Wilhelmina Kinderziekenhuis

CPET in Children

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Disclosures

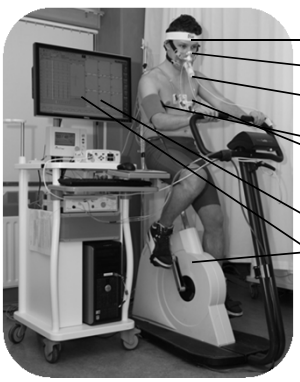
- NONE

Automobile Physiology…Performance related to size

Outline

- Equipment & protocols
- Adult – child differences in CPET parameters
- Example: CPET in CF

Equipment for Pediatric CPET



- Pediatric probe
- Small mask
- Sensitive flow meter
- Small cuff
- Small electrodes
- Small bike
- Modified protocol
- Different norm values

Protocols for pediatric CPET

Aim: 6-10 min young children, 8-12 min adolescents

Tabel 4.6 Godfrey-protocol voor fietsergometrie bij kinderen

	< 120 cm	120-150 cm	> 150 cm
Start	10 watt	15 watt	20 watt
Increment / min	10 watt	15 watt	20 watt

Warm-up: 3 min unloaded cycling
Increment in RAMP fashion

TABLE 4. *The Bruce protocol, half-Bruce protocol, and Dubowy protocol for treadmill ergometry.*

	Bruce protocol			Half-Bruce protocol			Dubowy protocol		
Stage	Speed (km h^{-1})	Slope (%)	Time (min)	Speed (km h^{-1})	Slope (%)	Time (min)	Speed (km h^{-1})	Slope (%)	Time (min)
1	2.7	10	3	2.7	10	1.5	2.0	0	1.5
2	4.0	12	3	3.4	11	1.5	2.5	0	1.5
3	5.5	14	3	4.0	12	1.5	3.0	3	1.5
4	6.8	16	3	4.7	13	1.5	3.5	6	1.5
5	8.0	18	3	5.4	14	1.5	4.0	9	1.5
6	8.8	20	3	6.0	15	1.5	4.5	12	1.5
7	9.7	22	3	6.7	16	1.5	5.0	15	1.5
8				7.3	17	1.5	5.5	18	1.5
9				8.0	18	1.5	6.0	21	1.5
10				8.4	19	1.5	6.5	21	1.5
11				8.8	20	1.5	7.0	21	1.5
12				9.2	21	1.5	7.5	21	1.5

Note: adapted from (24-26).

Godfrey S. Exercise testing in children. Philadelphia: WB Saunders, 1974
Dubowy KO, et al. Cardiol Young. 2008;18(6):615-23.
Hebestreit H, et al Respiration. 2015 epub

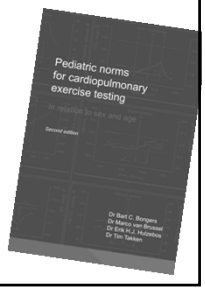
Pediatr Cardiol
DOI 10.1007/s00246-015-1205-6

REVIEW ARTICLE

A Systematic Review of Reference Values in Pediatric Cardiopulmonary Exercise Testing

Samuel Blais[1,2] · Jade Berbari[1,2] · Francois-Pierre Counil[1,2] · Frederic Dallaire[1,2]

values. Each laboratory should select the set of reference values that best represent their patient's characteristics while favoring studies of good methodological quality with appropriate validation.



