

HBOT IN CEREBRAL PALSY

an observational longitudinal study



CHU Sainte-Justine
Mother and Child
University Hospital Center

For the love of children

Université 
de Montréal

Dr. Pierre Marois, MD, F.R.C.P.(c)
Dr. Michel Vanasse, MD, F.R.C.P.(c)
Dr. Jean Lambert, PhD.

Pilot study (McGill 1999)

- **25 children with spastic diplegia**
- **Improvement in gross and fine motor skills**

Double blind study

- Published in « **The Lancet** » 2001
- One group (HBO) treated at 1.75ATA, 100 % O₂
- One group (HBA) treated at 1.3ATA, 21 % O₂ (mild hyperbaric treatment-Hyperbaric air)

Gross Motor Function Measure

GMFM

- Developed specifically for assessing changes in gross motor function
- Criterion-based observational measure
- 88 items
- 5 dimensions :
 - a = lying and rolling
 - b = sitting
 - c = crawling and kneeling
 - d = standing
 - e = walking, running and jumping
- Each item is scored on a 4-points scale :

0 = no initiation

1 = initiated activity

2 = partially completed

3 = completes activity

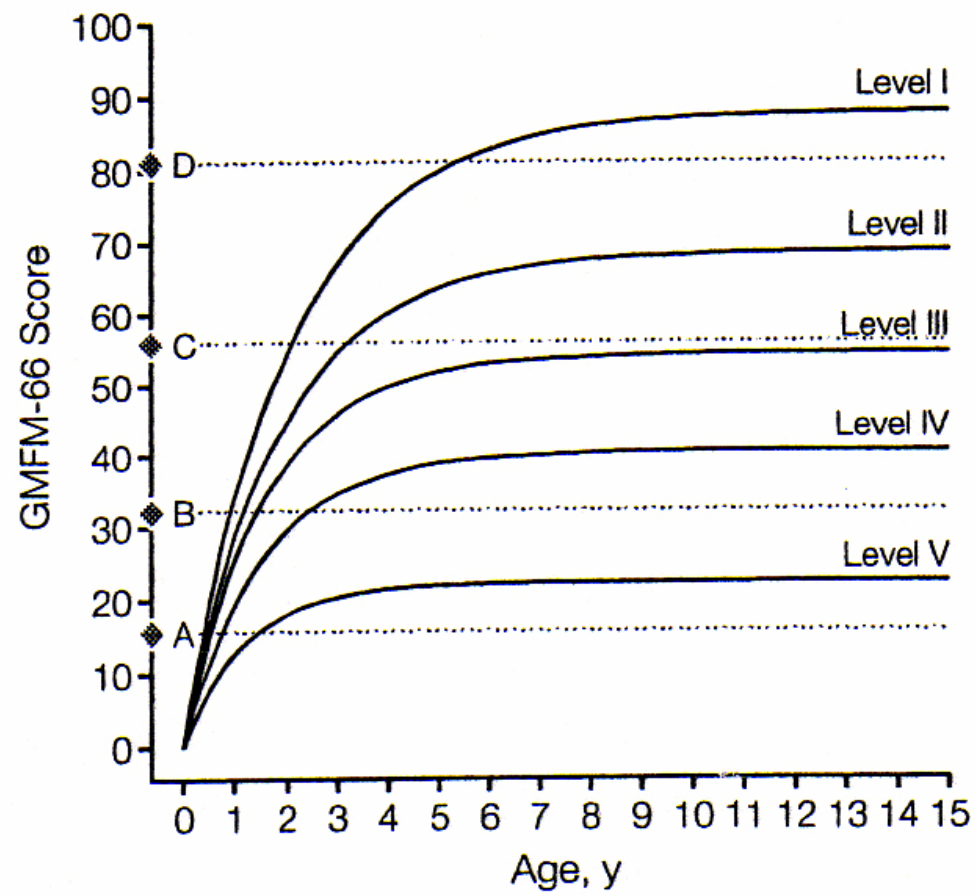


Table 2: Between groups comparison for changes over time in gross motor function(GMFM):

A = Lying and rolling, B = Sitting, C = Crawling and kneeling, , D = Standing, E = Walking, Running, Jumping

Scales	Groups	Baseline	Post-intervention (40 treatments)			3 months follow-up		
		mean $\pm$ std	mean difference* (95% CI)	p-value ⁽¹⁾	p-value ⁽²⁾	mean difference* (95% CI)	p-value ⁽¹⁾	p-value ⁽²⁾
A	HBO	88.4 $\pm$ 13.1	+1.9 (+0.4; +3.3)	0.014	0.113	+2.4 (+0.7; +4.2)	0.008	0.564
	HBA	91.1 $\pm$ 11.2	+2.6 (+1.0; +4.2)	0.002		+2.3 (+0.4; +4.3)	0.020	
B	HBO	72.8 $\pm$ 31.0	+3.9 (+1.3; +6.4)	0.004	0.811	+3.3 (+1.2; +5.5)	0.003	0.658
	HBA	81.1 $\pm$ 28.9	+3.2 (+1.0; +5.5)	0.006		+3.2 (+1.3; +5.1)	0.001	
C	HBO	58.3 $\pm$ 39.8	+3.9 (+2.0; +5.7)	<0.001	0.565	+5.0 (+2.2; +7.8)	<0.001	0.082
	HBA	72.0 $\pm$ 36.2	+2.6 (+1.1; +4.1)	0.001		+1.6 (-0.1; +3.3)	0.071	
D	HBO	38.1 $\pm$ 36.5	+3.3 (+1.6; +5.1)	<0.001	0.564	+4.2 (+2.0; +6.4)	<0.001	0.685
	HBA	51.6 $\pm$ 34.9	+2.8 (+1.1; +4.5)	0.002		+3.8 (+2.0; +5.6)	<0.001	
E	HBO	28.8 $\pm$ 33.6	+1.5 (+0.3; +2.7)	0.014	0.018	+1.8 (+0.5; +3.2)	0.010	0.023
	HBA	35.6 $\pm$ 30.4	+3.7 (+2.5; +5.0)	<0.001		+4.7 (+2.9; +6.6)	<0.001	
Global	HBO	57.3 $\pm$ 28.5	+2.9 (+1.9; +3.9)	<0.001	0.544	+3.4 (+2.2; +4.5)	<0.001	0.966
	HBA	66.3 $\pm$ 26.1	+3.0 (+2.1; +3.9)	0.001		+3.1 (+2.2; +4.1)	<0.001	

* Positive score means improvement in motor function over time.

(1) Paired t-test for within groups changes between baseline and final assessment.

(2) Comparison between groups : ANCOVA model controlling for baseline values.

TESTS	HBO	HBA	Difference
Visual span (CORSI)	+	+	No
Word span (familiar words)	-	+	No
Word span (non-familiar words)	-	-	No
Visual span (Images)	+	+	No
TOVA (Auditory)			
Correct responses	+	+	No
Correct non responses	+	+	No
TOVA (Visual)			
Correct responses	+	+	No
Correct non responses	+	+	No

Table 5: Pediatric Evaluation of Disability Inventory (PEDI)

SCALES	Groups	Baseline		Post-intervention (40 treatments)			3 month follow-up		
		n	mean ±std	mean difference* (95% CI)	p-value ⁽¹⁾	p-value ⁽²⁾	mean difference* (95% CI)	p-value ⁽¹⁾	p-value ⁽²⁾
Functional Skills:									
Self care	HBO	56	57.6 ± 13.8	+2.8 (+1.6; +4.0)	<0.001	0.92	+3.5 (+2.0; +4.9)	<0.001	<0.01
	HBA	54	60.3 ± 13.0	+2.7 (+1.3; +4.0)	<0.001		+5.1 (+3.1; +7.1)	<0.001	
Mobility	HBO	55	46.7 ± 22.2	+2.9 (+1.3; + 4.5)	<0.001	0.41	+4.2 (+2.2; +6.1)	<0.001	0.69
	HBA	54	53.0 ± 19.2	+1.8 (-0.1; +3.8)	0.06		+2.9 (+0.9; +5.0)	<0.01	
Social Function	HBO	56	63.4 ± 12.0	+3.0 (+0.7; +5.3)	0.01	0.72	+4.0 (+1.7; +6.2)	<0.001	0.46
	HBA	54	65.5 ± 12.7	+3.0 (+0.9; +5.1)	<0.01		+3.0 (-0.2; 6.2)	0.07	

* Positive score means improvement over time.

(1) Paired t-test for within group changes between baseline and final assessment.

(2) Comparison between groups : ANCOVA model controlling for baseline values, age and developmental age.

The facts

● BOTH GROUPS

- Clinically and statistically improved
- With regards to :
 - . Gross motor
 - . Memory, attention
 - . Functional skills

**10 times more progress during the
2 months of HBO therapy (while all
other therapies were ceased) than
during the 3 months of follow up
(while they received physical and
occupational therapy)**

Quebec double blind study

111 children (2001)

Lancet's editorial

Although the results did not indicate that hyperbaric oxygen had any benefit over slightly pressurised air (*mild hyperbaric treatment*), they showed that both groups of children improved substantially with respect to gross motor function, speech, attention, memory and functional skills. The researchers postulate that either the two treatments were equally effective or the mere act of participating in a trial that promoted communication with other motivated children and parents had a positive effect.

