The Value of Exercise in the Cystic Fibrosis Clinic

Dr Patrick J Oades
Participation in physical activity on a regular basis has important health benefits.

In healthy adults at least 150 minutes of physical activity each week (moderate-vigorous intensity)

**Improves:**
- Cardio-respiratory fitness
- Bone health

**Reducing the risk of non-communicable diseases:**
- Obesity
- Heart disease
- Depression
Exercise performance

- Lung function
- Inflammation
- Nutrition
- BMI
- Body composition
- Hb
- Cardiovascular health
- Age, sex & Ht
- Genetic factors
- Self image & self esteem
- Motivation
- Effort
- Training

QoL
Peripheral circulation:
- CO₂ production
- Creatine – PO₄
- Pyr – lac
- O₂ consumption

MUSCLE

Pulmonary circulation:
- O₂ flow
- CO₂ flow

HEART AND BLOOD

Expired
- VCO₂
- VO₂

LUNGS

- CAD
- Heart failure
- Other HD
- Anemia

- Obstructive
- Restrictive
- Infiltrative
- Chest wall

- Occlusive
- Autonomic dysfunction

- PPH
- Thromboembolic
- 1° and 2° PVD

Energy
Manifestations of Cystic Fibrosis

General
- Growth failure (malabsorption)
- Vitamin deficiency states (vitamins A, D, E, K)

Nose and sinuses
- Nasal polyps
- Sinusitis

Liver
- Hepatic steatosis
- Portal hypertension

Gallbladder
- Biliary cirrhosis
- Neonatal obstructive jaundice
- Cholelithiasis

Bone
- Hypertrophic osteoarthropathy
  - Clubbing
- Arthritis
- Osteoporosis

Intestines
- Meconium ileus
- Meconium peritonitis
- Rectal prolapse
- Intussusception
- Volvulus
- Fibrosing colonopathy (strictures)
- Appendicitis
- Intestinal atresia
- Distal intestinal obstruction syndrome
- Inguinal hernia

Lungs
- Bronchiectasis
- Bronchitis
- Bronchiolitis
- Pneumonia
- Atelectasis
- Hemothysis
- Pneumothorax
- Reactive airway disease
- Cor pulmonale
- Respiratory failure
- Mucoid impaction of the bronchi
- Allergic bronchopulmonary aspergillosis

Heart
- Right ventricular hypertrophy
- Pulmonary artery dilation

Spleen
- Hypersplenism

Stomach
- GERD

Pancreas
- Pancreatitis
- Insulin deficiency
- Symptomatic hyperglycemia
- Diabetes

Reproductive
- Infertility
  (aspermia, Absence of vas deferens)
- Amenorrhea
- Delayed puberty
Cystic fibrosis

CFTR gene (7q31.2)

Chromosome 7

Autosomal Recessive Inheritance
Cystic Fibrosis

- Thick, sticky mucus blocks airway
- Thick, sticky mucus blocks pancreatic and bile ducts
- CFTR gene
- Chromosome 7

**FIGURA 1**

- Hígado Normal
- Hígado con Cicatrices (Fibrosis)
- Cirrosis
Malabsorption
Poor appetite when unwell
High energy demands of infection.
Intrinsic energy wasting defect.
Diabetes.
Eating disorders.

Pancreatic enzymes
High energy diet
Supplements
Insulin

POOR NUTRITION

GOOD NUTRITION
POOR NUTRITION

GOOD NUTRITION

BODY COMPOSITION
LBM - strength
BMD
Adequate adiposity
Energy stores
Growth / Puberty

EXERCISE
Treatment:
Benefits of exercise on lung disease in CF

- ↑Airway clearence (↑ ventilatory flows, ↓ sputum viscosity, vibration & impact).
- ↑ lung function / slows the rate of decline.
- ↓ Exacerbation rate and hospitalisations
- ↓ Reduced mortality
- ↑ Functional capacity
- ↑ QoL / self esteem

**NEED TO PERFORM AIRWAY CLEARENCE TOO!** Pausing for huff or coughing.

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Effects of exercise on respiratory flow and sputum properties in patients with CF. *Dwyer et al, Chest 2011;139:870.*
Quality of life is associated with physical activity and fitness in CF. *Hebestreit et al. BMC Pulm Med. 2014;14:26.*
Physical training for cystic fibrosis.