ISBN: 978-90-8891-998-5
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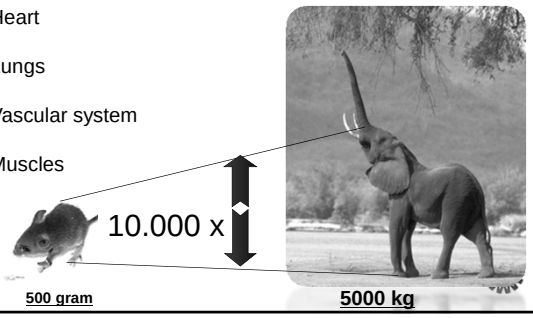
Standard design cardiopulmonary system

VO_2max most important design parameter

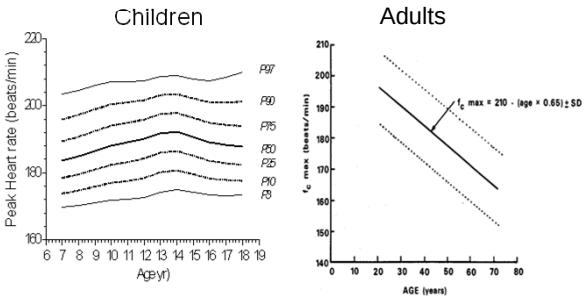
All mammals have standard blue print:

