רות
בית חולים רות רפפורט לילדים
רמב"ם-הקריה הרפואית לבריאות האדם

לרינגוסקופיה במאמץ:
העתיד כבר כאן!

רונן בר-יוסף
כנס איגוד ריאות ילדים השנתי
גליליון
2018

תפקודי נשימה של א.ו.

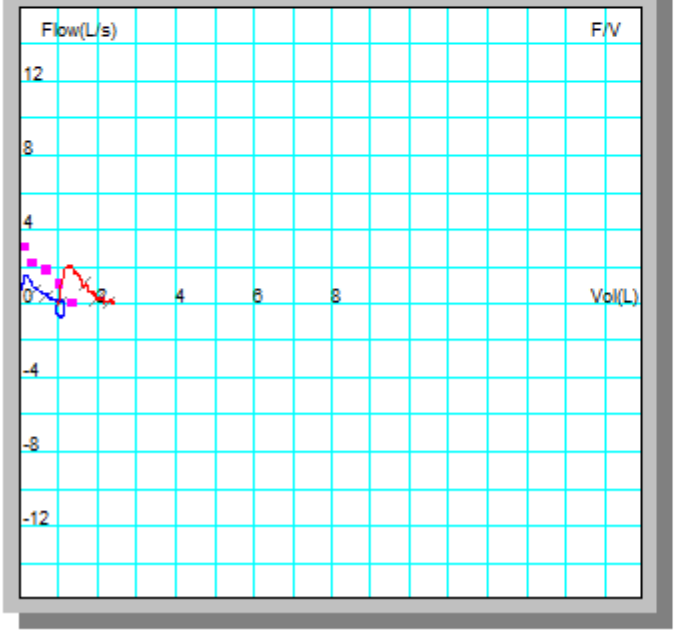
רות
בית חולים רות רפפורט לילדים
רמב"ם-הקריה הרפואית לבריאות האדם

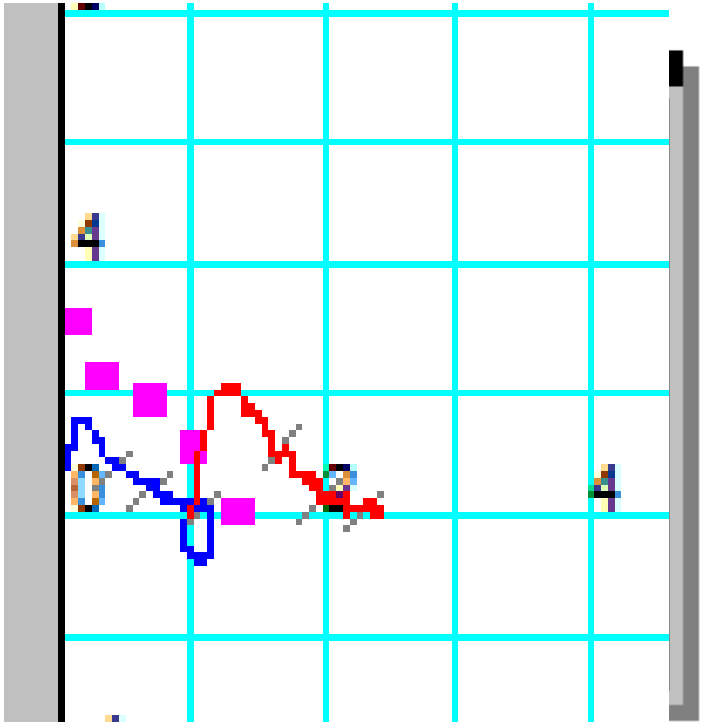
Results

Result	Pred	Pre	%Prd	Post	%Prd	%Chg
FVC (L)	1.36	1.13	83%	1.43	105%	27%
FEV1 (L)	1.27	0.76	60%	0.98	77%	29%
FEV1/FVC	0.86	0.67	78%	0.69	80%	2%
FEF25-75% (L/s)	1.61	0.53	33%	0.62	39%	18%
PEFR (L/s)	3.05	1.59	52%	2.02	66%	27%
Vext %	---	2.36	---	2.89	---	22%

Test comments (Pre):
Test comments (Post):

FVC Flow vs. Volume





How common is EID?

Respir Med. 2014 Jun;108(6):852-8. doi: 10.1016/j.rmed.2014.03.010. Epub 2014 Mar 27.

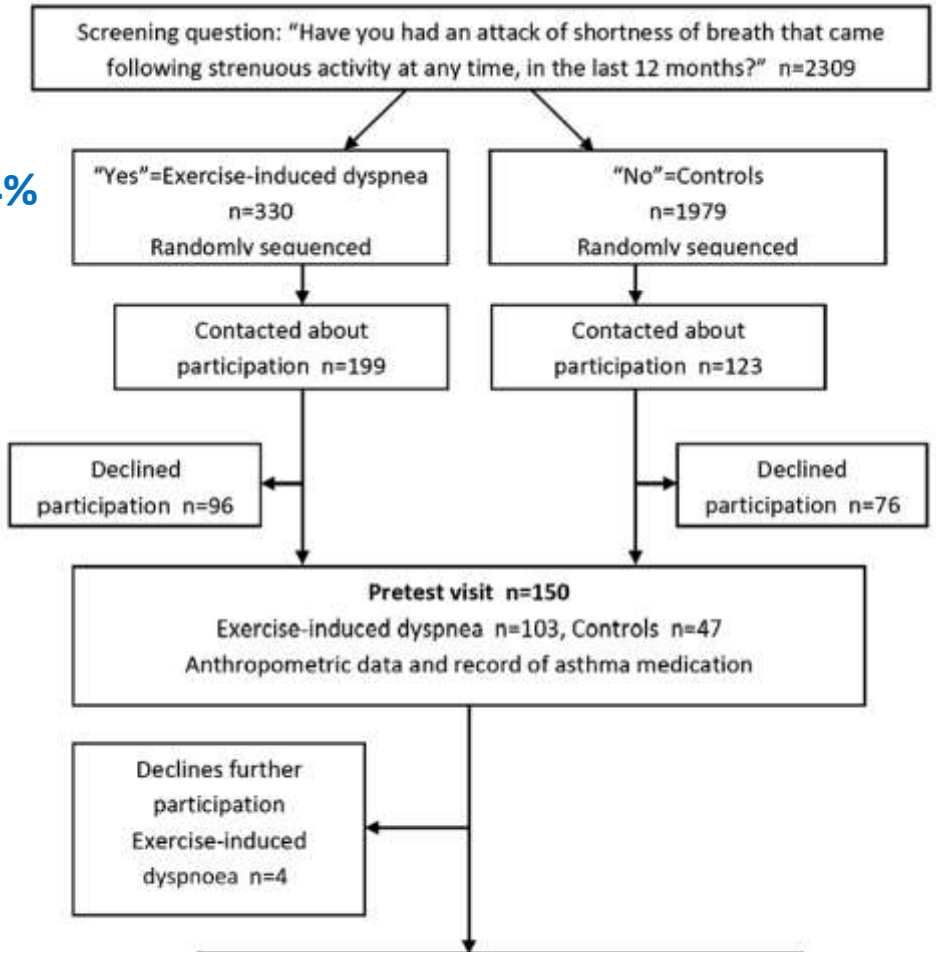
Exercise-induced dyspnea is a problem among the general adolescent population.

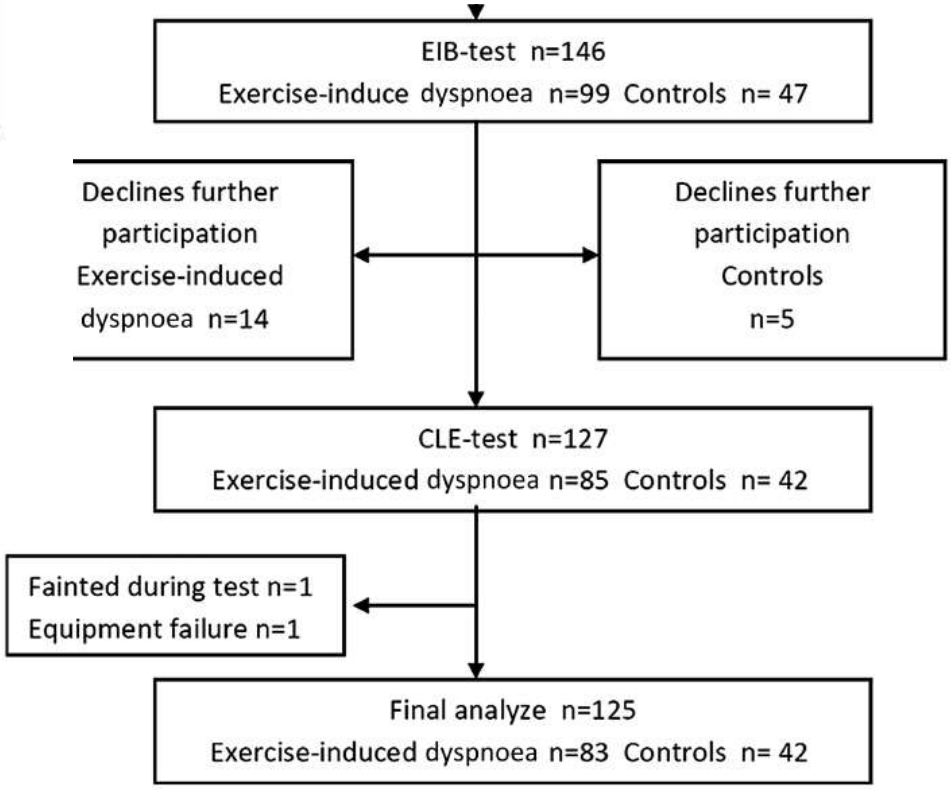
Johansson H[1], Norlander K[2], Hedenström H[3], Janson C[4], Nordang L[2], Nordvall L[5], Emtner M[6].

- Parents were asked to complete a questionnaire together with their child on EID
- 2309 responded
- **14%** (n = 330) reported EID

14%

12-13 year old adolescents





Johansson H, *et al. Thorax* 2015;**70**:57–63.