- Improves aerobic capacity (VO2max)
  
  *Gruber W et al. Eur Respir J. 2011;38:1336–1342.*

- Improves strength, lean body mass and self concept.
  

*Bradley JM, Moran F. Cochrane Database of Systematic Reviews 2008.*

Regular physical activity may:

- Diminish dyspnoea
- Improve exercise tolerance.

Exerts a positive influence on:

- Bone mineral accretion
- Blood glucose regulation
- Posture
- Appetite
Other considerations

• Nutritional support: fluid, energy & salt intake.
• Infection control - cross-infection risk,
  – Patients must be segregated from their CF peers
  – Advised not to socialise or exercise together in rehabilitation programs.
  – Testing equipment sterile/environment.
• Psychological support, dealing with limitations
As perception of illness severity ↑:
• Participation in exercise decreases.
• Patients describe ↓ importance & ↑ burden of exercise activities when compared to other therapies.


Adherence to prescribed exercise programs reported at around 50%.

EXERCISE TREATMENT

Training format and frequency? – Influences the pattern observed in outcomes.

Individualised (gender, age, maturity, interests)
Variety (to maintain interest)
Reinforced – Trainer.
Cost (time and money).
Adherence?
Sustainable?

Pull back intensity during exacerbations.
Lifelong regular physical activity should be part of daily care.
Recommendations:

**Habitual activity:** children 60min/day; adult 150- 300 min/week

**Aerobic exercise** - prescribe (7+) at an intensity relative to max aerobic capacity.
Children: 30- 60 min/day, moderate/vigorous devel. appropriate activity.
Adults: 30-60 min/day of moderate/vigorous activity.

**Resistance training** prescribe (13+) relative to max strength.
Repetitive bouts 2-3x/week.
Avoid Valsalva and other breath-holding patterns.

**Considerations:**
- Rest / Posture / Joint flexibility
- Drugs & co-morbidities (severe impairment of lung function, hypoxaemia, post transplant, recent haemoptysis / PnTx, pregnancy, low BMI, CFRD, low BMD).
- Risks (Injury/arrhythmias/hypoglycaemia/pneumothorax), all very rare
Habitual Activity

Aerobic Endurance Training
Interval training (Higher intensity with rest periods)

Strengthening Training.

Variety

ADULTS CONCURRENT ACTIVITY

OMUSCLE BULK

VO2max

% BODY FAT

CHILD’S PLAY

MUSCLE BULK

ALL ACTIVITY UNDERPINNED WITH:

• NUTRITION SUPPORT (inc. FLUID INTAKE AND NaCl)
• MAINTENANCE OF FLEXIBILITY, ESPECIALLY IN OLDER GROUPS

↓ TIME & ↑ VARIETY AIDS ADHERENCE

*DECLINES WITH AGE BUT THE MORE THE BETTER

THE ROLE OF EXERCISE AND PHYSICAL ACTIVITY IN OPTIMISING OUTCOMES AMONG PATIENTS WITH CF.

TESTING

USUAL
Ht & Wt, BMI
SaO2
FEV1
Symptoms
Signs
Respiratory microbiology
SOMETIMES
CXR
HRCT
Bronchoscopy

Measures of Exercise Performance?

Detailed, objective measures of physiological health. STANDARDISATION
‘OUTCOMES’ used for
1. Monitoring
2. Response to intervention
What more does exercise testing tell us?

Lung function and exercise tests monitor different aspects of the disease. Poor relationship between these two tests, especially in mild/mod disease. Peak oxygen uptake (Vo2peak) and forced expiratory volume in 1 s (FEV1) are independent predictors of mortality in CF.


**ATS/ACCP Statement on cardiopulmonary exercise testing.**  
‘The use of CPET in patient management is increasing with the understanding that resting pulmonary and cardiac function testing cannot reliably predict exercise performance and functional capacity and that, overall, health status correlates better with exercise tolerance rather than resting measurements’.
International multi-disciplinary consensus endorsed by ERS & ECFS.

Testing evaluates physical limitation and explores exercise related symptoms.

Gold standard is an incremental test to measure:

- SaO2,
- Ventilatory gas exchange,
- VO2max
- max WR

Exercise capacity – prognosis / QoL

Cycle Ergometer - Godfrey Protocol.

