

Six-Minute Walk Test (6MWT) In Early Onset Scoliosis (EOS)

What does it tell us?
How can I use it in my practice?



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Disclosure

- Noriaki Kawakami NPO Japan Spinal Deformity Institute (JSDI) (a, e)
Medtronic (b)
Kisco (b)
EOS imaging (a)

- Hiroko Matsumoto SRS (a)
POSNA (a)
Japan Spinal Deformity Institute (JSDI) (a, b)
CSSG (b)

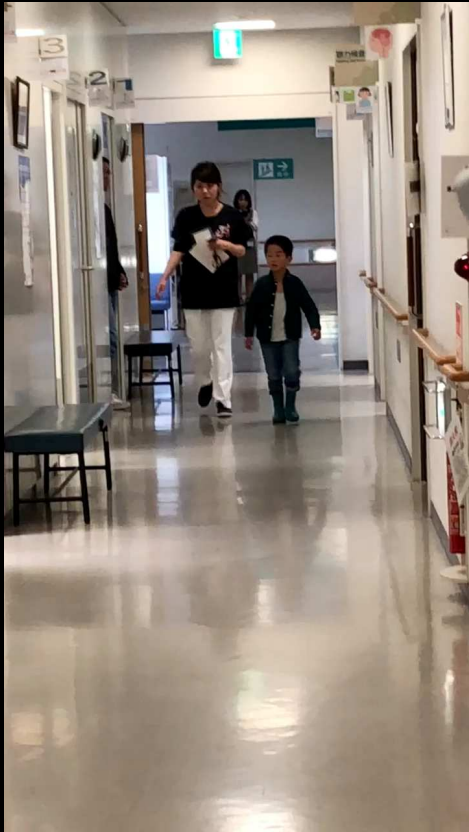
- Gregory Redding No relationship

- a. Grants/Research Support
- b. Consultant
- c. Stock/Shareholder
- d. Speakers' Bureau
- e. Other Financial Support

No relevant financial relationships for this presentation



6-Minute Walk Test (6MWT)



Assess the submaximal level of functional capacity.
⇒ considered a major predictor of **quality of life**
(Li 2007)

- To **evaluate functional capacity** to exercise in several cardiopulmonary and neuromuscular conditions (Chetta 2001, Kerem 2005, Moalla)
- To evaluate **effect of a given treatment** or rehabilitation program (Li 2005, Enright 2003)

American Thoracic Society

ATS Statement: Guidelines for the Six-Minute Walk Test

THIS OFFICIAL STATEMENT OF THE AMERICAN THORACIC SOCIETY WAS APPROVED BY THE ATS BOARD OF DIRECTORS
MARCH 2002

■ Technical aspects of the 6MWT to standardize

Location: indoors, flat, straight, corridor with a hard surface
30 meter (20-50 m) in length.

Patient preparation:

- Comfortable clothing with shoes for walking.
- Usual walking aids during the test (cane, walker, etc.).

Measurements:

- Sit at rest in a chair for 10 minutes before the test starts.
- **Walk as far as possible for 6 minutes, but not run or jog**
- Borg scale: baseline dyspnea and overall fatigue
- Heart rate, respiratory rate, SaO₂

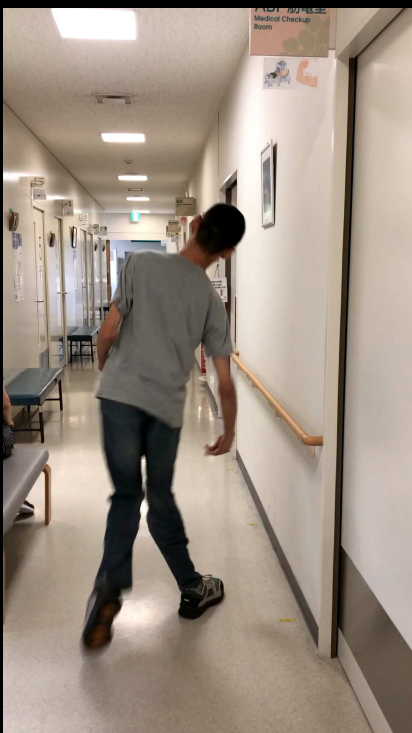
TABLE 2. THE BORG SCALE

0	Nothing at all
0.5	Very, very slight (just noticeable)
1	Very slight
2	Slight (light)
3	Moderate
4	Somewhat severe
5	Severe (heavy)
6	
7	Very severe
8	
9	
10	Very, very severe (maximal)