Collet and Government position:

- This study demonstrated that HBO in C.P. is ineffective!!!!**
- The impressive change were secondary to a placebo effect (even if there was no placebo group!!!!)**

Agency for Healthcare Research and Quality (U.S.dept. of Health)

The authors of the trial thought that the children in both groups improved because participation in the study provided an opportunity for more stimulating interaction with their parents. This is speculative, however, because there was no evidence to suggest that the parents and their children had less time together, or less stimulating interaction, before the study began.....

The possibility that pressurized room air had a beneficial effect on motor function should be considered the leading explanation.

« An error does not become truth by reason of multiplied propagation, nor does truth become error because nobody sees it ».

Ghandi

● Études avec HBO et P.C.

Auteur	Endroit	Nb. de sujets	Nb. de traitements.	Conclusion
Machado (1989)	Sao Paulo, Brésil	230	20	Diminution de la spasticité dans 94 à 98 % des cas. 6 mois post-traitements : amélioration fonctionnelle cognitive ou au niveau de la spasticité chez 75,6 % des enfants.
<u>Cordoba-Cabeza</u> (1998)	<u>Las Tunas</u> , Cuba	14	20	Une réponse satisfaisante a été observée chez les patients traités dans la première année suivant la lésion, avec des résultats plus importants et plus rapides.
<u>Montgomery et al.</u> (1999)	Montréal, Canada	25	20	Les résultats démontrent une amélioration de la motricité grossière dans 3 des 5 items du <u>Gross Motor Function Measure</u> (GMFM), une amélioration de la motricité fine et une réduction de la spasticité.
<u>Barrett</u> (1999)	Université de Galveston, Texas, USA	14	60	L'oxygénothérapie hyperbare a produit des améliorations aux évaluations de la motricité grossière et fine, et a diminué la spasticité chez ces patients atteints de paralysie cérébrale.
Packard (2000)	Université de <u>Cornell</u> , USA	26	40	Chez certains enfants avec paralysie cérébrale modérée à sévère, il y a une évidence que l'OHB améliore les habiletés motrices, l'attention, le langage et le jeu. Chez certains enfants une amélioration de la vision a été notée. Ce ne sont pas des changements miraculeux. Les enfants ont toujours la paralysie cérébrale, mais ce sont des changements substantiels.

Études avec HBO et P.C.

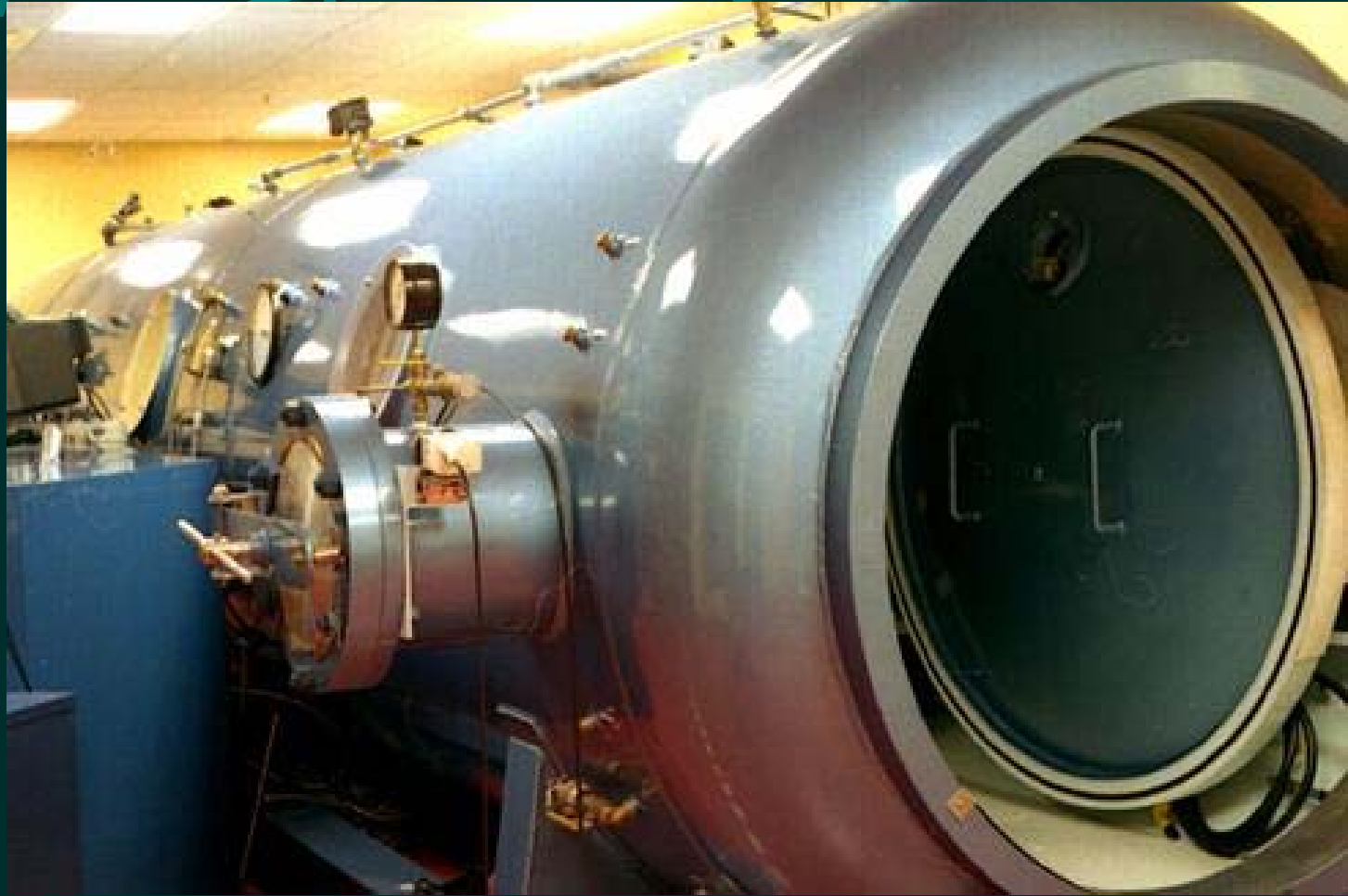
Auteur	Endroit	Nb. de sujets	Nb. de traitements.	Conclusion
Collet et al. (2001)	Montréal, Canada	111 (1 groupe testé à 1,3ATA et 21% d'O ₂ et 1 groupe testé à 1,75ATA et 100% d'O ₂)	40	Les deux groupes de participants se sont améliorés de façon substantielle en ce qui a trait à la motricité grossière, le langage, l'attention, la mémoire et les habiletés fonctionnelles. Les auteurs postulent que ou bien les 2 traitements ont été également efficace ou que le simple fait de participer à une recherche qui permettait une communication avec d'autres enfants a eu un effet positif.
Waalkes et al. (2002)	U.S Army	8	80	Les évaluations comparées pré et post traitement utilisant plusieurs mesures fonctionnelles ont démontré une amélioration dans la fonction motrice grossière et une réduction du temps total de soins nécessaires aux enfants atteints de paralysie cérébrale.
Sethi et Mukherjee (2003)	New-Delhi, Inde	30 (15 : OHB + ergothérapie 15 : ergothérapie seule)	40	Le rythme de progression au niveau de la motricité grossière du groupe expérimental (OHB + ergothérapie) est beaucoup plus rapide que le groupe contrôle (ergothérapie seule).
Marois et Vanasse (2006)	Montréal, Canada	118	40	Améliorations importantes au GMFM de l'ordre de 3,96% pour l'ensemble des sujets.
Mukherjee (2006)	New-Delhi, Inde	84	40	Le rythme de progression au niveau de la motricité grossière du groupe expérimental (OHB + thérapie) est beaucoup plus rapide que le groupe contrôle (thérapie seule).