Introduction

רות
בית חולים רות רפפורט לילדים
רמב"ם-הקריה הרפואית לבריאות האדם

Oxford Dictionary:

dyspnea | dyspnoea [British]
First use: mid 17th century
Origin: Latin from Greek *duspnoia*, from *dus-* "difficult" + *pnoē* "breathing"

- Involves the perception of difficulty or painful breathing
- Complex psycho-physiologic sensation
- Many causes that can be anatomic, physiologic, or psychologic
- Exertional dyspnea indicates dyspnea that occurs or worsens during physical activity

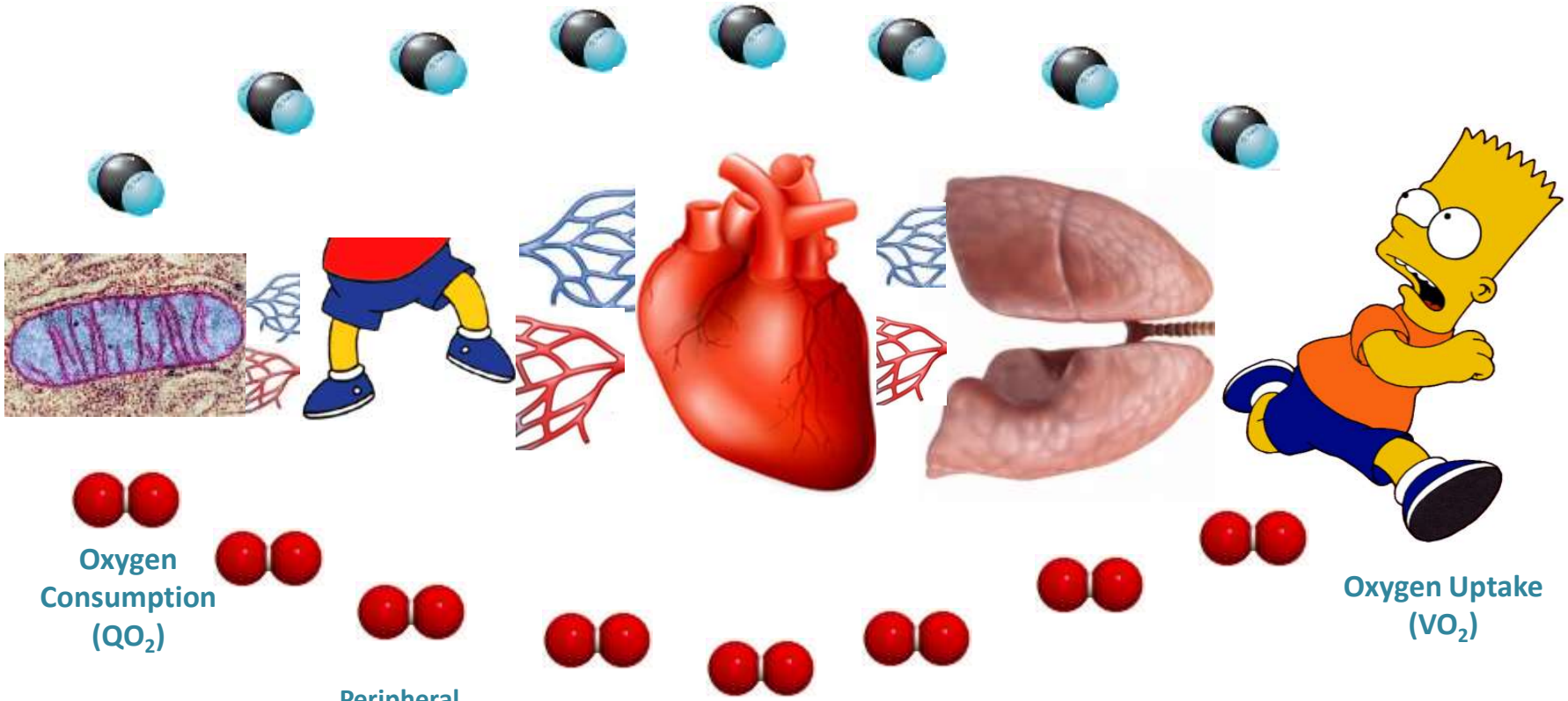
Case: E.G.

- 13 yr old girl
- Medical history: stridor as a child
- Previously an athlete
- Exertional dyspnea
- Stopped exercising
- Asking for help!!!

Exercise in the office

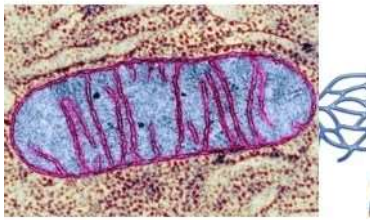
- 80 steps, ~ 3 minutes
- Moderate intensity
- Pulse oximeter (BP +/-)
- 2 eyes, 2 ears
- 100% attention
- Best to perform with the patient

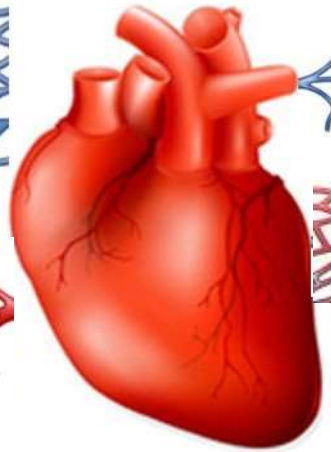
יכולת מאמץ על רגל אחת

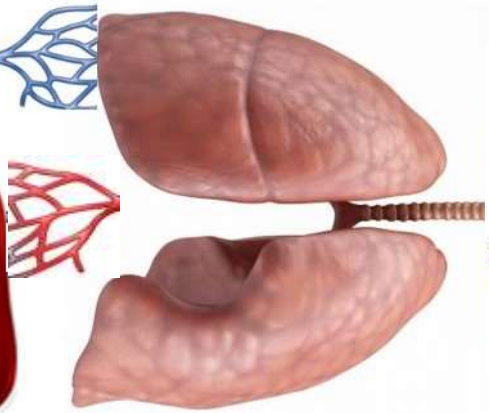


Peripheral circulation

Pulmonary circulation







- Mitochondrial disorders

- Obesity
- Myopathy
- Chronic Muscle disorder

- Occlusion
- Hypertension
- Vasoregulatory asthenia

- Heart disease
  - Coronary
  - Myocardial
  - Valvular
- Anemia

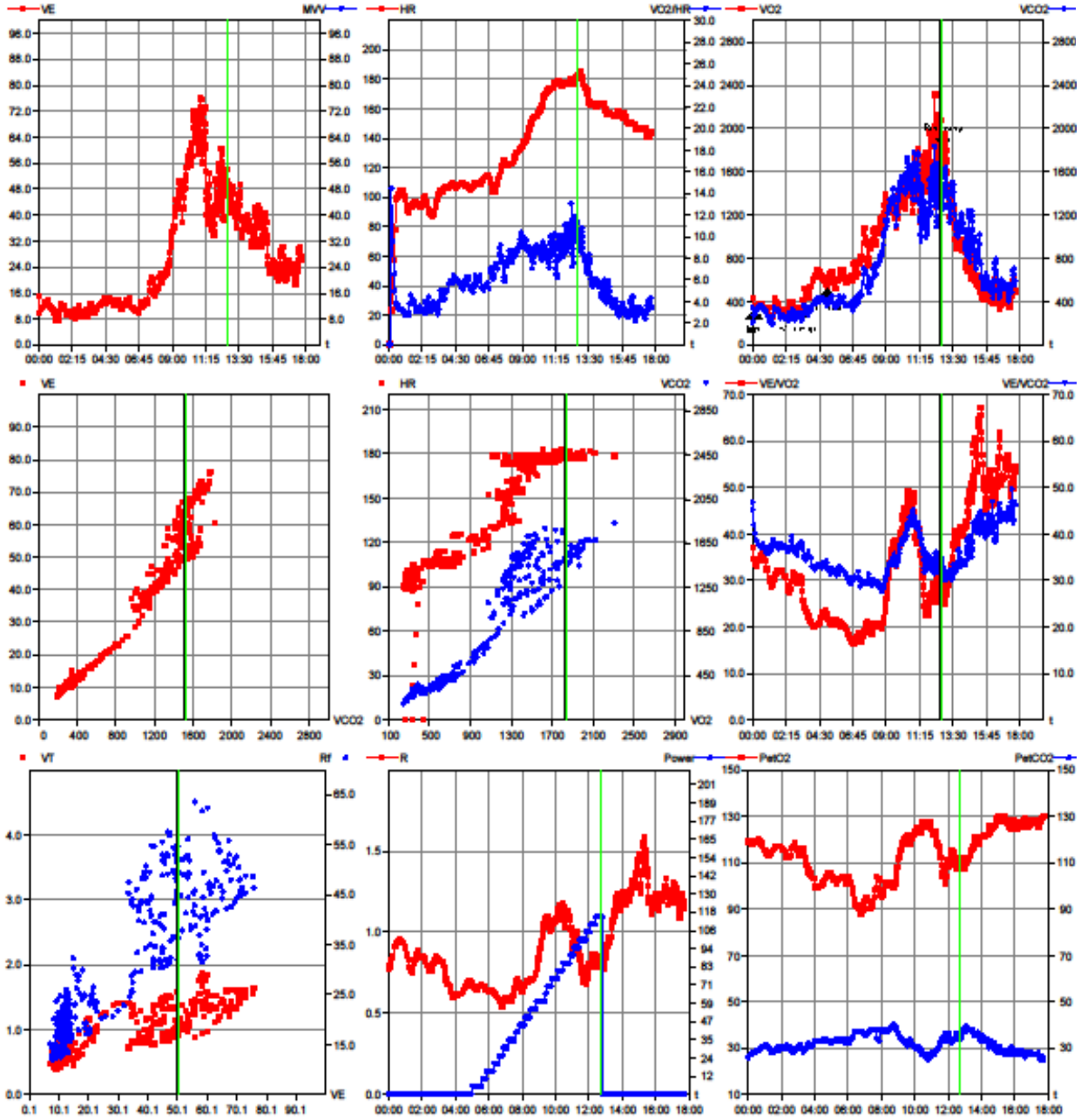
- Thromboemboli
- Vasculitis
- Pulmonary hypertension

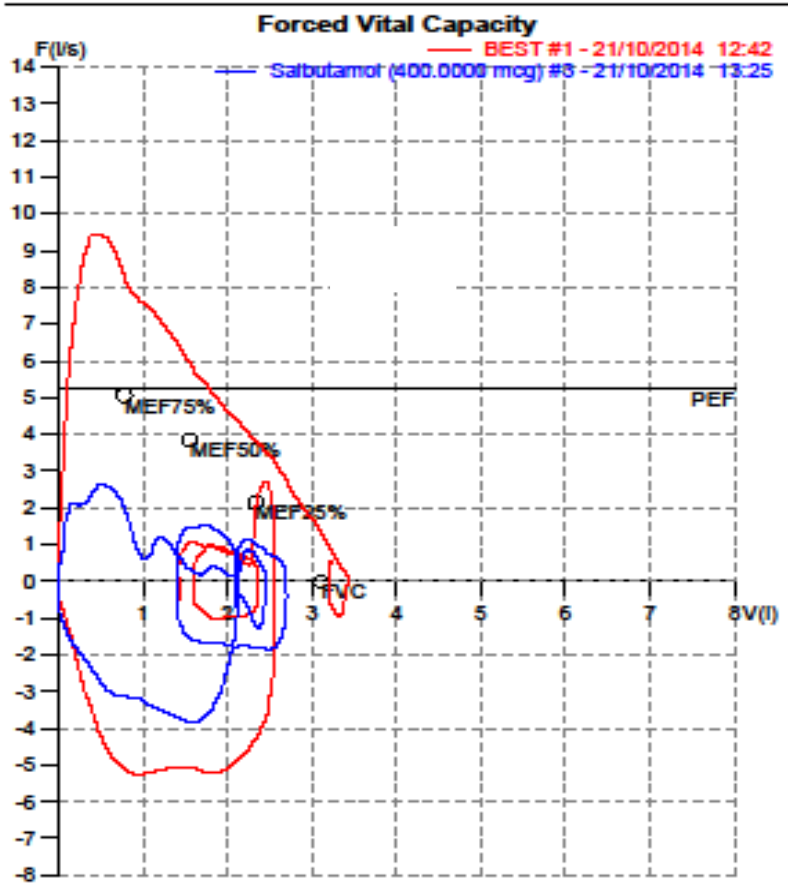
- Obstruction
- Restriction
- Chestwall
- Infiltrative

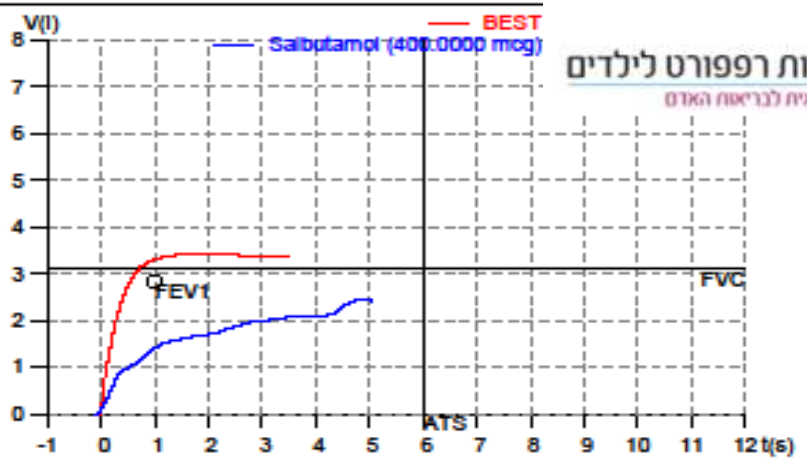
Airway → Lower / Upper

Case: E.G. cont.