■ Easy to do in the outpatient setting



6MWT for Evaluation of Walking Ability in Neuromuscular conditions



THE 6-MINUTE WALK TEST AND OTHER ENDPOINTS IN DUCHENNE MUSCULAR DYSTROPHY: LONGITUDINAL NATURAL HISTORY OBSERVATIONS OVER 48 WEEKS FROM A MULTICENTER STUDY

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DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY

ORIGINAL ARTICLE

Walking ability and predictors of performance on the 6-minute walk test in adults with spastic cerebral palsy

GRETHE MAANUM¹ | REIDUN JAHNSEN^{1,2} | KATHRINE F FRØSLIE^{1,2,3} | KERSTIN L LARSEN¹ | ANNE KELLER⁴

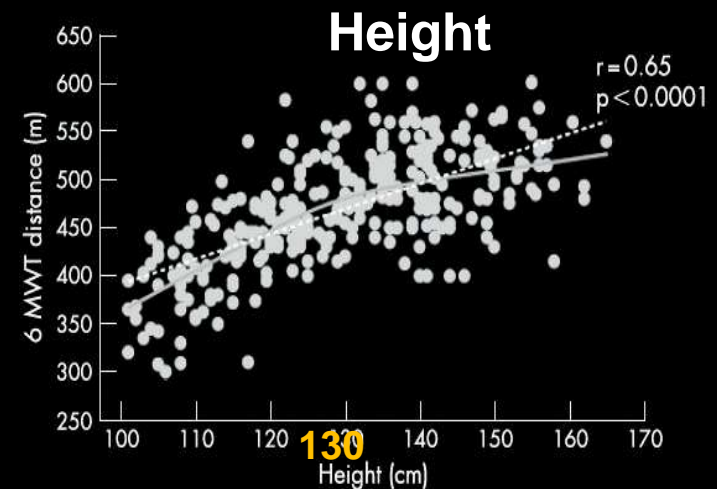
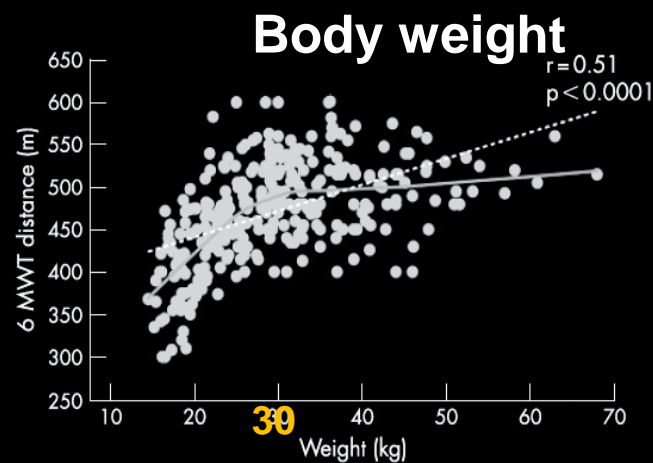
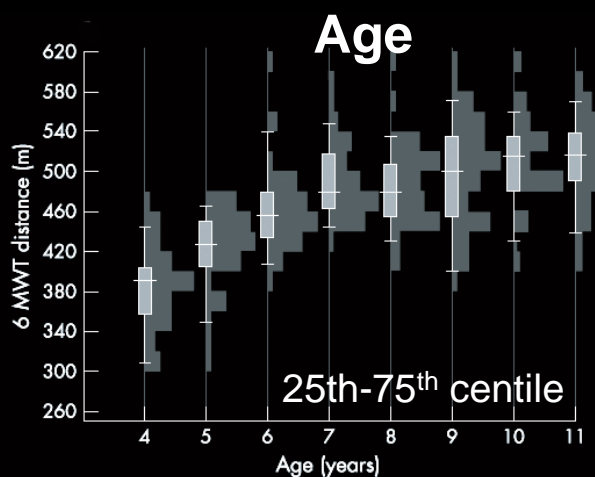
6MWT works well as a predictor of walking ability in patients with CP and Duchenne muscular dystrophy .



The 6-minute walk test: normal values for children of 4–11 years of age

A E Lammers,¹ A A Hislop,² Y Flynn,¹ S G Haworth^{1,2} Arch Dis Child 2008;93:464–468.