Clinique Hyperbare Magali 2001

- **Multiplace chamber**
- **Treating mostly neurological conditions**







AJM evaluation group

- Therapists specialized in the use of evaluation tools
- GMFM

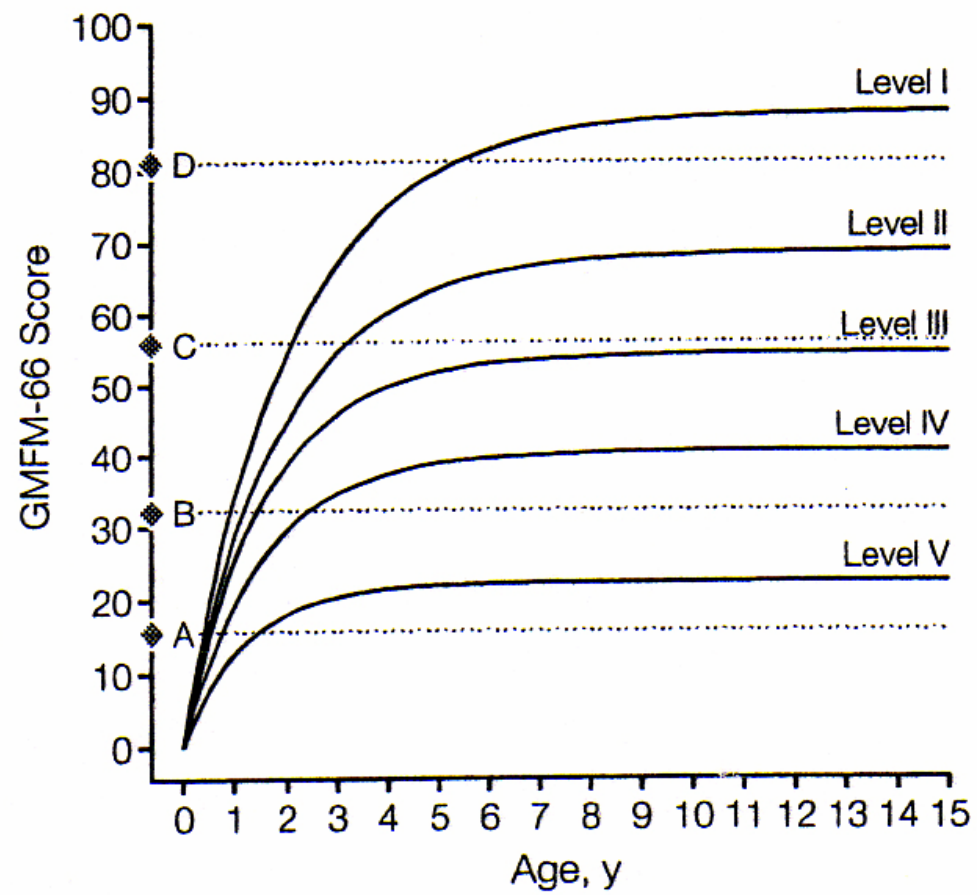
- 200 files of patients treated (2001-2006)
- 120 cases retained for the study
 - C.P. diagnosis
 - More than 30 Tx
 - GMFM pre and post treatment
 - Two files excluded (results too impressive)

Characteristics

Nb:		118
Age		6 years, 4 months
Sexe	M	61
	F	57

Diagnosis	Quadriparesia	87	73,7 %
	Diplegia	21	17,8 %
	Hémiplegia	6	5,1 %
	Others	4	3,4 %

GMFCS	Level		
	I	5	4,2 %
	II	16	13,6 %
	III	23	19,5 %
	IV	40	33 %
	V	34	28,8 %



● Treatment protocol

● 1 hour, 5 days / week, 8 weeks

● 1.5 ATA, 100% O₂

- One set of Tx: 118
- Two sets of Tx: 40
- Three sets of Tx: 20

● Evaluations

- GMFM

- Pre treatment

- 2 months post treatment

Gross Motor Function Measure

GMFM

- Developed specifically for assessing changes in gross motor function
- Criterion-based observational measure
- 88 items
- 5 dimensions :
 - a = lying and rolling
 - b = sitting
 - c = crawling and kneeling
 - d = standing
 - e = walking, running and jumping
- Each item is scored on a 4-points scale :

0 = no initiation

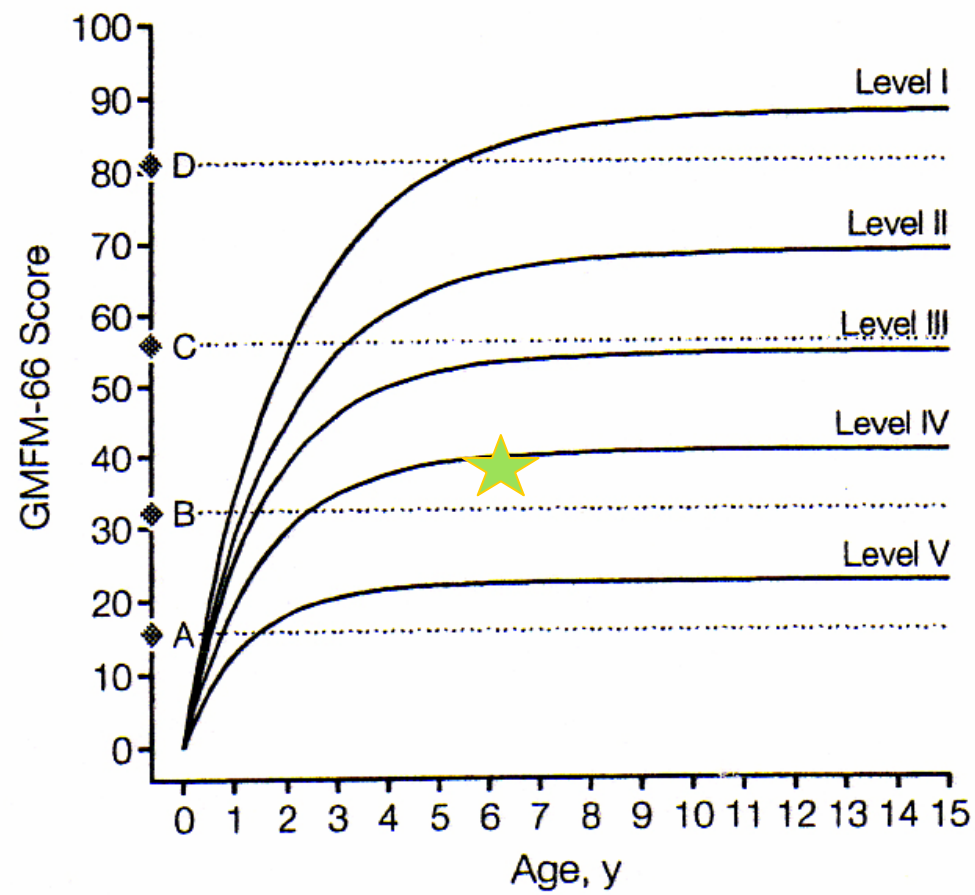
1 = initiated activity

2 = partially completed

3 = completes activity

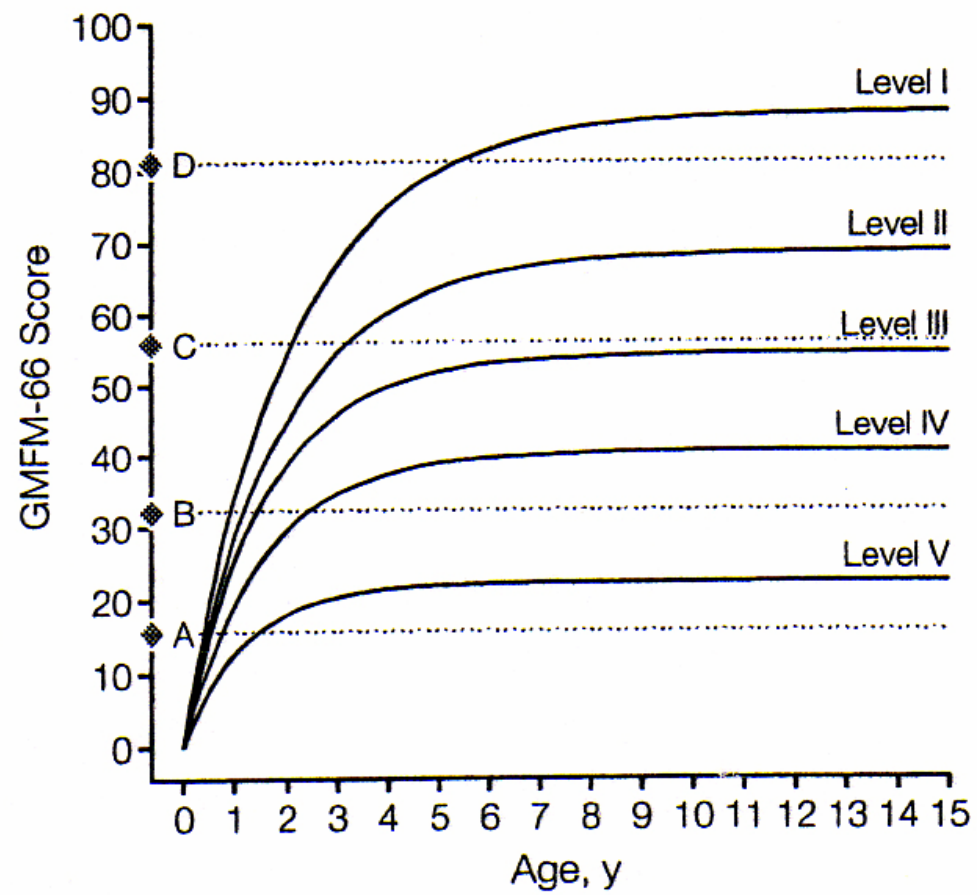
- **Some children continued their usual regimen of therapy**
- **Many stopped completely during the HBOT therapy**

Nb	118		
Age	76,36 months	(6 years, 4 months)	± 6,9 months
Nb Tx	39,0		± 0,6
Evaluation interval	3,9 months		± 0,16
GMFM pre treatment	36,73		± 2,68