- Skin test positive to: dust, grass, trees…
- MCT very positive, weak response to bronchodilators
- Normal Echo study
- Resting spirometry - normal
- Treated with Ventolin/symbicort
- Daily Ventolin use


VE
MVV
HR
VO2/HR
VO2
VCO2
VE
VCO2
HR
VCO2
VE/VO2
VE/VCO2
VT
Rf
R
Power
PetO2
PetCO2



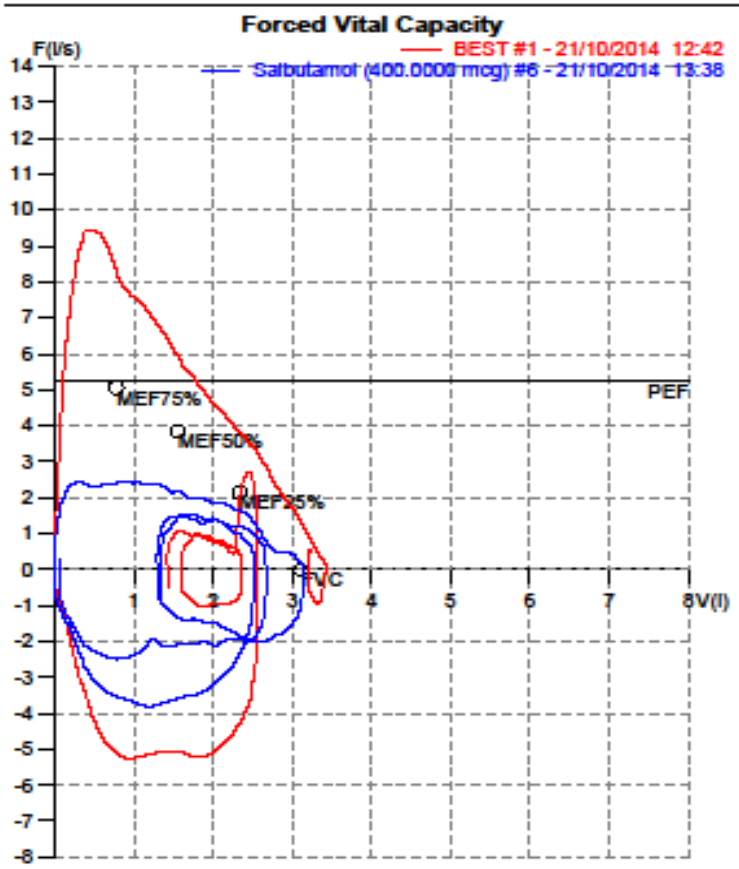


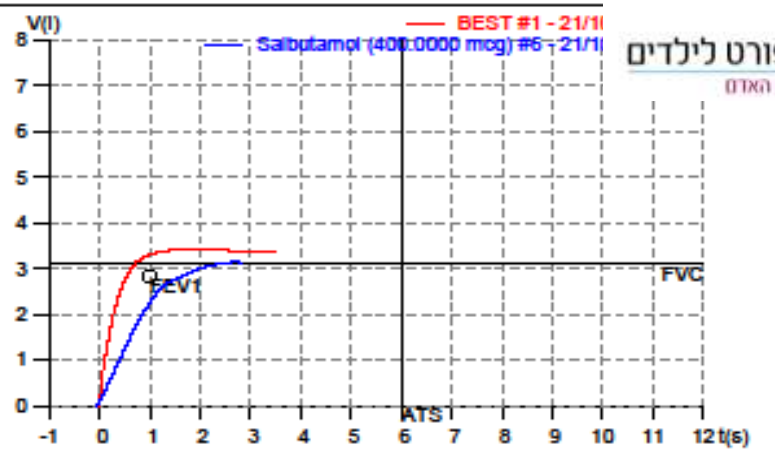
רות
בית חולים רות רפפורט לילדים
רסב"ם-הקריה הרפואית לבריאות האדם

לאחר המאמץ

Forced Vital Capacity

Parameter	UM	Description	Pred.	TEST#1	%Pred.	POST#3	%Test#1
Best FVC	l(btps)	Best Forced Vital Capacity	3.11	3.46	111	2.47	-28.7
FVC	l(btps)	Forced Vital Capacity	3.11	3.46	111	2.47	-28.7
FEV1	l(btps)	Forced Exp Volume in 1 sec	2.82	3.35	119	1.41	-57.8
PEF	l/sec	Peak Expiratory Flow	5.24	9.43	180	2.62	-72.2
PIF	l/sec	Peak Inspiratory Flow		0.96		1.26	+30.8
FEV1/FVC%	%	FEV1 as % of FVC	84.5	96.8	115	57.2	
FEF25-75%	l/sec	Forced mid-expiratory flow		5.06		0.56	-88.9
MEF75%	l/sec	Max Exp Flow @ 25% FVC	5.06	7.77	154	2.52	-67.6
MEF50%	l/sec	Max Exp Flow @ 50% FVC	3.84	5.39	140	1.19	-78.0
MEF25%	l/sec	Max Exp Flow @ 75% FVC	2.14	3.16	148	0.40	-87.4
FET100%	sec	Forced Expiratory Time		1.7		4.9	+195.1
IC	l(btps)	Inspiratory Capacity		2.56		2.13	





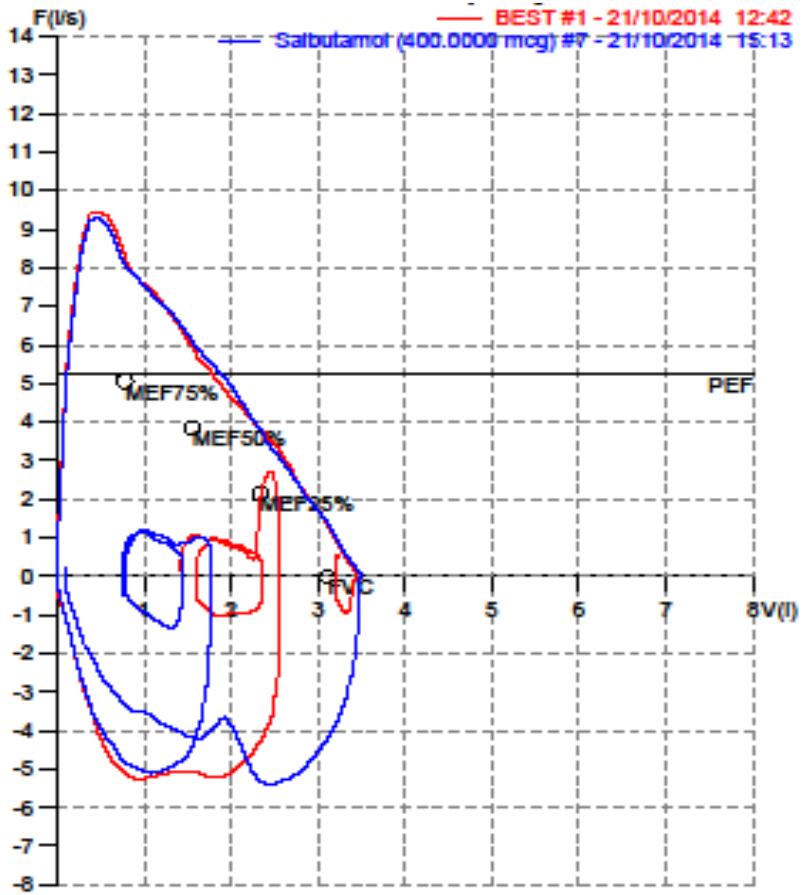
לאחר ונטולין

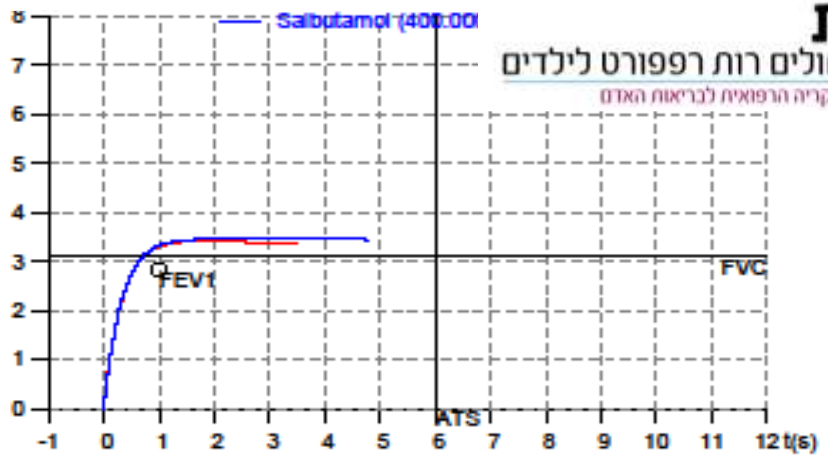
Forced Vital Capacity

Parameter	UM	Description	Pred.	TEST#1	%Pred.	POST#6	%Test#1
Best FVC	l(btps)	Best Forced Vital Capacity	3.11	3.46	111	3.17	-8.5
FVC	l(btps)	Forced Vital Capacity	3.11	3.46	111	3.17	-8.5
FEV1	l(btps)	Forced Exp Volume in 1 sec	2.82	3.35	119	2.23	-33.4
PEF	l/sec	Peak Expiratory Flow	5.24	9.43	180	2.46	-73.9
PIF	l/sec	Peak Inspiratory Flow		0.96		2.50	+160.0
FEV1/FVC%	%	FEV1 as % of FVC	84.5	96.8	115	70.4	
FEF25-75%	l/sec	Forced mid-expiratory flow		5.06		2.09	-58.7
MEF75%	l/sec	Max Exp Flow @ 25% FVC	5.06	7.77	154	2.40	-69.1
MEF50%	l/sec	Max Exp Flow @ 50% FVC	3.84	5.39	140	2.16	-60.0
MEF25%	l/sec	Max Exp Flow @ 75% FVC	2.14	3.16	148	1.61	-49.1
FET100%	sec	Forced Expiratory Time		1.7		2.6	+59.6
IC	l(btps)	Inspiratory Capacity		2.56		2.52	

Maximum Voluntary Ventilation

Parameter	UM	Description	Pred.	TEST#2	%Pred.