Healthy 328 children (54% male) aged 4 to 11 years



- 6MWD: Linear relationship up to a weight of 30 kg and a height of 130 cm
- Provides **data on normal children** against which the performance of sick children and the response to therapeutic intervention can be judged

References Values of 6MWT for Healthy Children

References	Subjects (n)	Country of origin	Age (years)	Equations suggested	r ²	Test methodology	Predictive variables of DW
Li, et al, 2005	1.445	China	7-16	DW(boys) = 554.16+(dif. HR x 1.76)+ [height (cm)x1.23] DW(girls) = 526.79+(dif. HR x 1.66)+ [height (cm)x0.62]	0.43 0.37	30 m corridor	Dif. HR and height
Geiger, et al, 2007	528	Austria	3-18	DW(boys) = 196.72+(39.81 x age) - (1.36 x age ² + 132.28 x height DW(girls) = 188.61+(51.50 x age) - (1.86 x age ² + 86.10 x height	0.49 0.50	20 m corridor; equipment with a wheel to measure the distance	
Lammers, et al, 2007	328	United Kingdom	4-11	Not supplied	-	30-50 m corridor	Age, body weight, and height
Priesnitz, et al, 2009	188	Brazil	6-12	DW(m) =145.343 + [11.78 x age(years)] + {262.22 x height(m)} + {0.611 x dif. HR(bpm)} - {2.684 x body weight(kg)}	0.37	30 m corridor	Age, height, body weight, BMI, Dif. HR
Ulrich, et al,2013	496	Switzerland	5-16	DW(boys) = 13.40 x age(years) – 2.16 x body weight(kg) + 185.53 x height(m) + 276.92 DW(girls) = 372.3 x height(m) – 2.635 x body weight(kg) + 172.05	?	30 m	BP, age, body weight, height, SpO ₂ , HR

6-minute Walk Test in EOS

No studies reported 6MWT test in EOS until we presented.



- 6MWT instead of PFT for small children when started rib-based device for GFS in 2009.

◆ ICEOS 2017

Preop.

(Kawakami, Matsumoto, Redding)

◆ ICEOS 2018

Postop.

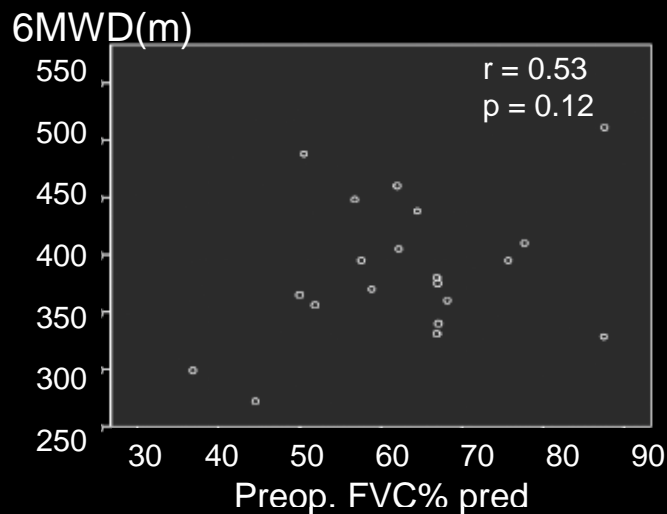
(Kawakami, Matsumoto, Redding)



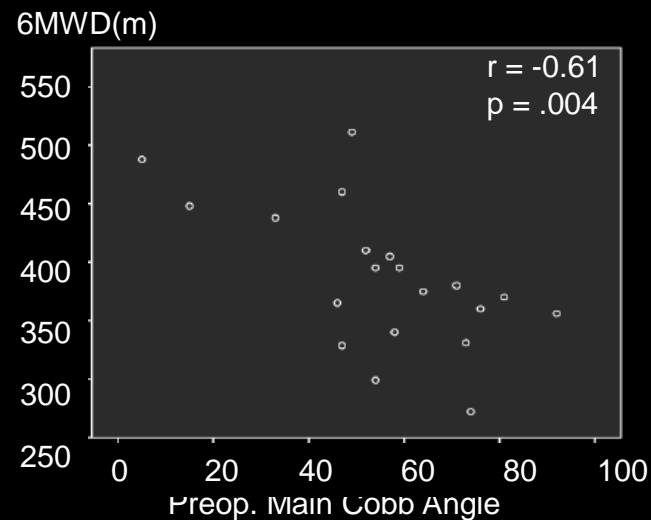
Pre-operative Six Minute Walk Performance in Children with Congenital Scoliosis