- Heart
- Lungs
- Vascular system
- Muscles

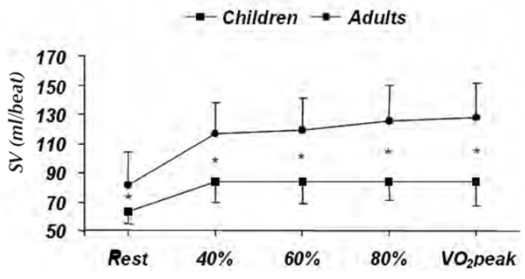


Adult Child Differences in CPET parameters

Peak Heart Rate

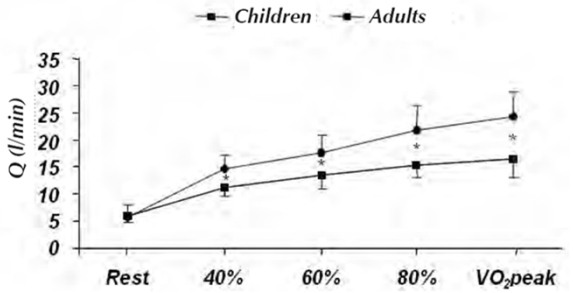


Cardiac Stroke Volume



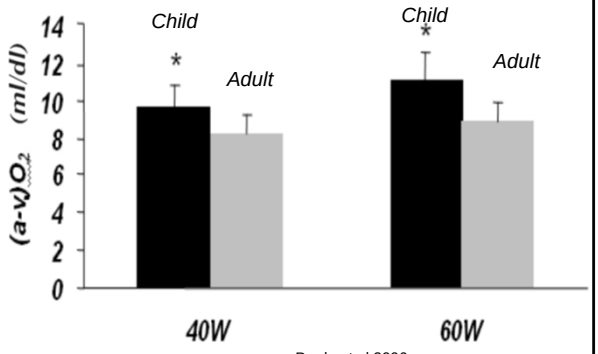
Prado et al 2006

Cardiac Output



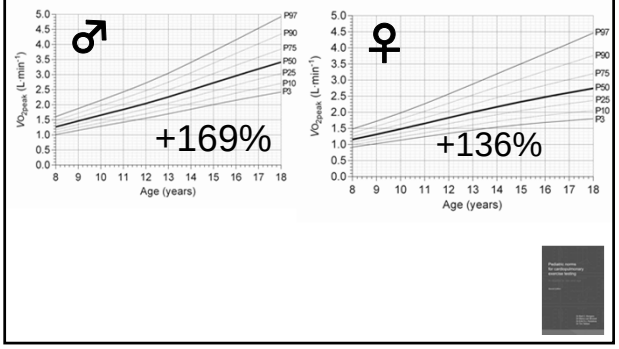
Prado et al 2006

Arterio-venous Oxygen Difference

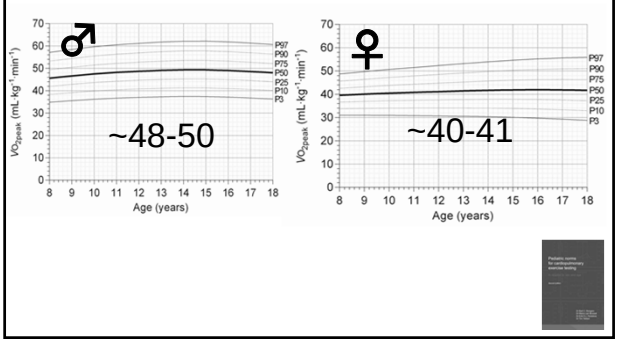


Prado et al 2006

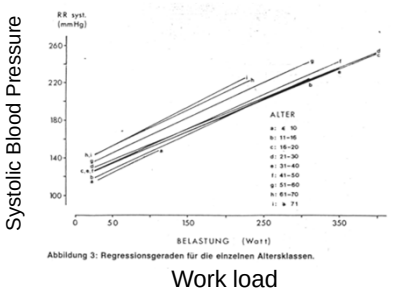
VO_{2max} (L/min) - Dutch Norms



$VO_{2max/kg}$ - Dutch Norms



Blood Pressure

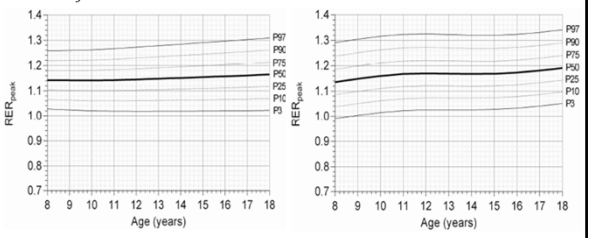


Work load

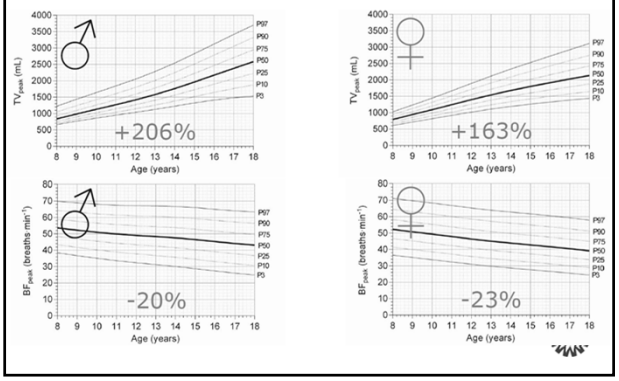
Heck et al. Normwerte des Blutdrucks bei der Fahrradergometrie. Deutsche Zeitschrift fur Sportmedizin. 1984;(7):243-249

