - symmetrical sitting, weight bearing activity, midline orientation

- Pay attention to various complications

- Focus on not only function but, participation

- A 'navigator' in the transition from pediatric to adult care

경청해주셔서 감사합니다

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