Noriaki Kawakami, et al. Presented at ICEOS AM in 2017

Evaluation of preop. 6MWT in 20 pts. with CS to determine the relationship between 6MWD and %FVC predicted BMI, and Cobb angle



**not correlate with BMI%
or %FVC predicted**



correlated with Cobb angle



Summary of Preop. 6MWT in EOS with CS

- The 6MWD **reduced** in all patients, ranging from 10-30% of predicted values.
- **Absolute values of walking distance** were most useful to correlate with clinical features.



Improvement of Functional Outcome Using 6-minute walk in Patients with Congenital Scoliosis Treated by Growth Friendly Surgery: Five Years FU Study

Noriaki Kawakami, et al. Presented at ICEOS AM in 2018

Purpose: To investigate changes in 6MWT pre & post serial surgical treatment in congenital scoliosis

Methods: 44 pts. (age at surg. 5.8)

Compared 6MWD with BMI, %FVC at postop. 1, 2, & 5 yrs.

	Preop.	Immediate Postop.	1-year Postop.	2-year Postop.	5-year Postop.
Major curve (°)	72 ± 28	53 ± 23	56 ± 22	56 ± 22	52 ± 23
BMI (%tile)	53 ± 30	---	51 ± 29	43 ± 31	34 ± 27
%FVC Predicted	58 ± 17	---	57 ± 15	57 ± 15	54 ± 16
6-minute Walk (m)	344 ± 86	---	374 ± 74	390 ± 78	434 ± 80

Results: Standardized 6MWD was compromised at preop but did not worsen postoperatively.



Summary of Postop. 6MWT in EOS with CS

- Over the 5-year period of study, 6MWD increased by $86 \pm 97\text{m}$ (**17.2m/year**) .
(cf. normal children 16-25m/y)
- The change in FVC did not correlate with the change of 6MWD over 5 years.
($p=0.30$)

➔ **Improvement in 6MWT occurs despite persistently reduced lung function, suggesting improvements in balance, strength, and stride length may be more important determinants of performance by growth-friendly surgery.**



Comparison of 6MWT with EOSQ-24

- Congenital EOS patients who underwent Growth-friendly surgery (VEPTR)
- Both 6MWT & EOSQ-24 performed twice
 - 1st test: mean 3.2 yrs. from index surgery
 - 2nd test: mean 5.3 yrs. from index surgery

N=49

	Preop.	1 st 6MWT	2 nd 6MWT
Age	5.6 ± 1.5	8.8 ± 2.0	10.9 ± 2.0
Scoliosis (°)	68.1 ± 24.9	58.6 ± 23.1	42.9 ± 13.2
6MWD (m)		432	456
EOSQ-24 HRQoL		82 ± 12	81 ± 10
FVC (liter)		0.92 ± 0.29	1.11 ± 0.37
%FVC		58.8 ± 17.9	59.2 ± 17.0



6MWD correlated with Some Domains in EOSQ-24 at both the 1st and 2nd test

	1 st 6WMT	2 nd 6WMT
General Health	0.6053	0.9275
Pain/Discomfort	0.5694	0.2849
Pulmonary function	0.2951	0.9169
Transfer	0.3676	0.1018
Physical function	0.3606	0.0032
Daily living	0.0430	0.0359
Fatigue/Energy	0.1301	0.9848
Emotion	0.1716	0.3060
Parent burden	0.0612	0.2241
Financial burden	0.7663	0.1757
Satisfaction	0.2867	0.0094
Total HRQoL	0.0559	0.1646

(P value)

Serial growth-friendly interventions may not negatively affect QOL below their baseline preoperatively



Assessment Tools

Radiographic modalities

+

■ Psychological status

Questionnaire
EOSQ-24
SRS-22, 24, 30

Factors which should be assessed

Trunk proportion
Muscle strength
Balance
Nutritional status
Lung function
Cardiac function

Ps
Infl

Tools assessing general physical function

■ Physical function

- Radiographic
- Physiological
 - Lab exam
 - PFT
 - ECG

- Ex .tolerance test
- 6MWT
- Etc.