לאחר שעה

Forced Vital Capacity

Parameter	UM	Description	Pred.	TEST#1	%Pred.	POST#7	%Test#1
Best FVC	l(btps)	Best Forced Vital Capacity	3.11	3.46	111	3.49	+0.9
FVC	l(btps)	Forced Vital Capacity	3.11	3.46	111	3.49	+0.9
FEV1	l(btps)	Forced Exp Volume in 1 sec	2.82	3.35	119	3.35	+0.1
PEF	l/sec	Peak Expiratory Flow	5.24	9.43	180	9.30	-1.4
PIF	l/sec	Peak Inspiratory Flow		0.96		5.40	+462.8
FEV1/FVC%	%	FEV1 as % of FVC	84.5	96.8	115	96.0	
FEF25-75%	l/sec	Forced mid-expiratory flow		5.06		5.05	-0.2
MEF75%	l/sec	Max Exp Flow @ 25% FVC	5.06	7.77	154	7.84	+0.9
MEF50%	l/sec	Max Exp Flow @ 50% FVC	3.84	5.39	140	5.61	+4.1
MEF25%	l/sec	Max Exp Flow @ 75% FVC	2.14	3.16	148	2.88	-8.7
FET100%	sec	Forced Expiratory Time		1.7		1.7	+0.5
IC	l(btps)	Inspiratory Capacity		2.56		1.78	

Exercise-induced laryngeal obstruction (EILO)

- Definition: Breathing problem which is not present at rest, triggered by exercise, and isolated to the larynx at either a glottic or supraglottic level

EILO - History

- 1842: Dunglison et al. - first descriptions of the periodic occurrence of laryngeal obstruction associated with dyspnea and noisy breathing

- 1983: Christopher et al. - first comprehensive description of the syndrome of vocal cord dysfunction (VCD) presenting as asthma

THE NEW ENGLAND JOURNAL OF MEDICINE June 30, 1983

VOCAL-CORD DYSFUNCTION PRESENTING AS ASTHMA

- 1984: recognized as a cause of adolescent exertional dyspnea and described as a cause of “choking during athletic activities”

EILO

- Despite the long-standing recognition → minimal progress in defining the epidemiology, etiology, pathophysiology, optimal diagnostic strategies, and optimal treatment strategies

	Studies	Patients		
		Mean	Median	Total
Case report or case series	136	6	1	868
Case–control	11	75	97	826
Cross-sectional	25	59	60	1480
Total	172	18	1	3174

Eur Respir J 2017; 50:

Table 1. Prior terms used for describing inducible laryngeal obstructions.

Inspiratory vocal cord dysfunction
Expiratory vocal cord dysfunction
Variable vocal cord dysfunction
Vocal cord *malfunction*
Laryngeal *dysfunction*
Laryngeal *dyskinesia*
Episodic laryngeal *dyskinesia*
Adult laryngomalacia
Late-onset laryngomalacia
Laryngeal *spasm*
Episodic paroxysmal *laryngospasm*
Recurrent *laryngospasm*
Spasmodic croup
Laryngeal *stridor*
Paradoxical vocal *fold* motion
Paradoxical vocal *fold* dysfunction
Paradoxical vocal cord *adduction*
Paradoxical vocal cord *motion*
Paradoxical vocal cord *movement*
Paradoxical vocal cord *dysfunction*
Paradoxical vocal cord *syndrome*
Exercise-induced *laryngospasm*
Exercise-induced *vocal cord dysfunction*
Exercise-induced *laryngeal dysfunction*
Exercise-induced *laryngochalasia*
Exercise-induced *paradoxical vocal fold motion*
Exercise-induced *stridor*
Irritant-associated vocal cord dysfunction
Irritant vocal cord dysfunction
Munchausen's stridor
Emotional laryngeal wheezing
Hysterical stridor
Non-organic acute upper airway obstruction
Psychogenic stridor
Psychogenic vocal cord dysfunction
Psychogenic upper airway obstruction
Psychogenic pharyngeal constriction
Psychogenic respiratory distress
Factitious asthma
*Functiona*l laryngeal dyskinesia
Functional upper airway obstruction
Functional airway obstruction
Functional laryngeal obstruction
Functional laryngeal stridor
Functional stridor

רות
בית חולים רות רפפורט לילדים
רמב"ם-הקריה הרפואית לבריאות האדם

Over 40 terms have been used to describe disorders characterized by symptomatic episodes of laryngeal obstruction

ERS/ELS/ACCP 2013 international consensus conference nomenclature on inducible laryngeal obstructions

Inducible laryngeal obstruction: an official joint European Respiratory Society and European Laryngological Society statement

Eur Respir J 2017; 50: 1602221

Epidemiology

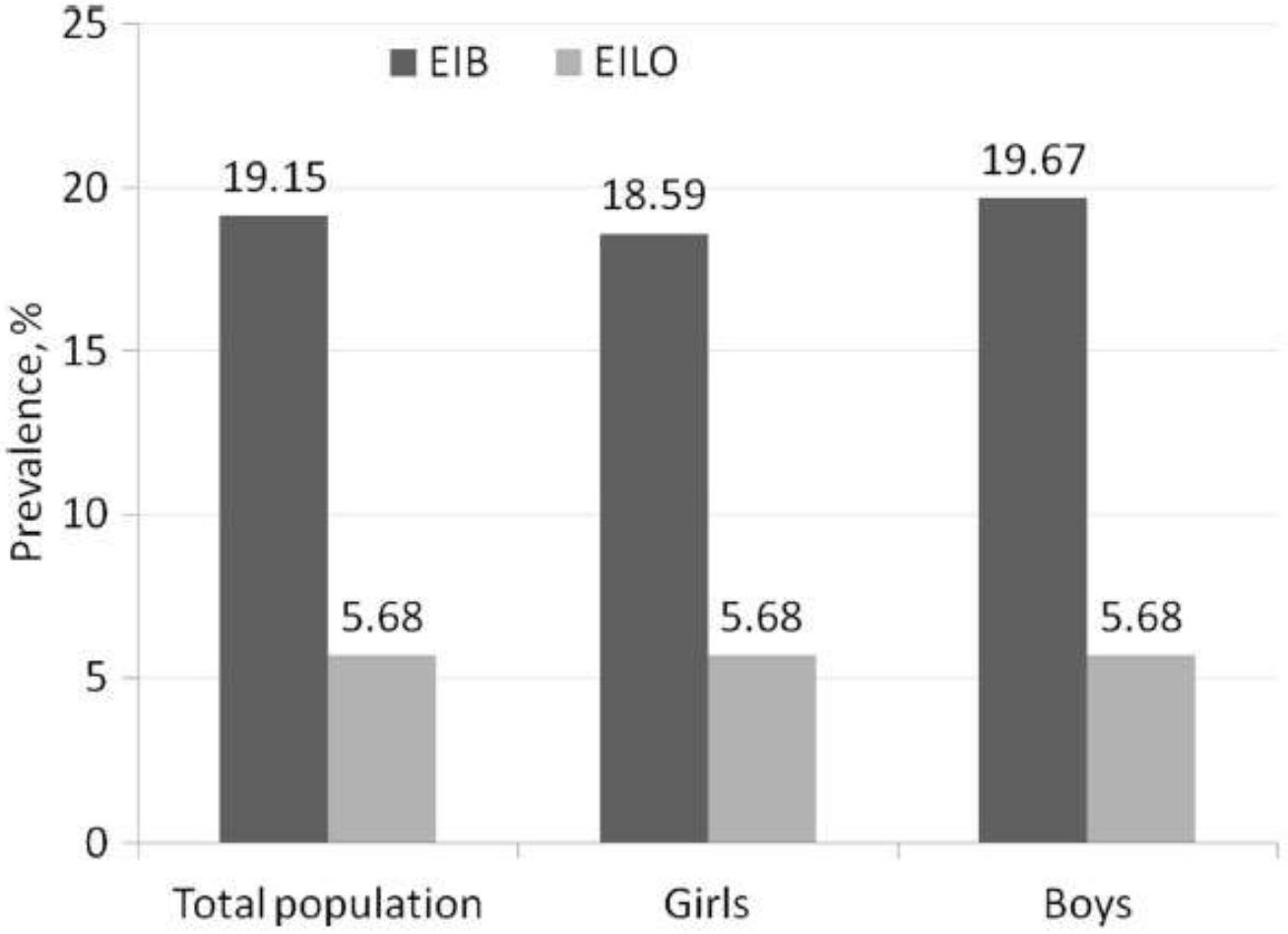
- The prevalence of EILO in adolescents and young adults appears to be in the range of 5–7% in northern Europe
- Some report a higher female prevalence (mainly adolescents)
- In a study of 94 patients diagnosed using the CLE test, average age was ~15 years, and 68% were female, similar to other adolescent groups
- Our experience: 20 patients, 15.8 y/o, range 10-20 years

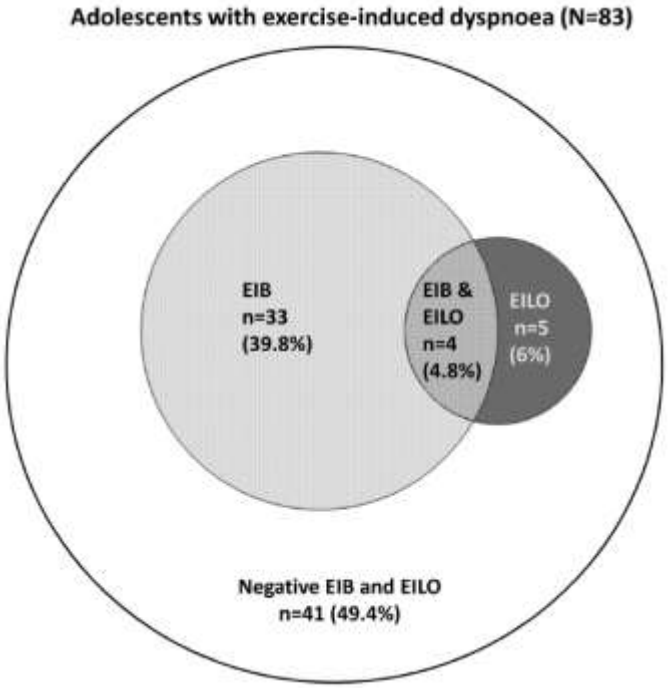
CLE - Continuous Laryngoscopy during Exercise