● GMFM change : *GMFM post. Tx – GMFM pre Tx*

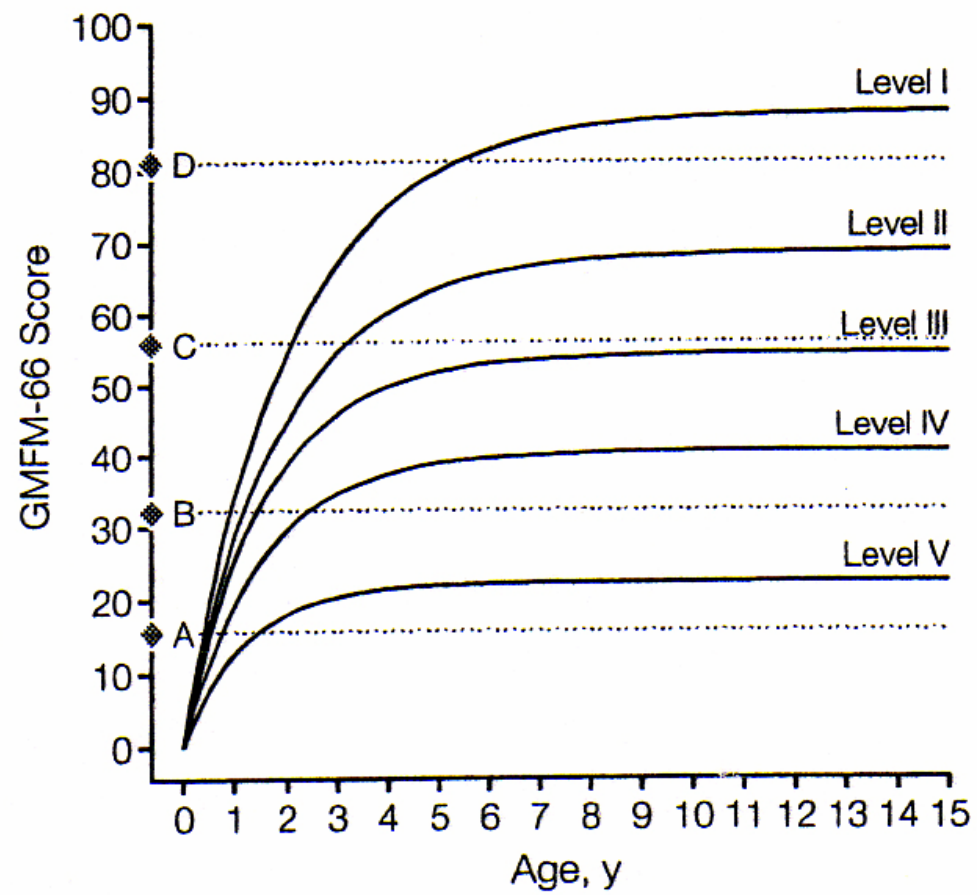
Does not take into account:- interval between evaluations
-importance of disability
-age



● Rate of change : *GMFM change*

*Interval (mo)
between pre Tx
and post Tx
évaluations*

Does not take into account:-importance of disability
-age



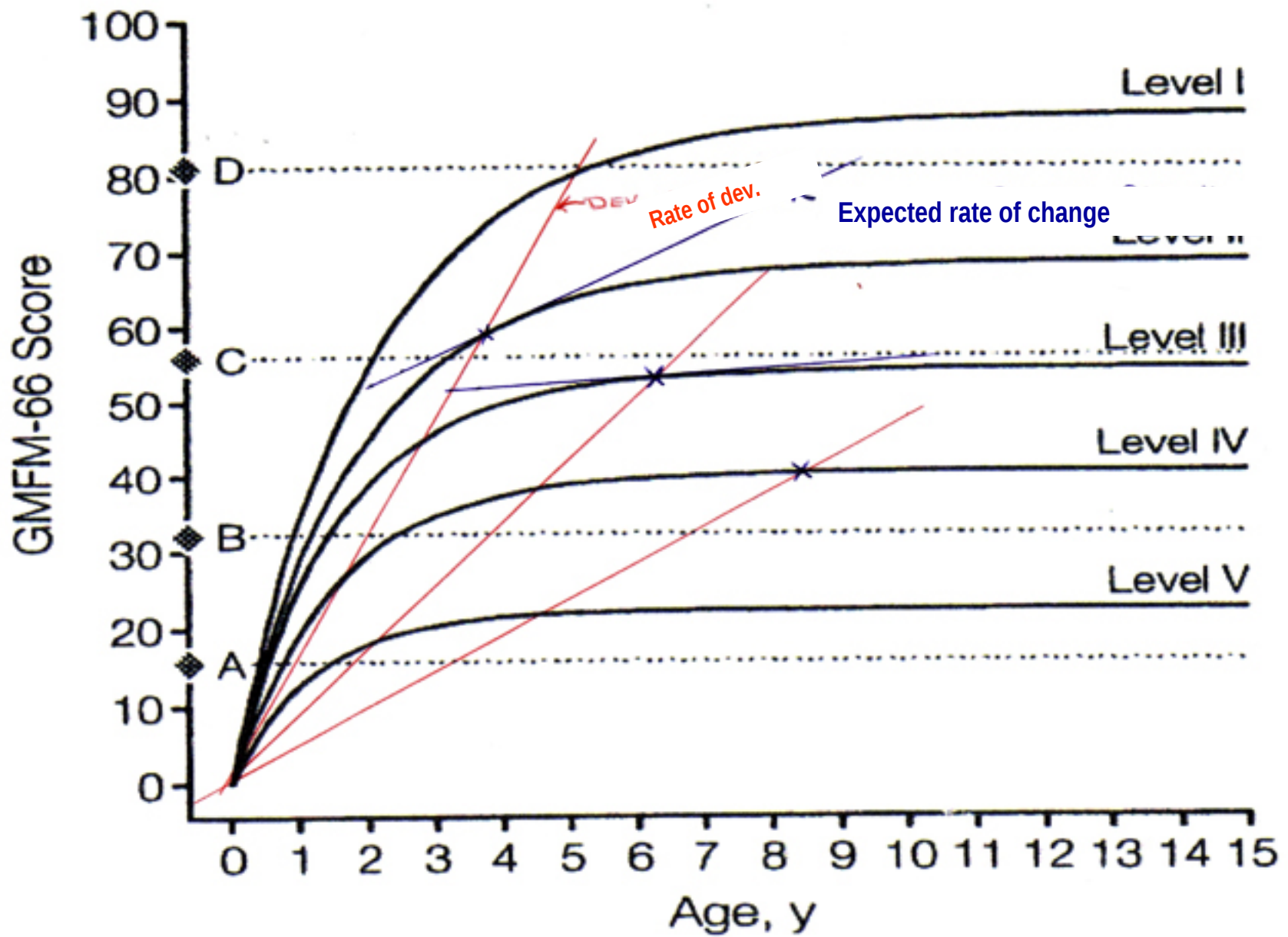
● **Relative change :**

$$\frac{\text{GMFM change}}{\text{GMFM pre Tx}}$$

Does not take into account:-interval between evaluations
-age

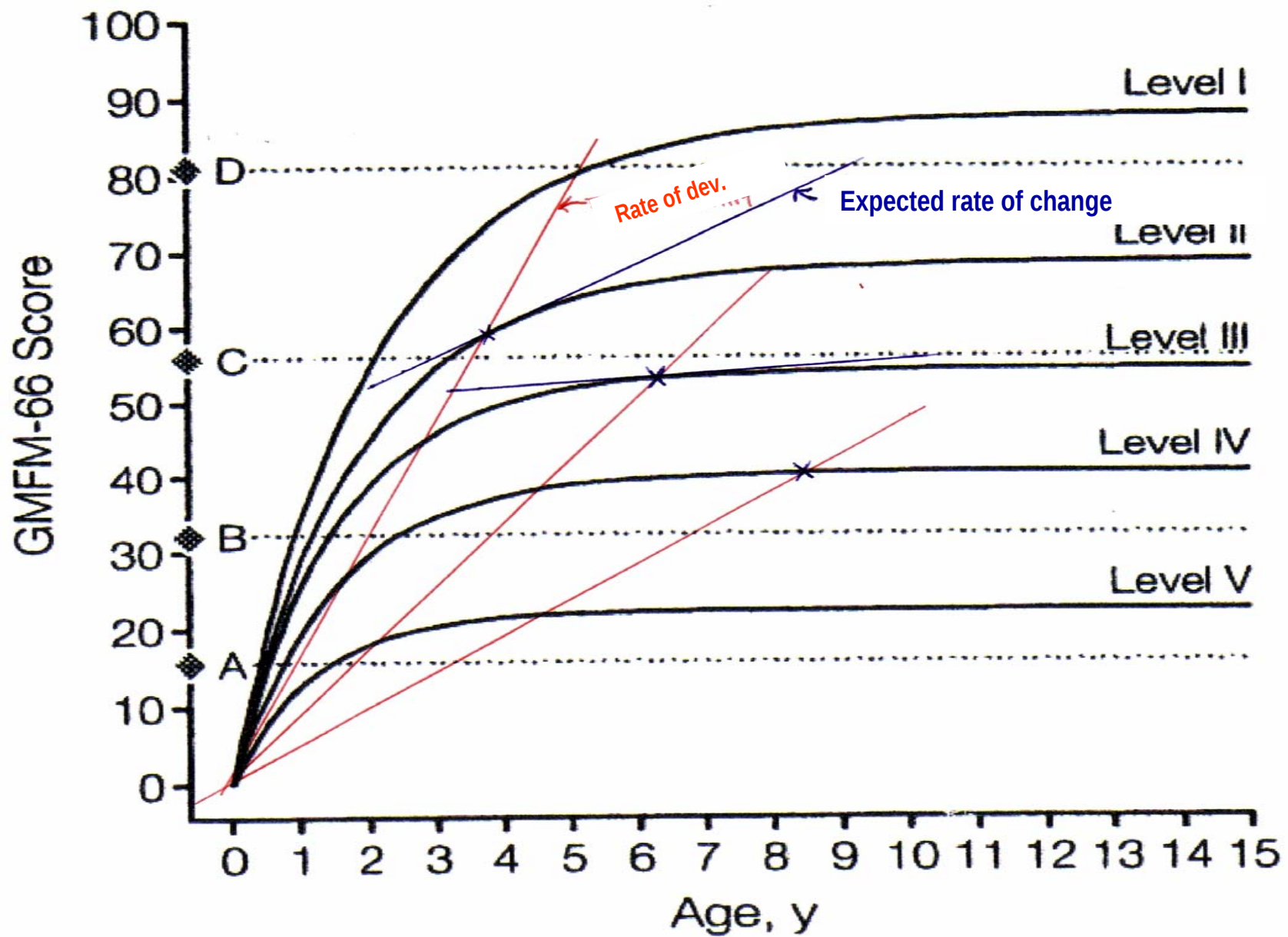
● **Rate of development :**
(average dev. rate since birth)

$$\frac{GMFM \text{ Pre Tx}}{\text{Age (mo)}}$$



- Expected rate of change (or natural evolution rate) :

cannot be easily calculated but always much lower than rate of development (average development rate since birth)