RER peak

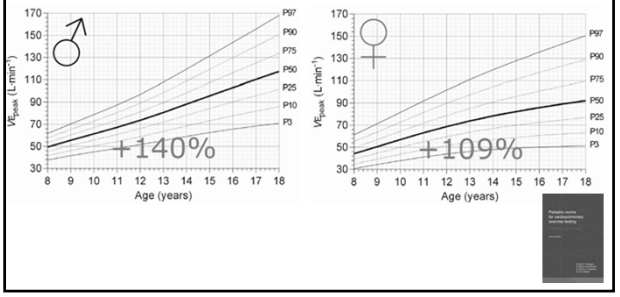
- Boys
- Girls



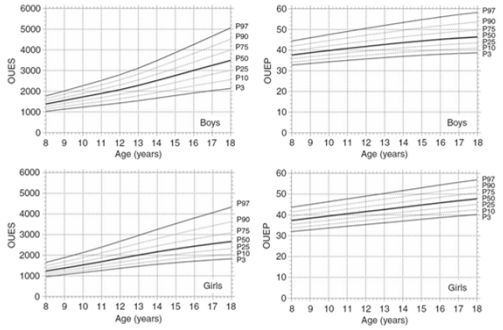
Breathing pattern at Peak Exercise



Peak minute ventilation

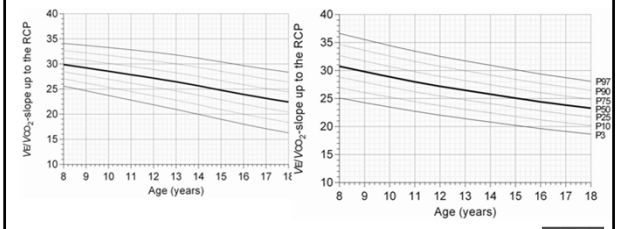


Oxygen Uptake Efficiency (Slope & Plateau



Bongers BC, Hulzebos EH, Helbing WA, Ten Harkel AD, van Brussel M, Takken T. Response profiles of oxygen uptake efficiency during exercise in healthy children. Eur J Prev Cardiol. 2015 (epub).

Ventilatory Drive (VE/VCO_2 slope)



Criteria for maximal effort

Subjective criteria:

- Unsteady walking, running or biking
- Sweating
- Facial flushing
- Clear unwillingness to continue CPET despite encouragement

Objective criteria:

- RERpeak > 1.0
- HRpeak> 180 beats/min
- VO_2 plateau in final minute (infrequently observed)
- ***NB: never stop test if criteria are met***

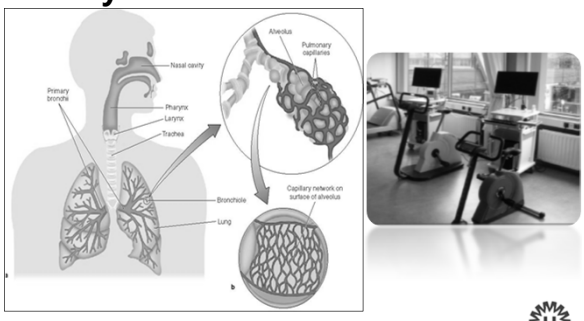
Important Adult-Child Differences

Hemodynamic	Difference with Adults
– VO_{2peak} (L/min)	Lower
– Submaximal HR	Higher
– HRpeak	Higher
– SV (sub)max	Lower
– CO at $\%VO_{2peak}$	Lower
– Δ avO_2 at $\%VO_{2peak}$	Higher
– Blood flow to muscle	Higher
– SBP, DBD	Lower
– Myocardial Ischemia	Rare
Ventilatory	
– Tidal Volume	Lower
– Respiratory Rate	Higher
– VE peak	Lower
– Ventilatory drive	Higher
– Ventilatory efficiency	Lower

Important Adult-Child Differences cont'ed

Metabolic	Difference with Adults
– Glycolytic activity	Lower
– Fat oxidation	Higher
– CHO oxidation	Lower
– Peak blood lactate	Lower
– A-lactic capacity	Lower
– Lactate clearance	Same
– Recovery after high intensity exercise	Faster

Example: Exercise Testing in Patients with Cystic Fibrosis



Respiration

Guidelines

Respiration
DOI: 10.1159/000439057

Received: June 30, 2015
Accepted: July 27, 2015
Published online: September 9, 2015

Statement on Exercise Testing in Cystic Fibrosis

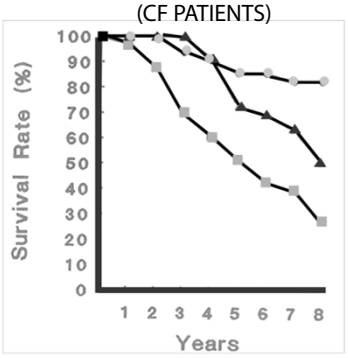
Helge Hebestreit[a] Hubertus G.M. Arets[b, c] Paul Aurora[d] Steve Boas[f]
Frank Cerny[g] Erik H.J. Hulzebos[c] Chantal Karila[j] Larry C. Lands[k]
John D. Lowman[h] Anne Swisher[i] Don S. Urquhart[e]
for the European Cystic Fibrosis Exercise Working Group

WHY: CPET in CF - Applications

- Routine monitoring and assessment of exercise-related symptoms
- Pretransplant assessment
- Physical activity counselling/ recommendations/ exercise prescription
- Interim functional assessment