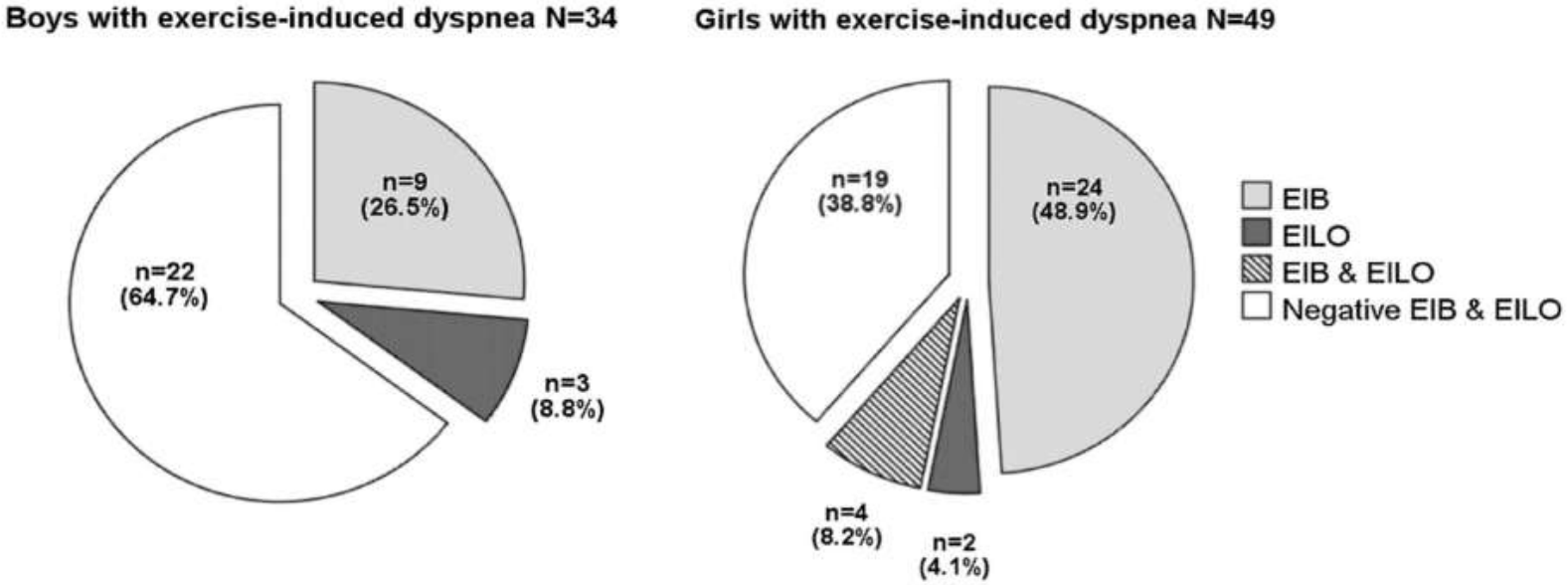
Eur Respir J 2017; 50: 1602221

Prevalence of exercise-induced bronchoconstriction and exercise-induced laryngeal obstruction in a general adolescent population

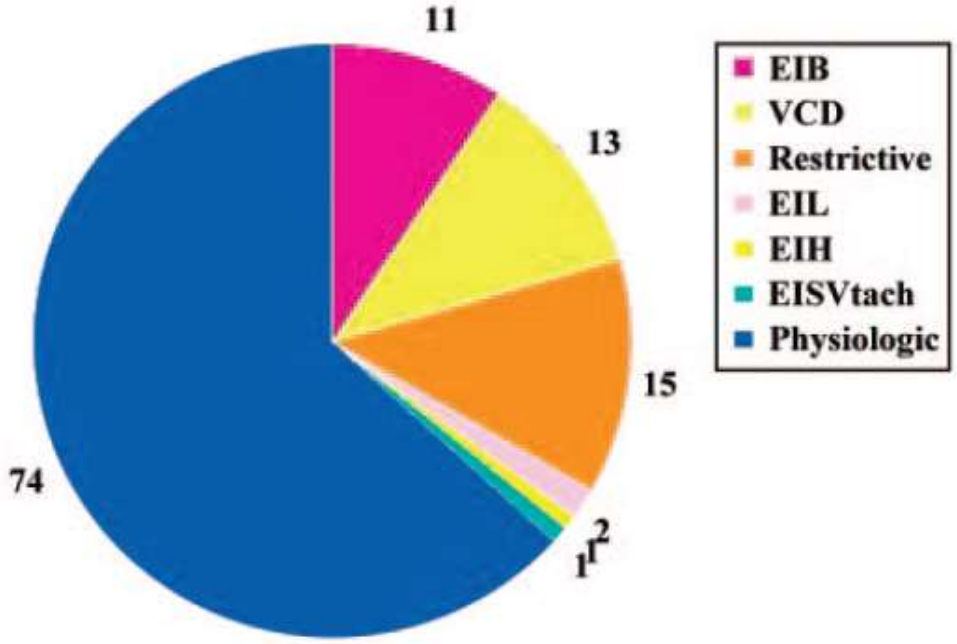
Johansson H, *et al*. *Thorax* 2015;**70**:57–63.







Johansson H, *et al. Thorax* 2015;**70**:57–63.



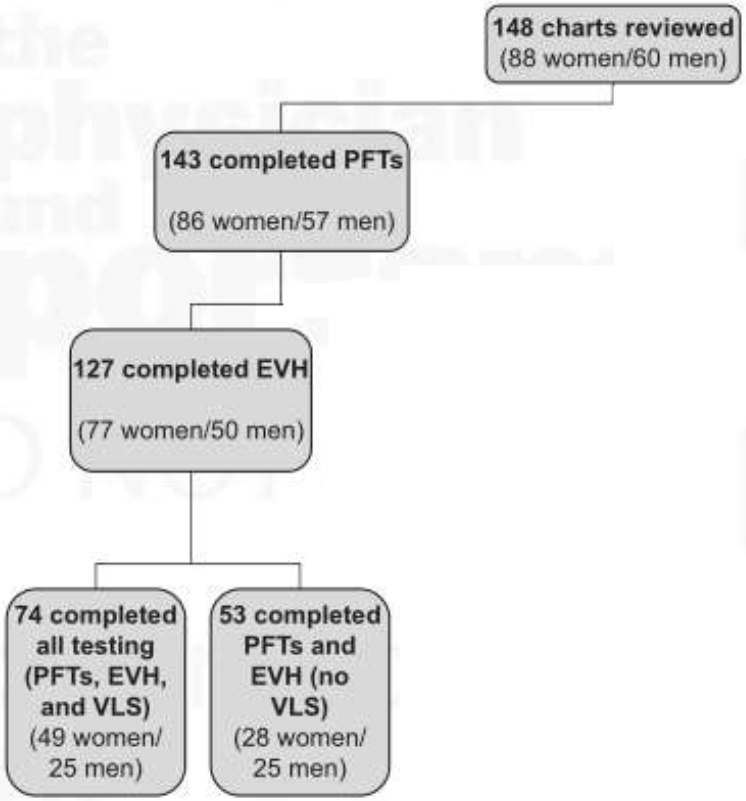
- 142 children and adolescents with EID (age range: 6–21 yrs)
- Although all had EID, 41 (29%) reported dyspnea only with competitive athletic activity
- ~70% had been previously diagnosed with and treated for asthma without clinical response
- Symptoms of EID were reproduced during exercise testing in 117 patients
- EIA was identified as the cause of EID in only 11/117

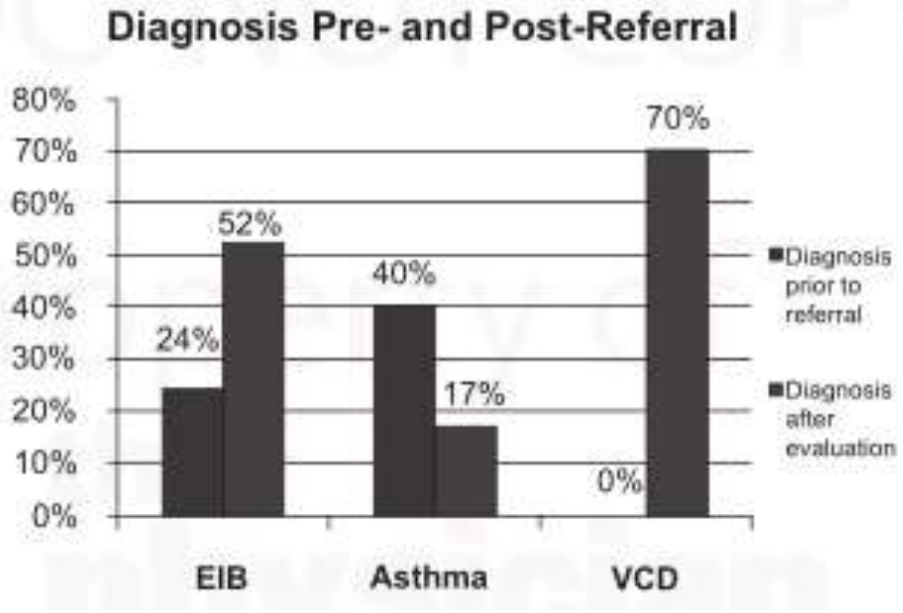
Ann Allergy Asthma Immunol. 2005;94:366–371.

Phys Sportsmed. 2012 May;40(2):28-33. doi: 10.3810/psm.2012.05.1962.

Etiology of dyspnea in elite and recreational athletes.

Hanks CD[1], Parsons J, Benninger C, Kaeding C, Best TM, Phillips G, Mastronarde JG.





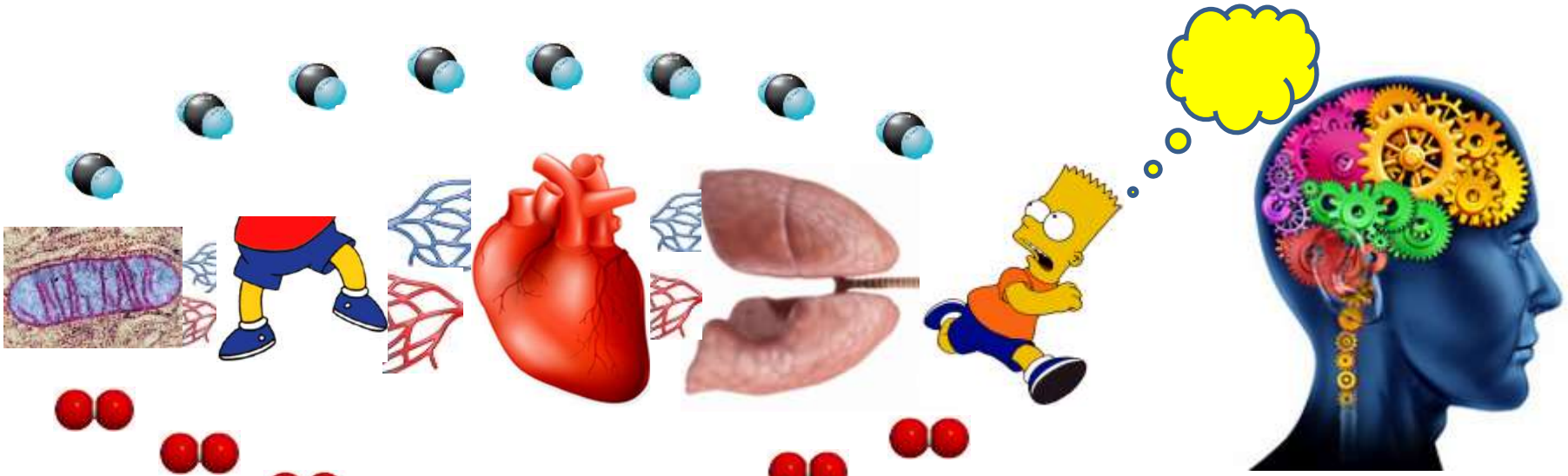
Abbreviations: EVH, eucapnic voluntary hyperventilation; PFT, pulmonary function testing; VLS, videolaryngostr