● Efficacy ratio :
$$\frac{\text{Rate of change}}{\text{Rate of development}}$$

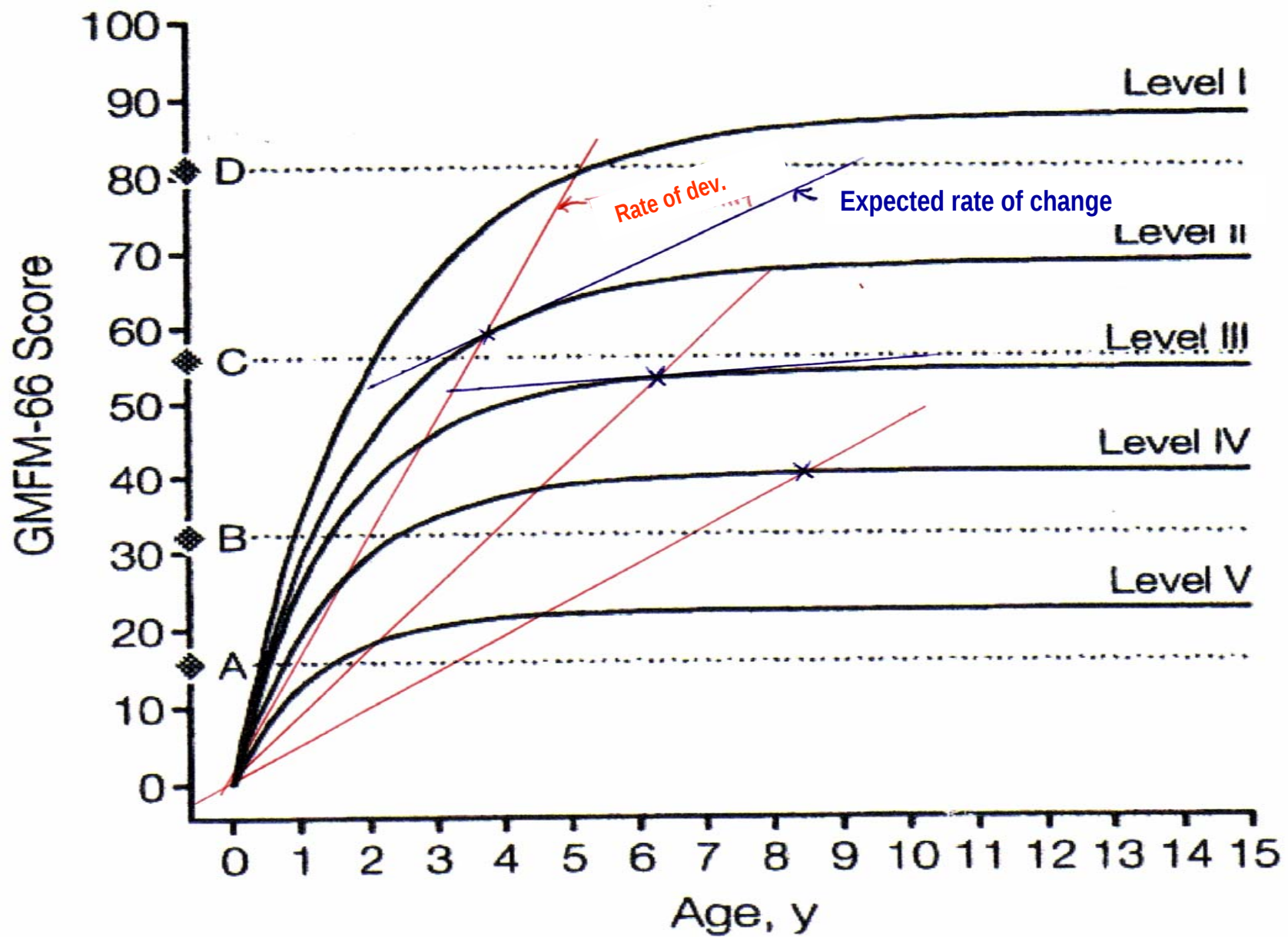
If efficacy ratio is 1, it means that

Rate of progress = Rate of development

Takes into account: -interval between evaluations

-age

-importance of disability

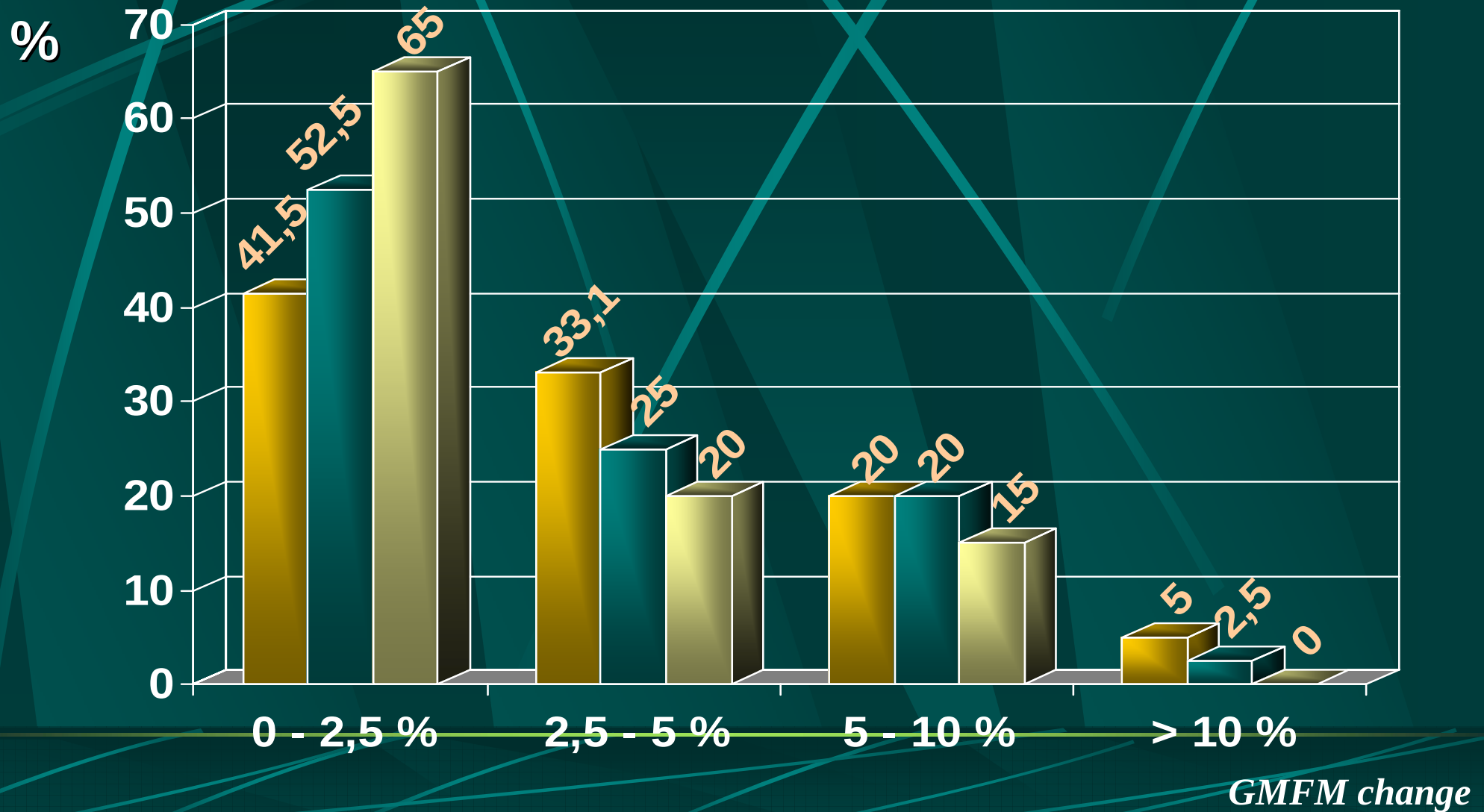


	<i>GMFM change</i>	<i>P. Value</i>
Pre GMFM 1 n:118	3,96 %	0,000
Post GMFM 1		
Pre GMFM 2 n:40	3,09 %	0,000
Post GMFM 2		
Pre GMFM 3 n:20	1,77 %	0,058
Post GMFM 3		