VO_{2MAX} & Survival

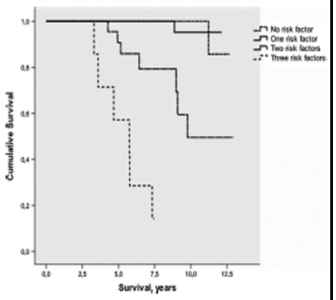
(CF PATIENTS)



Nixon PA, Orenstein DM, Kelsey SF, Doershuk CF. The prognostic value of exercise testing in patients with cystic fibrosis. N Engl J Med. 1992;327(25):1785-8.

Survival in contemporary 11-14 year old children with CF

- 127 cf patients
- Mean age 12.7 years
- FEV1: 77%
- CPET (bike)
- 7.5 years follow-up

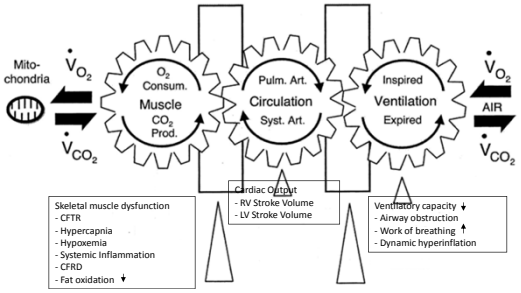


† Cut-off point (as determined by receiver operating characteristic curve analysis): BMI ≤15.13; FEV_1%pred ≤ 68.08; peak VE/VO_2 >34.87.

Hulzebos EH, Bomhof-Roordink H, van de Weert-van Leeuwen PB, Twisk JW, Arets HG, van der Ent CK, Takken T. Prediction of mortality in adolescents with cystic fibrosis. Med Sci Sports Exerc. 2014; 46(11):2047-52

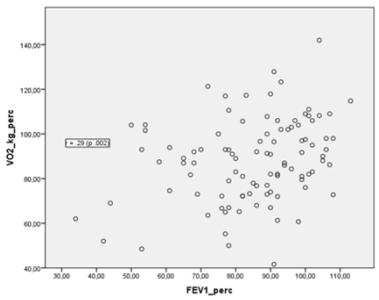
Exercise Limiting Factors in CF

More than lung disease



Poor relation between VO_2peak and FEV_1

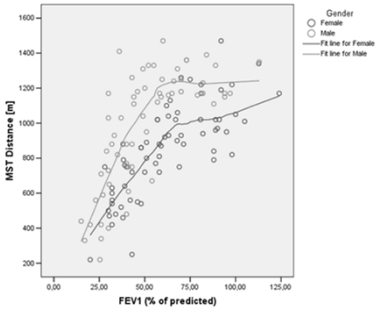
(Children with CF)



Unpublished observation WKZ

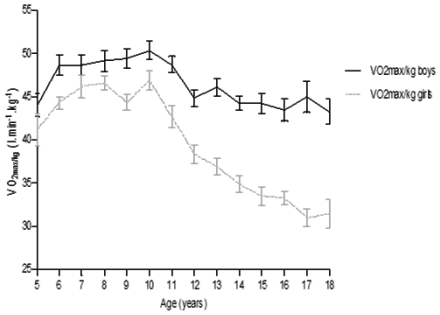
Relationship walk distance and FEV_1

(Adult CF patients)



Doeleman, Takken, Bronsveld & Hulzebos, Physiotherapy, accepted

Gender differences in CF

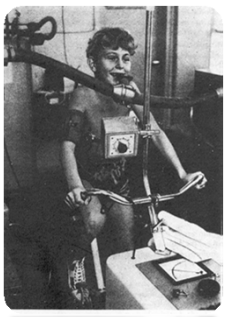


Unpublished observation WKZ

Take-Home Messages

- Also in children, never underestimate the power of CPET
- When testing children, appropriate equipment and protocol should be used;
- Because of the differences in physiology, **pediatric** reference values for CPET parameters should be used.

Thank You



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