Authors [reference]	Year	Population	Design	Findings
Hira and Singh [46]	2009	n=51 Patients referred to tertiary centre for treatment-refractory asthma	Cross-sectional	24% had VCD Age 32.9±12.4 years 58% female IOS-positive in 58% of cases and 15% of controls
Røksund *et al.* [2]	2009	n=151 cases and n=20 controls Patients with exertional dyspnoea consecutively referred to a tertiary clinic	Cross-sectional	75% had EILO Age 16.3±7.3 years 72% female Detailed description of laryngoscopic presentations
Christensen *et al.* [21]	2011	n=98 (n=556 invited to participate) General population	Cross-sectional	43% had EILO Age 19 (14–24) years
Nielsen *et al.* [6]	2013	n=88 Athletes referred to CLE in a tertiary asthma clinic	Case series	35% had EILO Median (IQR) age 18 (11) years 77% female 43% had verified asthma
Tilles *et al.* [103]	2013	n=143 Patients with EILO confirmed by post-exercise laryngoscopy	Case series	All EILO-positive (by design) n=83 glottic (84% female); age 14±2.6 years n=60 supraglottic (77% female); age 14±2.3 years
Marcinow *et al.* [104]	2014	n=46 Elite athletes and age- and sex-matched non-athletes, both with verified PVFMD	Case–control	All PVFMD-positive (by design) Age 21 (18–69) years 70% female 39% had verified asthma
Hanks *et al.* [105]	2012	n=148 Athletes referred to a tertiary asthma clinic for evaluation of exertional dyspnoea	Cross-sectional	70% of tested (n=82) had VCD Median age 19 years 73% female 31% of VCD-positive subjects had verified EIB 6% had verified asthma
Johansson *et al.* [3]	2015	n=125 (n=2309 screened) General population with exertional dyspnoea	Cross-sectional	11% of cases and 4% of controls had EILO Mean (range) age 14.2 (13–15) years Estimated prevalence of EILO in

Etiology

- Mechanical insufficiency - laxity of muscles, ligaments or the laryngeal cartilages + high flow
- Neural dysfunction (reflex-associated VCD) - direct stimulation of sensory nerve endings in the respiratory tract may induce a protective reflex, triggering laryngeal closure
- Psychological contribution - physical manifestation of underlying psychological problems
- Comorbidities
  - Asthma
  - Reflux
  - Nasal disease (sinusitis)

Cardiopulmonary and beyond



History and Physical Examination Clues

- Specific Dyspnea complaints

- Dyspnea on rest?
- When did it first appear?
- When does it start after the beginning of exercise?
- Duration?
- What ameliorate/deteriorate?
- Effect duration of exercise?
- Co-complaints?
- Repetitively?
- Training vs. competition
- Treatment?
- Specific work up?

Physical examination

- Resting physical examination findings are not highly specific for EILO

Continuous Laryngoscopy during Exercise (CLE)

- EILO commonly arises from:
  - Supraglottic (i.e. aryepiglottic fold) obstruction
  - May be a pure glottic (i.e. VCD) phenomenon, or
  - Both

- The relationship between laboratory EILO and EILO "in the field" is yet to be studied
  - anecdotally, many athletes report heightened symptoms in the competitive environment

Exercise-induced laryngomalacia - EIL

Normal
Mid-Inspiratory Glottis

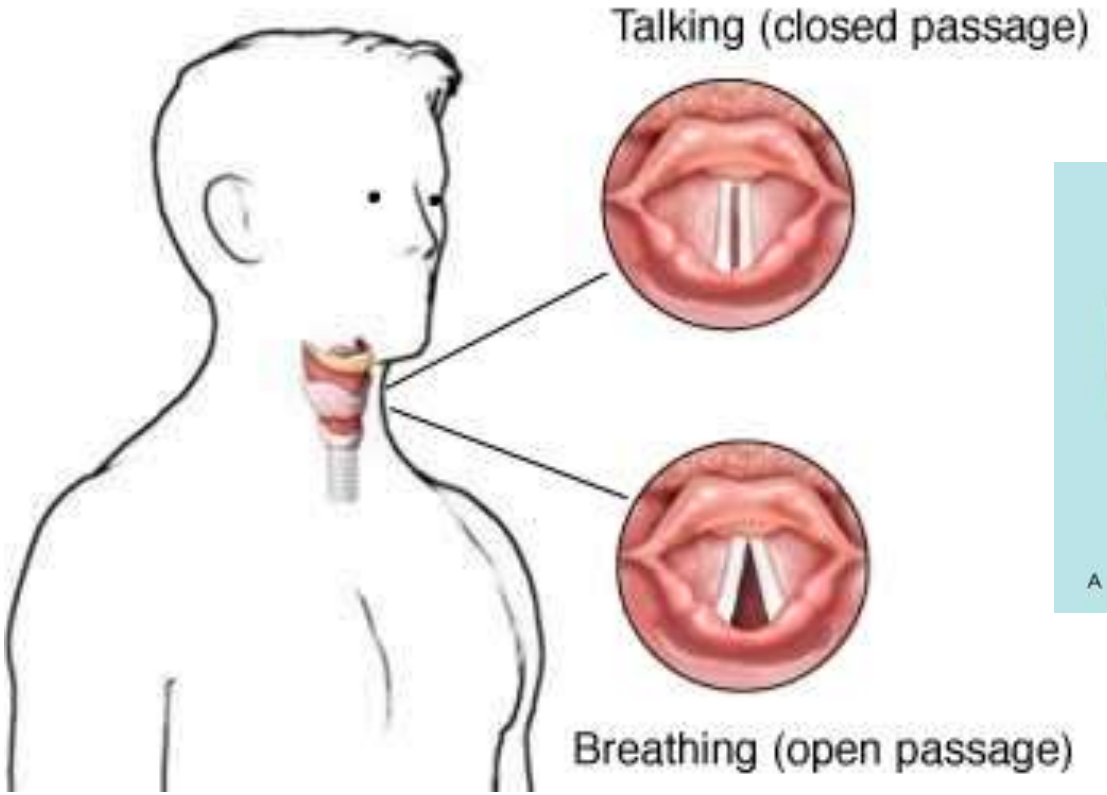
Mid-Inspiratory Prolapse
of Periglottic Structures
into Glottic Airway

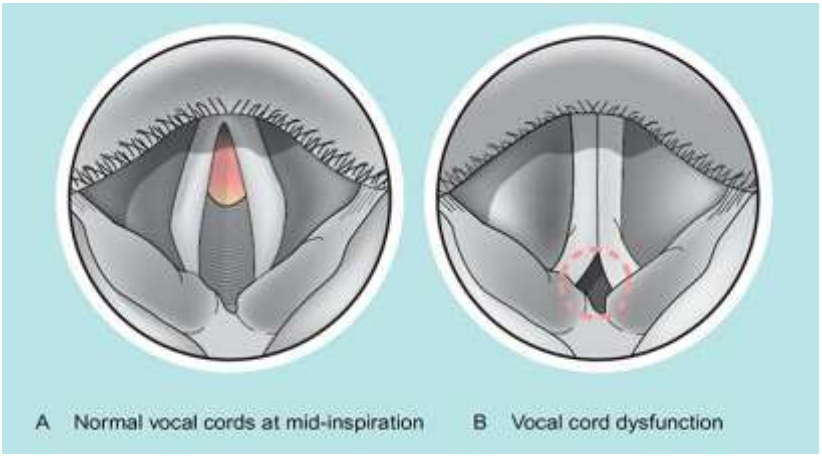
Vocal Cord Dysfunction (VCD)

- Vocal cords (voice box) do not open correctly
- Also referred to as “paradoxical vocal fold movement”
- Abnormal adduction of the vocal cords during the respiratory cycle (especially during the inspiratory phase)
- Produces airflow obstruction at the level of the larynx

Vocal Cord Dysfunction - VCD

Normal





EILO - Clinical manifestation

Symptoms

- Acute episodic / dramatic
  - Dyspnea/Difficulty breathing (73%)
  - Wheezing (36%)
  - Stridor (28%)
  - Chest tightness (25%)
  - Throat tightness (22%)
  - Voice changes/Hoarse voice (12%)
  - Cough
  - Aggravated by emotion
  - Pallor, lightheadedness, and paresthesias may occur

- Onset and resolution are typically abrupt

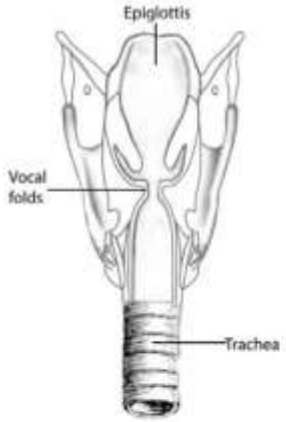
EILO - Clinical manifestation

- Hypoxemia and cyanosis are rare in cases of exercise-ILO (and should lead to other diagnostic considerations)

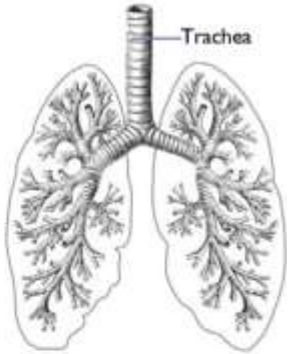
EILO vs. asthma

- EILO sometimes confused with asthma
- Asthma + EILO → up to 50%
- Treatment approach for EILO is very different than treatments used to manage and control asthma

EILO vs. EIB



EIIS		EIB
Inspiratory		Expiratory
Peaks at peak exercise		Peaks after exercise
Stops 1-5 min after exercise		Peaks 3-15 min after exercise



Refractory period	No	Yes

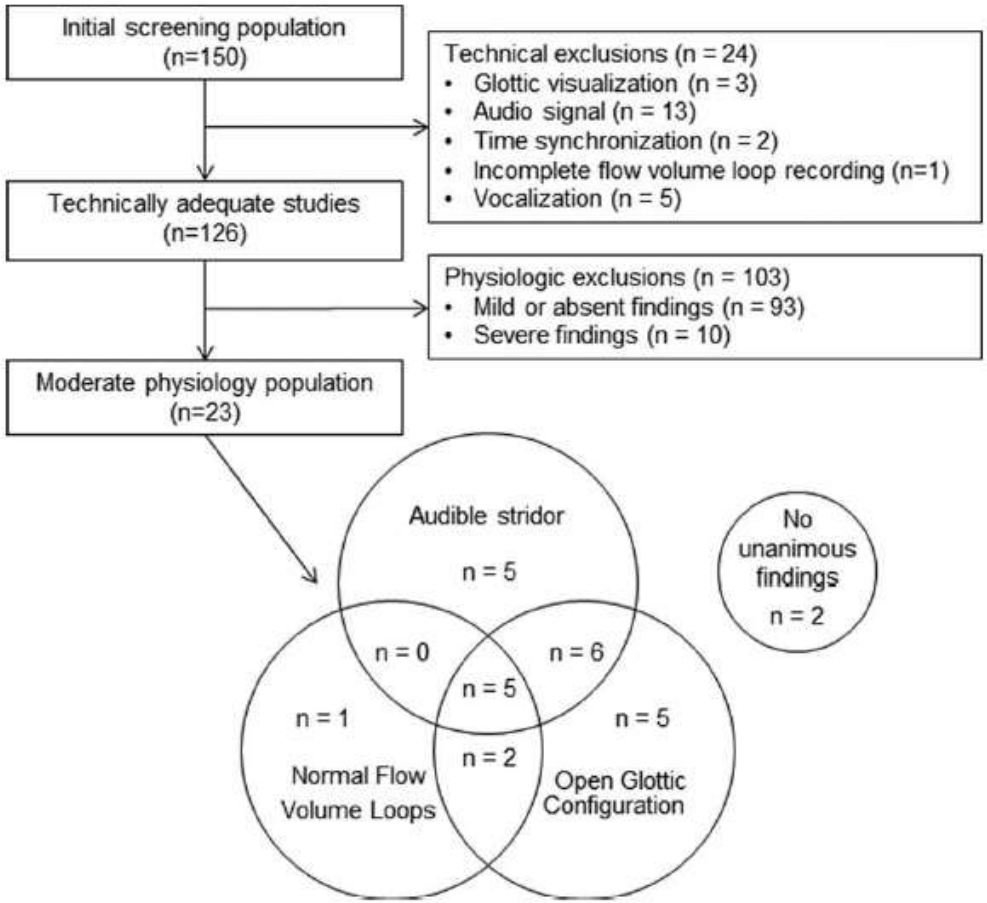
Diagnostic evaluation

- Diagnosed via a combination of:
  - Clinical history
  - Pulmonary function testing
  - Laryngoscopic visualization