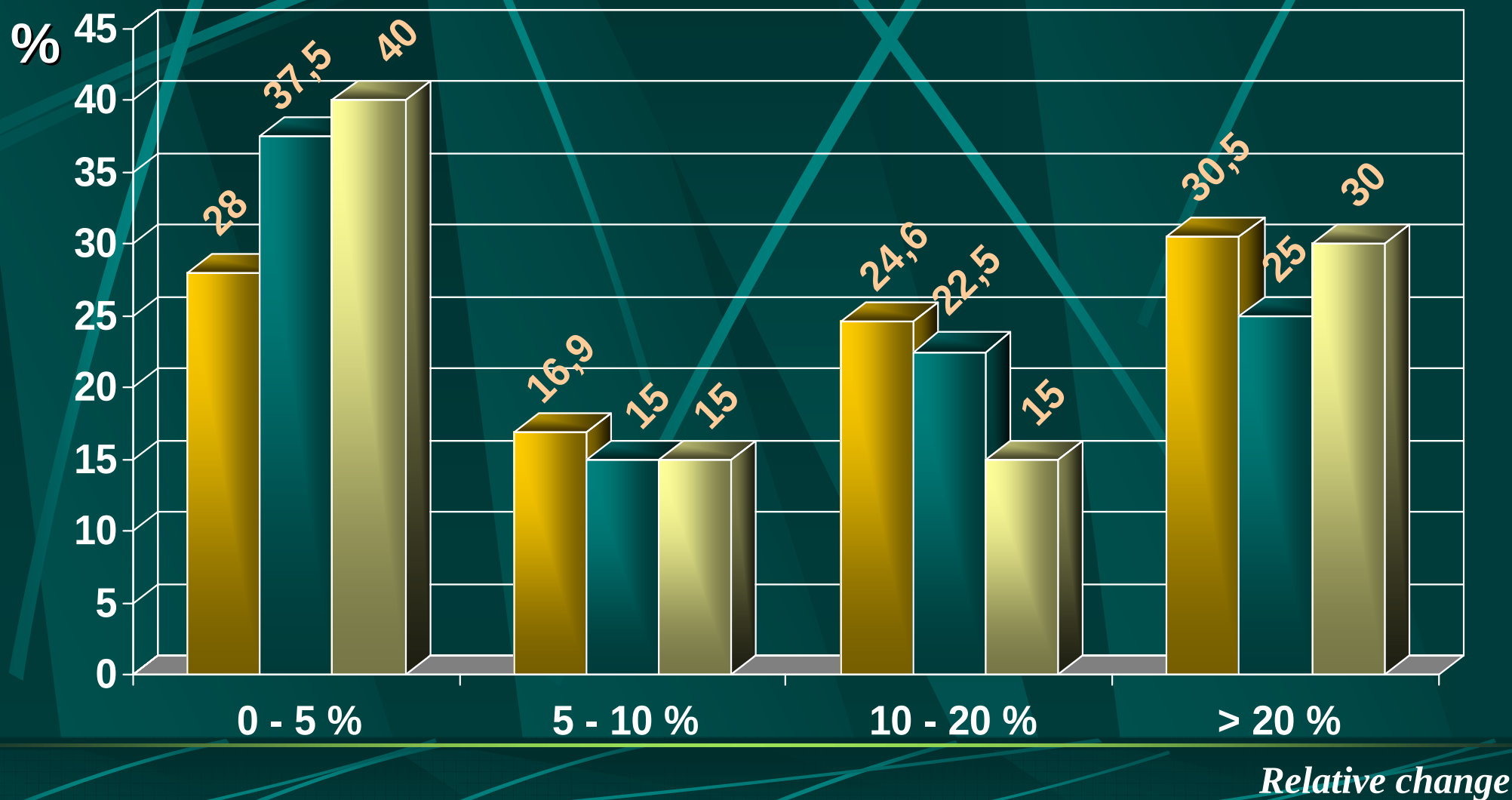
For all the patients

# Set of Tx	Nb of patients	Nb of Tx	Pre GMFM	GMFM Change	Relative change	Rate of change	Efficacy ratio
Set # 1	118	39	36,7	3,9	19 %	1,0	2,4
Set # 2	40	33	34,6	3,0	16 %	,71	1,95
Set # 3	20	35	30,4	1,8	8 %	,5	,72

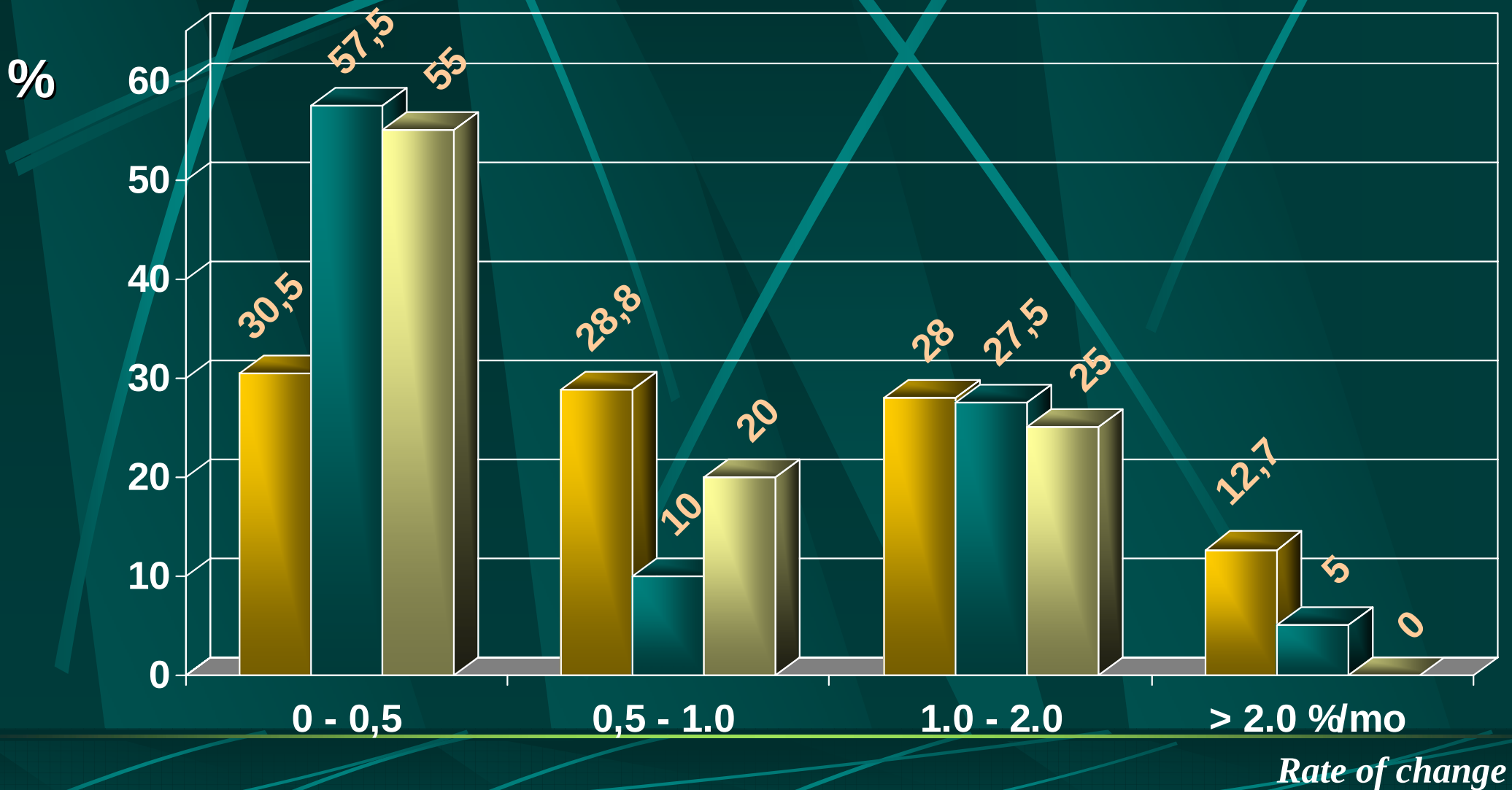
% of children vs GMFM change (3 sets of tx)