Clinical Usage Based on Pros & Cons of 6MWT

■ Advantages

- Simple, easy to do in clinic,
- Not require special equipment
- Assess physical function

□ Limitations

Impracticable for :

- Non-ambulator
- Not communicable (immature age, MR, etc.)
- "Lack of physical strength" (can not bear 6MW)
- No parents supportive



- 6MWT as one of routine evaluation tools
 - Patients who have GFS: Preop., at least once a year
 - Neuromuscular
 - Cardiopulmonary compromise



Unsettled Issue in 6MWT

Patients show the same 6MWD

98% at pre 6MWT

SaO₂ (%)

97-98% at post 6MWT

75 at pre 6MWT
78 at post 6MWT

Heart Rate
(bpm)

80 at pre 6MWT
112 at post 6MWT

How should we interpret physical function of both patients?

⇒ 6MWT should be evaluated by not only walking distance but also **HR and SaO₂** at pre- and post-6MWT.

In Summary

- 6MWT may be a useful measurement tool in assessing global physical function of ADL and QOL in EOS.
- 6MWT is likely an outcome of a combination of muscle strength, balance, nutritional status, cardiac and lung function as well as by age and physical status.
- 6MWT requires further investigation to determine the weight that each parameter has on it, to identify which factor modifiable by treatment can contribute to better ADL and QOL.





**Thank you for
your attention.**





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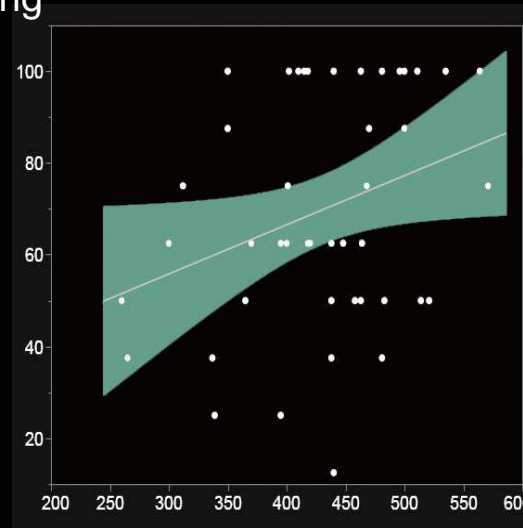
6MWD correlated with Daily Living of EOSQ-24 at both the 1st and 2nd test (N=49).

	1 st 6WMT	2 nd 6WMT	P value
General Health	75±18	71±15	0.0438
Pain/Discomfort	87±17	84±21	0.0024
Pulmonary function	88±14	89±15	0.0117
Transfer	85±22	88±18	0.1971
Physical function	87±17	89±14	0.0006
Daily living	70±26	72±24	<0.0001
Fatigue/Energy	73±23	73±18	<0.0001
Emotion	86±13	86±14	0.0022
Parent burden	69±15	72±15	0.0012
Financial burden	59±28	56±31	<0.0001
Satisfaction	53±23	55±31	<0.0001
HRQoL	82±12	81±10	<0.0001