- PFTs : blunting of inspiratory parts of the loop
  - ✓ **Repeatability is poor**
  - ✓ **Low sensitivity and specificity**
  - ✓ **Most common cause is suboptimal effort**
  - ✓ **No consensus over cutoffs**

The Laryngoscope

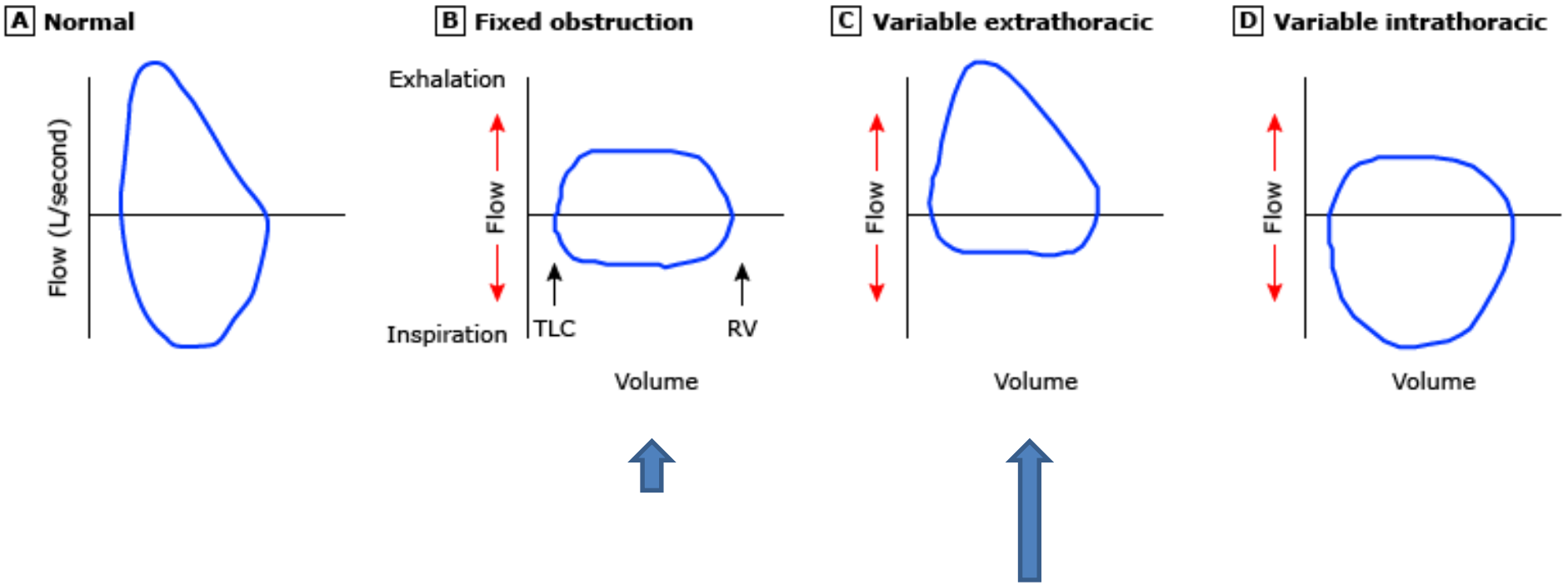
Glottic Configuration in Patients With Exercise-Induced Stridor: A New Paradigm

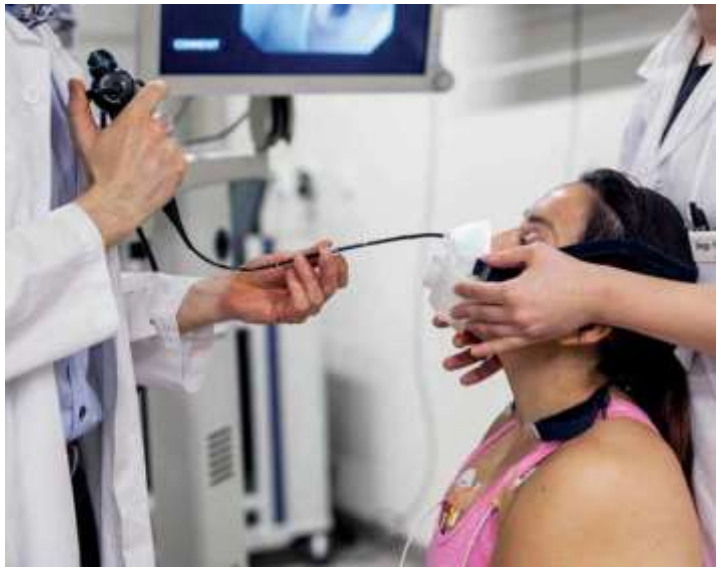


VCD – Diagnosis

- Spirometry during exercise (flow volume loop) or post (while still symptomatic)
- Flexible fiberoptic laryngoscopy in patients who showed signs of upper airway obstruction (stridor and/or flattening of the inspiratory portion of the flow-volume loop) during exercise testing
- Can't control with asthma therapy (as bronchodilators)