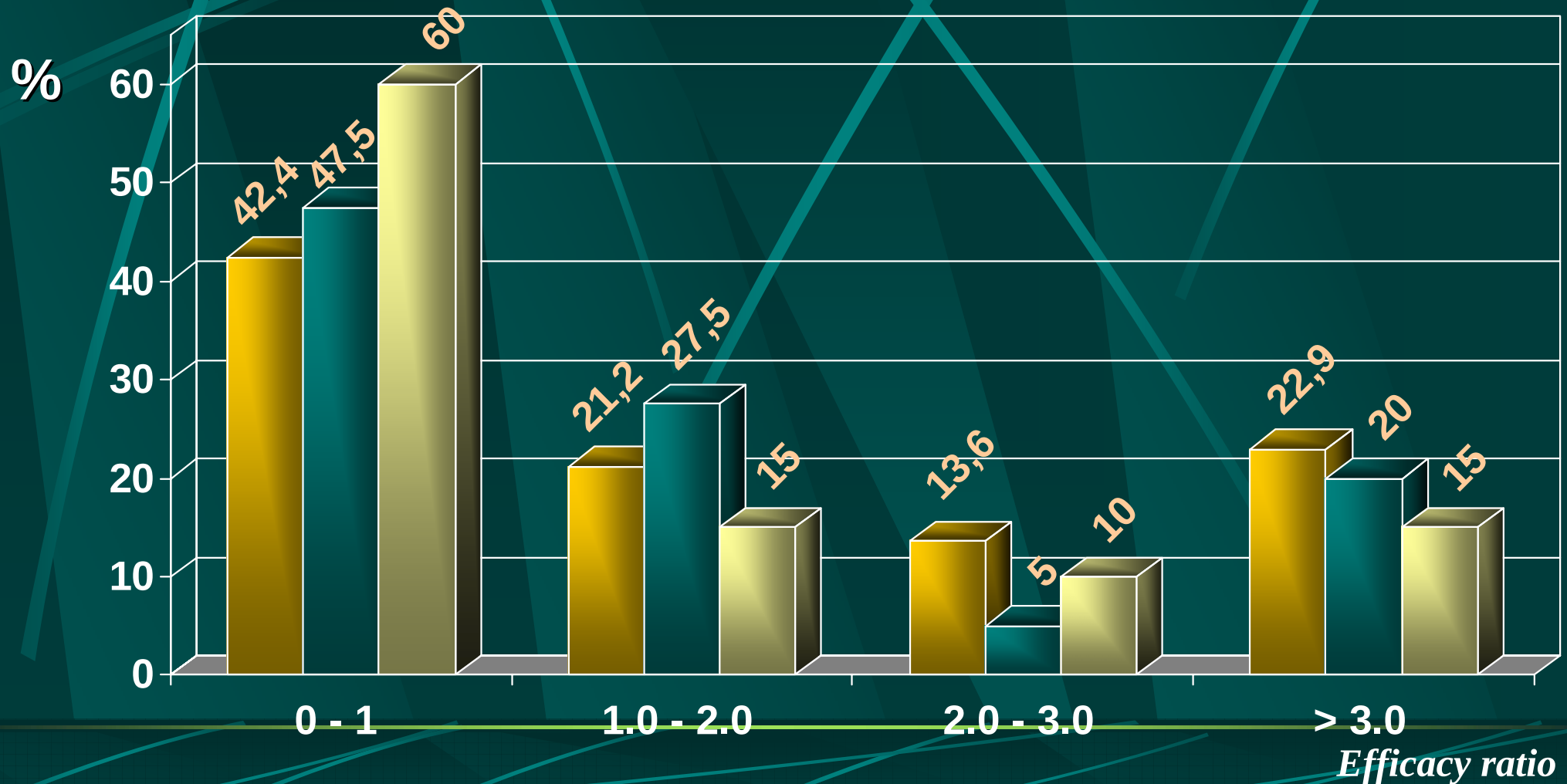
% of children, vs relative change (3 series of Tx)



% of children, rate of change (3 series of Tx)



% of children vs efficacy ratio (3 series of Tx)



Other studies (GMFM)

1. Physiotherapy

	N	Age (years)	Change	Time frame	Rate of change
Russel et al. (1989)	88	4,9	3,7	6 mo	,6 / mo
Trahan et al. (1999)	50	3,7 $\pm$ 1,6	5,7	8 mo	,7 / mo



Other studies (GMFM)

2. Selective Dorsal Rhizotomy ± Physiotherapy *

	n	Age (years)	Change	Time Frame	Rate of change
Hays et al. (1998)	92	7,5 ± 3,98	5,2 ± 1,8	12 mo	,5 / mo
Nordmark et al. (2000)	18	2,5 – 6	9,6	12 mo	,8 / mo
Wright et al. (1998) *	24	4,8 ± 1,1	11,8	12 mo	1,0 / mo
McLaughlin et al. (1994) *	34	7,6 ± 3,65	9,6 ± 6,9	12 mo	,8 / mo
Steinbok et al. (1997) *	30	4,1	11,3	9 mo	1,2 / mo
McLaughlin et al. (1998) *	43	6,45 ± 3,6	7,2	24 mo	,3 / mo

Other studies (GMFM)

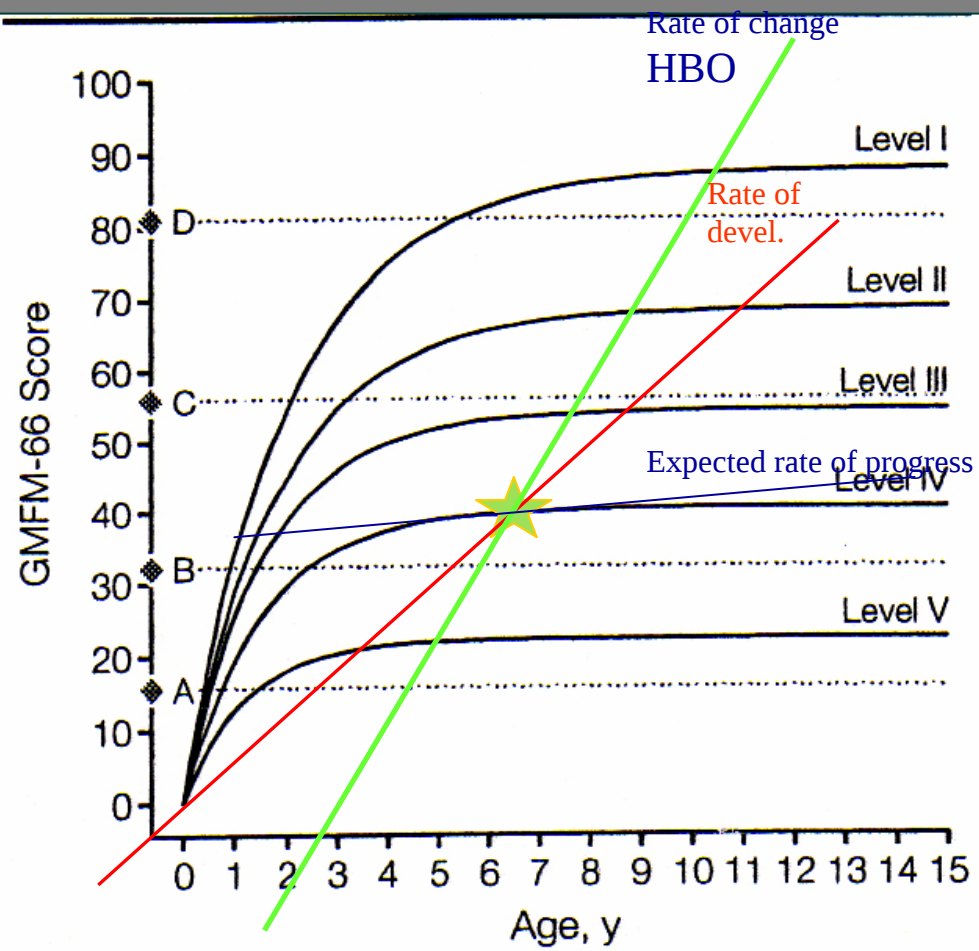
3. Other interventions

	n	Age (years)	Change	Time Frame	Rate of change
Damiano et al. (1998) <i>Strength Training</i>	11	8,8 ± 2,3	1,1	6 wks	,8 / mo
Steinbok et al. (1997) <i>Electrical Stimulation</i>	44	7,3	5,9	12 mo	,3 / mo
Almeida et al. (1997) <i>Intrathecal Baclofen</i>	1	11	6,4	24 mo	,3 / mo
Law et al. (1998) <i>Family Centered Functional Therapy</i>	5	Under 4	17,7 (Goal area only)	3 mo	
McGibbon et al. (1998) <i>Equine Movement Therapy</i>	5	9,6	7,4 (E only)	8 wks	

Other studies (GMFM)