EOSQ
Daily
living

1st 6MWT

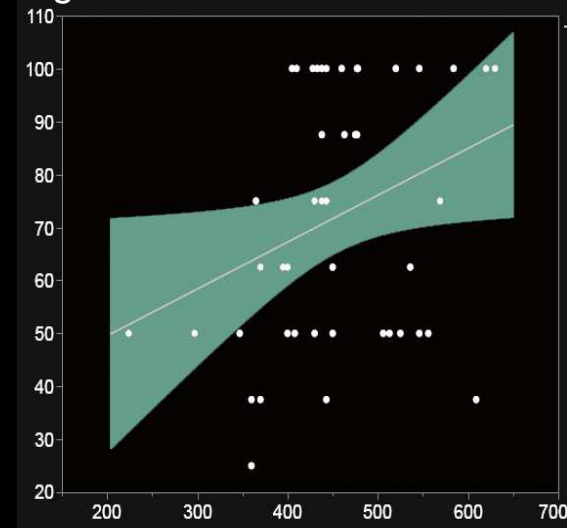
$R^2=0.091844$



EOSQ
Daily
living

2nd 6MWT

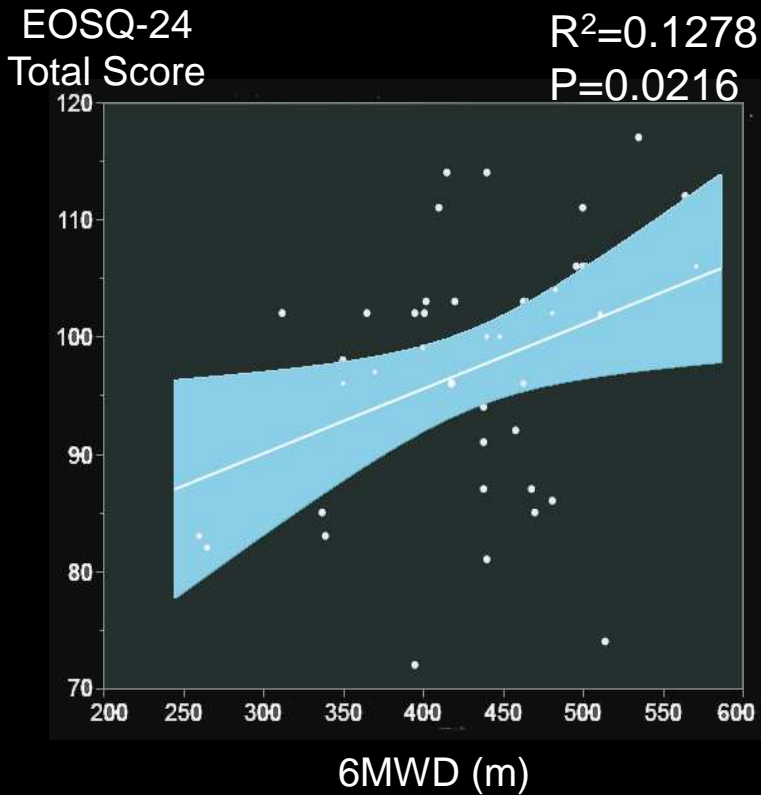
$R^2=0.17746$



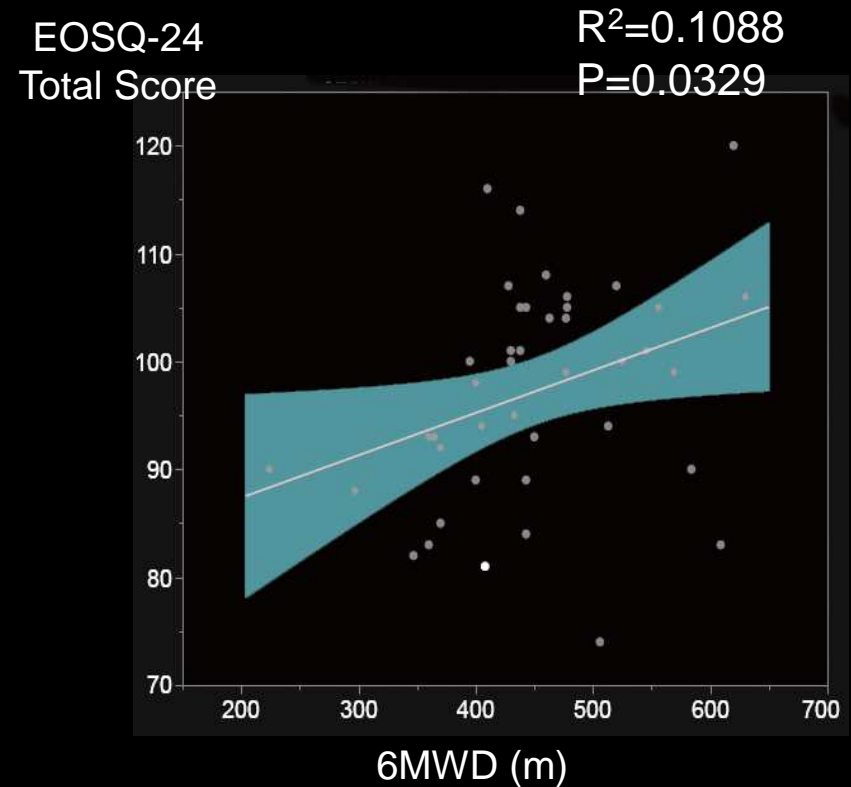
6MWD (m)



6MWD correlated with total score of EOSQ-24 in patients with EOS at both the 1st and 2nd test (N=49).



GFS for 2 years



⇒ Serial growth-friendly interventions for EOS may not negatively affect function & QOL below their baseline preoperatively