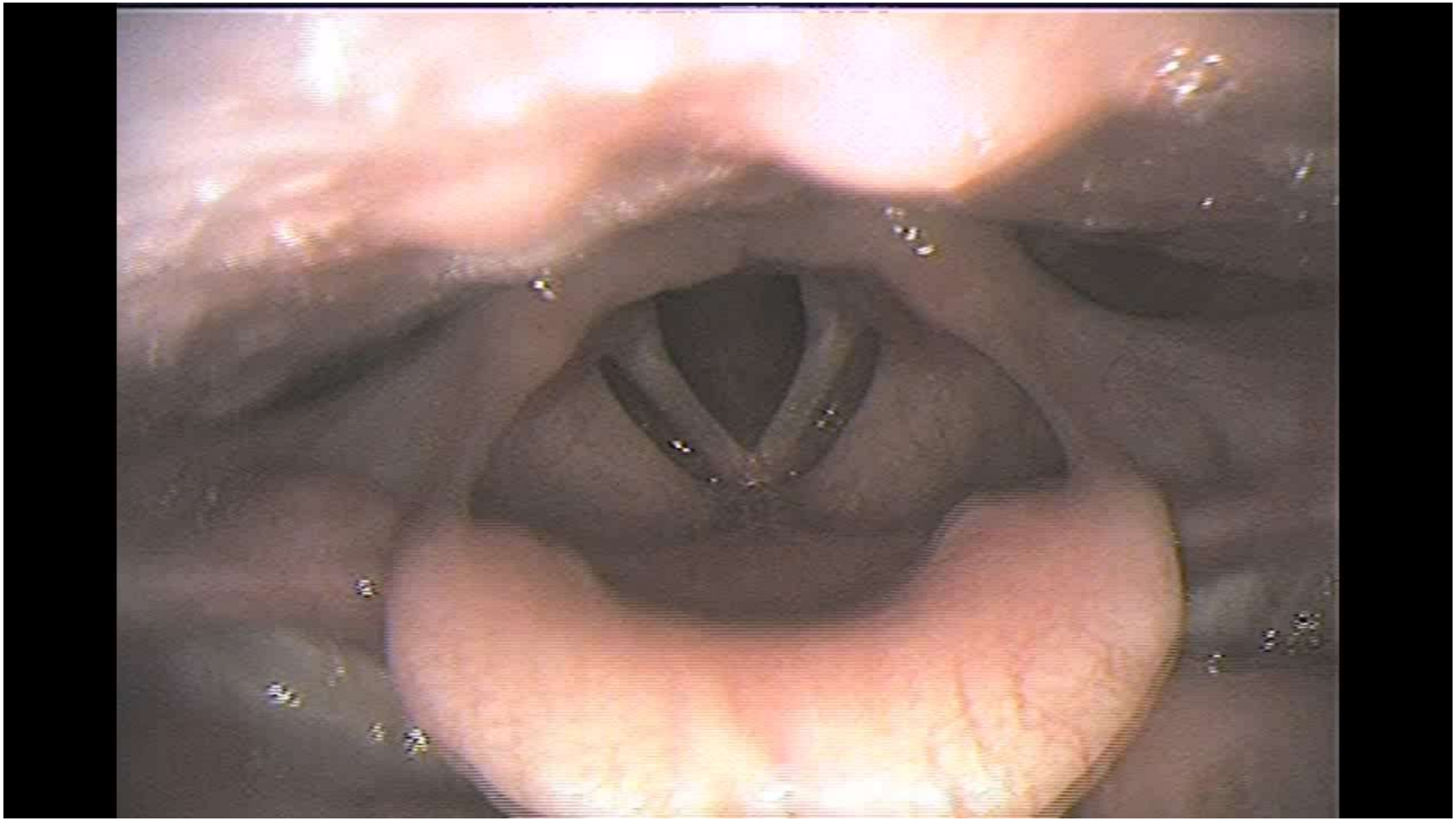
Spirometry

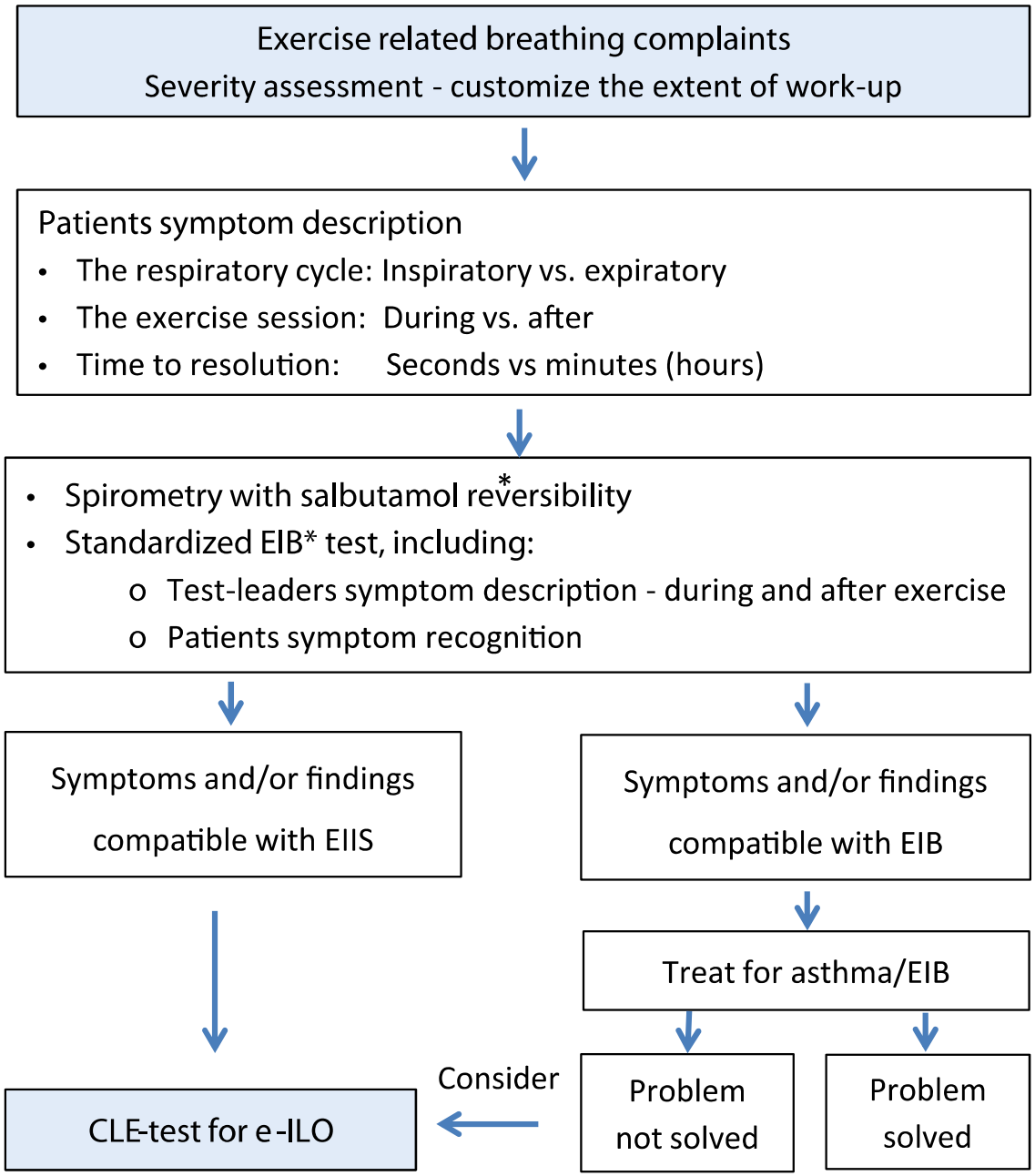

A Normal
Flow (L/second)
B Fixed obstruction
Exhalation
Flow
Inspiration
TLC
RV
Volume
C Variable extrathoracic
Flow
Volume
D Variable intrathoracic
Flow
Volume



Exercise laryngoscopy

Exercise laryngoscopy




Exercise related breathing complaints
Severity assessment - customize the extent of work-up
Patients symptom description
• The respiratory cycle: Inspiratory vs. expiratory
• The exercise session: During vs. after
• Time to resolution: Seconds vs minutes (hours)
• Spirometry with salbutamol reversibility*
• Standardized EIB* test, including:
o Test-leaders symptom description - during and after exercise
o Patients symptom recognition
Symptoms and/or findings compatible with EIIS
Symptoms and/or findings compatible with EIB
Treat for asthma/EIB
Problem not solved
Problem solved
Consider
CLE-test for e-ILO

EILO - Treatment

Non pharmacologic:

- ✓ Activities that relax the throat muscles :
  - Reassurance and education
  - Speech and voice therapy
  - Deep breathing techniques
  - Inspiratory muscle training
  - Hypnosis
  - Psychotherapy
  - Biofeedback

Combination!

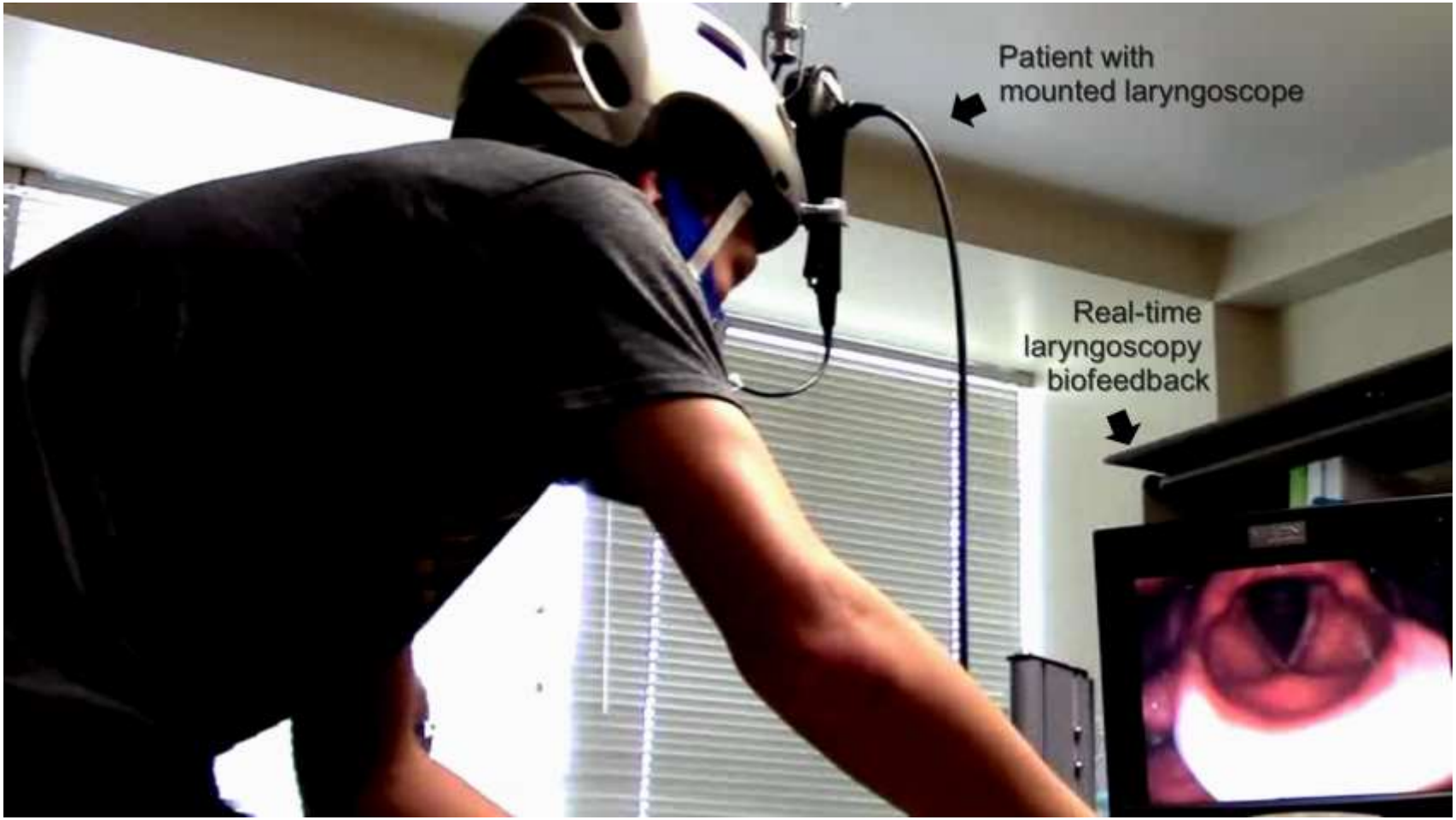
Pharmacological:

- ✓ Botox
- ✓ Topical lidocaine
- ✓ Low-dose tricyclic antidepressants (amitriptyline) for night sedation
- ✓ Managing co-factors as asthma, allergies or GERD

Surgical:

- ✓ Laser supraglottoplasty has been used to treat patients with severe supraglottic EILO

Exercise laryngoscopy - Biofeedback



Olin et al. Pediatric Pulmonology 52:813–819 (2017)

Therapeutic Laryngoscopy During Exercise: A Novel Non-Surgical Therapy for Refractory EILO

TABLE 1—Demographics of Participant Respondents

Age (years, SD)	17 (±3.5)
Gender (female, %)	28 (78%)
Race and ethnicity	
Causasian non-Hispanic (n, %)	33 (92%)
Causasian Hispanic (n, %)	3 (8%)
African-American (n, %)	0 (0%)
Asian (n, %)	0 (0%)
Athletic level	
Recreational (n, %)	1 (3%)
Competitive below junior varsity level (n, %)	6 (17%)
Junior varsity (n, %)	1 (3%)
Varsity (n, %)	19 (53%)
Collegiate (n, %)	8 (22%)
Professional (n, %)	1 (3%)

Olin et al. Pediatric Pulmonology 52:813–819 (2017)

Clinical Benefit

TABLE 2—Patient Perceived Procedural Success Regarding Safety and Tolerability, Educational Value, and Effectiveness

Group	n	Safe and tolerable (%)	Educational benefit (%)	Clinical benefit (%)
Overall	36	81	78	58
Age				
14 years and younger	7	29	43	43
Greater than 14	29	93	86	62
Gender				
Male	8	88	75	50
Female	28	79	79	61
Athletic level				
Junior varsity and below	8	63	75	38
Varsity and above	28	86	79	64
Number of procedures				
1	22	77	68	46
Greater than 1	14	86	93	79
Procedure timing				
Earliest patients	19	79	79	53
Later patients	17	82	77	65

TABLE 3—Observer Perceived

Clinical benefit (%)
80
56
89
70
84
67
87
77
83
80
80

Olin et al. Pediatric Pulmonology 52:813–819 (2017)

Conclusion

- Common
- Should be included in any exertional complains D/d (EILO vs. EIB)
- Diagnosis: history, CLE
- Treatment: M/P combination
- Referral center: Exercise center, ENT, pediatric pulmonology unit, speech therapy?

PERC
UC Irvine

רות
בית חולים רות רפפורט לילדים
רמב"ם-הקריה הרפואית לבריאות האדם

12 Exercise and Lung Function in Child Health and Disease

DAN M. COOPER, MD, RONEN BAR-YOSEPH, MD, TOD OLIN, MD, and SHLOMIT RADOM-AIZIK, PhD

The Biological Importance of Physical Activity in the Growing Child

Exercise in children and adolescents is not merely play, b is an essential component of growth and development. Children are among the most spontaneously physically acti human beings.[4] It is not surprising that habitual physic activity (HPA) is a major determinant of health across tl lifespan and health-related quality of life in both healtl children and in children with chronic diseases.[5–8] Despi

Exercise and Laryngeal Obstruction

Exercise-induced laryngeal obstruction (E-ILO) is the preferred term based on a recent international multispecialty consensus document, describing the condition in which glottic or supraglottic structures inappropriately obstruct the larynx during exercise, "causing breathing problems."[324] This condition was formerly known under the umbrella terms of vocal cord dysfunction and paradoxical vocal fold motion, and was first described in the modern literature in 1983.[325] It was recognized as a cause of adolescent exertional dyspnea in 1984 and later famously described as a cause of "choking during athletic activities."[326,327]

תודות!!

תודות!!