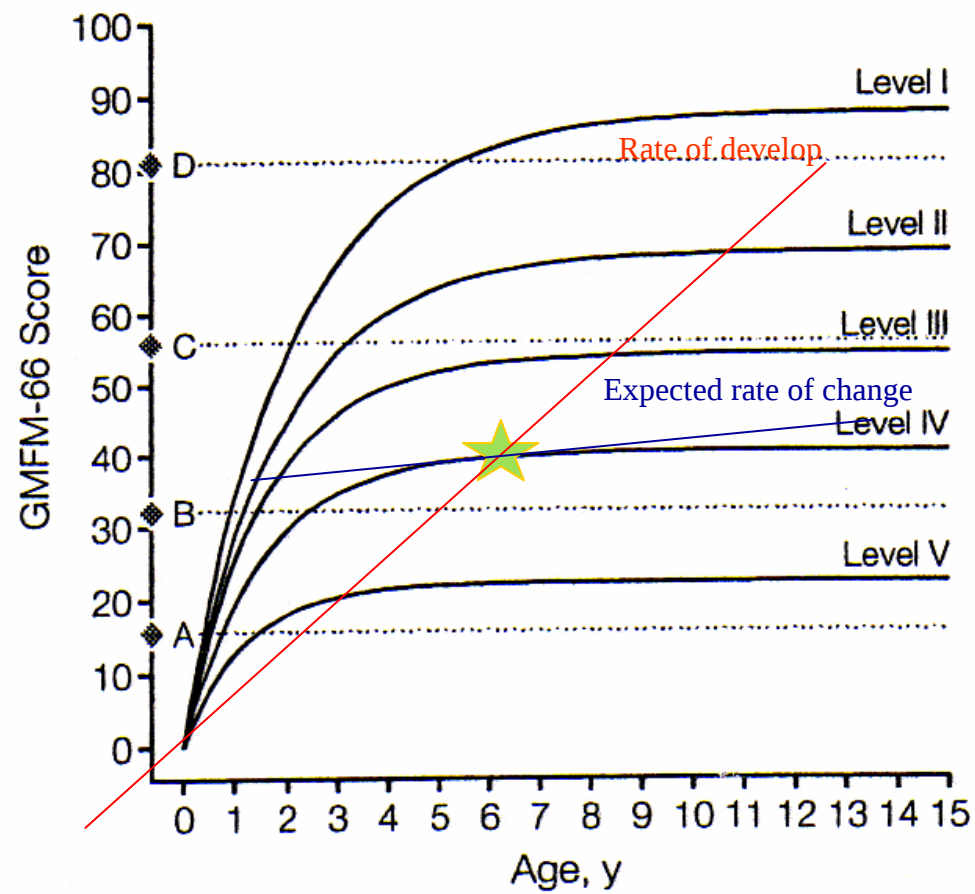
3. Other interventions

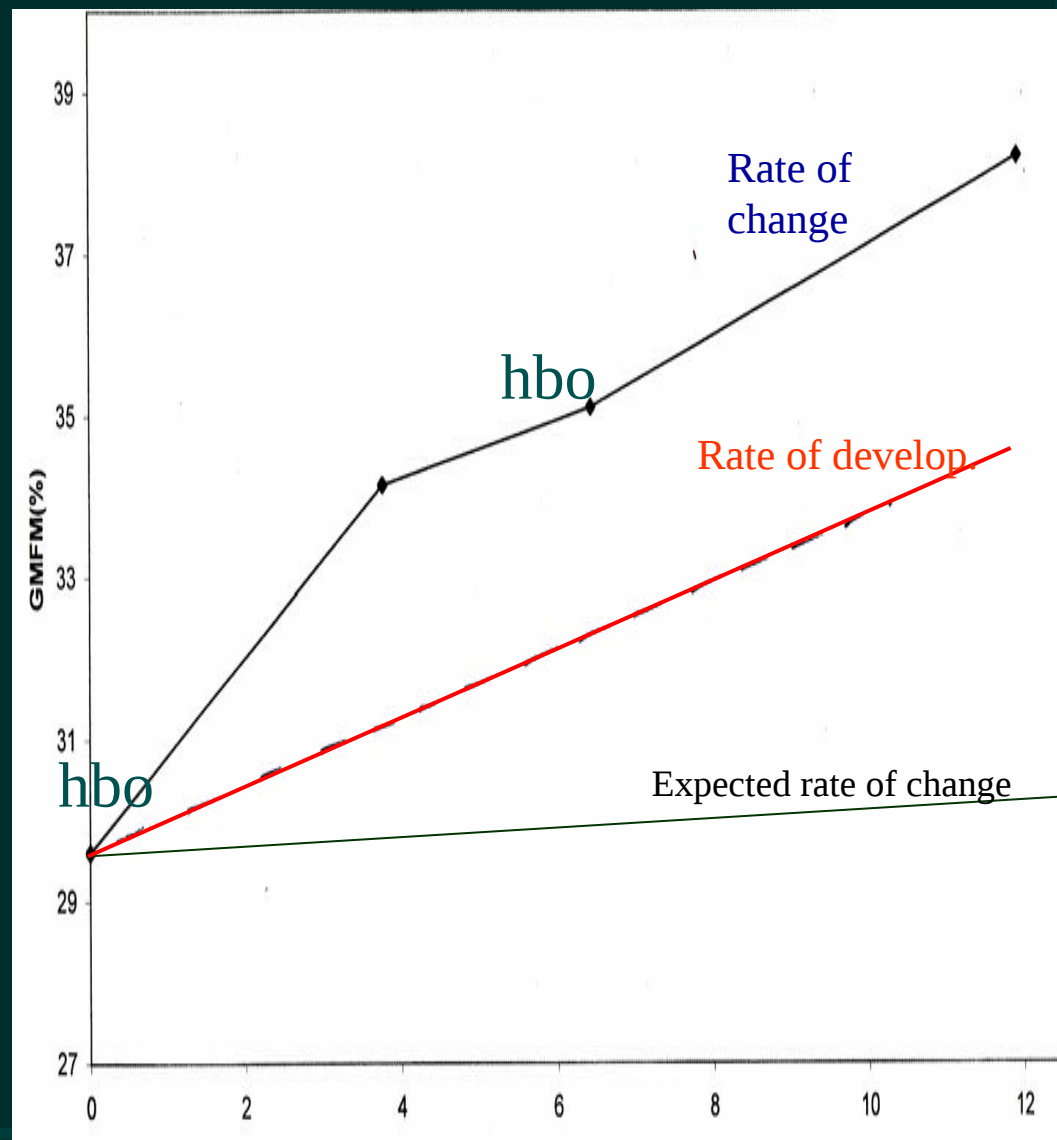
	n	Age (years)	Change	Time Frame	Rate of change
Montgomery et al. (1999) HBO	25	5,6 ± 1,6	4,9	1 mo	4,9 / mo
Collet et al. (2001) HBO	111	7,2	3,0	2 mo	1,5 / mo
Marois et al. (2006) HBO	118	6,4	3,9	3,9 mo	1,0 / mo



For the patients who received two sets of Tx

# Set of Tx	Nb of patients	Nb of Tx	GMFM Change	Relative Change	Rate of change	Efficacy ratio
Set # 1	40	39	4,5	23,7 %	1,29	2,9
Set # 2	40	33	3,0	16,6 %	,71	1,9





GMFM

K.B.



Other observations

- > 80 % of parents reported cognitive changes
- Fine motor changes
- Communication skills

Conclusion

- In this study, analysing the effects of HBOT in C.P., we found that the vast majority of children improved significantly (statistically and clinically) their gross motor function. This confirms the impressive changes measured in our two previous studies.

Conclusion

- In our three studies, the amount or the rhythm of progress were more important than those observed with other recognised therapies in c.p.



Thank you !

7 patients évalués avec ATEC

/// Autisme : 4

/// TED : 2

/// Dysphasie + traits autistiques : 1

ATEC

C.G., âgé de 10 ans, Dx : autisme

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
C.G. (1)	84 % (23)	73 % (20)	70 % (20)	43 % (20)	73 % (83)
40 sessions	84 % (23)	60 % (16)	55 % (17)	30 % (16)	62 % (72)
Écart	=	- 13 %	- 15 %	-13 %	- 11 %

ATEC

D.T., âgé de 6 ans, Dx : autisme

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
D.T. (1)	86 % (24)	76 % (20)	88 % (23)	20 % (13)	70 % (80)
40 sessions	86 % (24)	60 % (16)	55 % (17)	14 % (10)	53 % (67)
Écart	=	- 16 %	- 33 %	- 6 %	- 13 %

ATEC

M.R., âgé de 5 ans, Dx : autisme

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons -cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
M.R. (1)	84 % (23)	64 % (17)	65 % (19)	27 % (15)	62 % (74)
40 sessions	84 % (23)	45 % (13)	60 % (18)	10 % (9)	47 % (63)
Écart	=	- 19 %	- 5 %	- 17 %	- 15 %

ATEC

E.D., âgé de 4 ans, Dx : TED

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
E.D. (1)	45 % (12)	75 % (21)	65 % (19)	80 % (29)	71 % (81)
40 sessions	16 % (5)	60 % (16)	45 % (15)	33 % (17)	33 % (53)
Écart	- 29 %	- 15 %	- 20 %	- 47 %	- 38 %

ATEC

A.L.-MD., âgé de 11 ans, Dx : dysphasie + traits autistiques

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
A. L-MD. (1)	60 % (16)	26 % (10)	55 % (17)	33 % (17)	44 % (60)
40 sessions	56 % (15)	26 % (10)	45 % (15)	33 % (17)	40 % (57)
Écart	- 4 %	=	- 10 %	=	- 4 %

ATEC

I.S., âgé de 5 ans, Dx : autisme

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
I.S. (1)	83 % (23)	91 % (27)	80 % (22)	78 % (32)	90 % (104)
40 sessions	83 % (23)	70 % (19)	75 % (21)	65 % (27)	80 % (90)
Écart	=	- 21 %	- 5 %	- 13 %	- 10 %

ATEC

G.C., âgé de 7 ans, Dx : TED

	<i>Parole/langage communication (28)</i>	<i>Socialisation (46)</i>	<i>Sensoriel/cons- cience cognitive (36)</i>	<i>Santé/physique comportement (75)</i>	<i>Sommaire (180)</i>
G.C. (1)	30 % (8)	20 % (8)	9 % (5)	23 % (14)	14 % (35)
40 sessions	27 % (7)	17 % (6)	6 % (3)	20 % (13)	9 % (29)
Écart	- 3 %	- 3 %	- 3 %	- 3 %	- 5 %

Merci !