Field tests (6 min walk, 3 min step, SWT) – cheaper set up, much less info.
**Why use CPET?**

### ECG treadmill
- Ischemia/12-lead ECG
- Heart rate/HRR
- Blood pressure, double product
- Estimate of METs
- Symptoms/reason for stopping

### CPET
- Ischemia/12-lead ECG
- Heart rate/HRR
- Blood pressure, double product
- Measured work rate
- Symptoms/ reason for stopping
- Oxygen saturation
- **Maximal oxygen uptake (VO₂ max)**
- **Lactic acidosis threshold**
- Carbon dioxide output (VCO₂)
- Minute ventilation (V̇E), TV, RR/BR
- Ventilatory equivalents (V̇E/V̇CO₂, V̇E/V̇O₂)
- VO₂/ work rate relationship (ΔVO₂/ΔWR)
- O₂ pulse (SV x C(a-v)O₂ difference)
- Respiratory exchange ratio
- End tidal O₂, CO₂
- Blood gases/COHb
- Vd/Vt
  - P(A-a)O₂ → low V̇A/Q
  - P(a-ET)CO₂ → high V̇A/Q
- Expiratory flow pattern
Table 2
Patients’ physiological responses to CPET during the three visits.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximal exercise parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \dot{V}O_2^{\max} ) (L·min(^{-1}))</td>
<td>13</td>
<td>1.77 (0.57)</td>
<td>1.76 (0.56)</td>
<td>1.68 (0.55)</td>
</tr>
<tr>
<td>( HR_{\text{peak}} ) (b·min(^{-1}))</td>
<td>11</td>
<td>190 (12)</td>
<td>186 (14)</td>
<td>186 (19)</td>
</tr>
<tr>
<td>( \text{SaO}_2 ) (%)</td>
<td>13</td>
<td>95 (3)</td>
<td>96 (1)</td>
<td>96 (3)</td>
</tr>
<tr>
<td>( \text{RPE} )</td>
<td>13</td>
<td>9 (2)</td>
<td>9 (2)</td>
<td>9 (1)</td>
</tr>
<tr>
<td>( \text{RPD} )</td>
<td>13</td>
<td>7 (2)</td>
<td>6 (3)</td>
<td>8 (3)</td>
</tr>
<tr>
<td>Ramp peak power output (W)</td>
<td>13</td>
<td>157 (55)</td>
<td>148 (62)</td>
<td>145 (65)</td>
</tr>
<tr>
<td><strong>Submaximal parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{GET} ) (L·min(^{-1}))</td>
<td>12</td>
<td>1.00 (0.22)</td>
<td>0.93 (0.21)</td>
<td>1.05 (0.29)</td>
</tr>
<tr>
<td>( \text{MRT} ) (s)</td>
<td>11</td>
<td>42 (15)</td>
<td>65 (17)</td>
<td>54 (26)</td>
</tr>
<tr>
<td>( \dot{V}O_2 ) gain (mL·min(^{-1}·W^{-1}))</td>
<td>12</td>
<td>8.01 (1.36)</td>
<td>8.11 (1.22)</td>
<td>7.73 (2.64)</td>
</tr>
<tr>
<td>( \text{OUES}_{100} ) (mL·min(^{-1}·\log L^{-1}))</td>
<td>12</td>
<td>803 (227)</td>
<td>789 (181)</td>
<td>799 (218)</td>
</tr>
<tr>
<td>( \text{OUES}_{\text{GET}} ) (mL·min(^{-1}·\log L^{-1}))</td>
<td>12</td>
<td>797 (223)</td>
<td>730 (188)</td>
<td>756 (389)</td>
</tr>
<tr>
<td>( \dot{V}_E/\dot{V}CO_2) slope</td>
<td>12</td>
<td>34.13 (4.51)</td>
<td>33.26 (3.25)</td>
<td>32.14 (5.39)</td>
</tr>
<tr>
<td>( \dot{V}_E/\dot{V}O_2 ) at the \text{GET}</td>
<td>12</td>
<td>28.57 (5.45)</td>
<td>28.63 (3.84)</td>
<td>28.09 (4.58)</td>
</tr>
<tr>
<td>( \dot{V}_E/\dot{V}CO_2 ) at the \text{GET}</td>
<td>12</td>
<td>28.07 (3.96)</td>
<td>29.15 (5.43)</td>
<td>27.95 (5.51)</td>
</tr>
</tbody>
</table>

Values are means ± SD, with the range also displayed unless otherwise stated. \( \dot{V}O_2^{\max} \), maximal oxygen uptake; \( HR_{\text{peak}} \), peak heart rate; \( \text{SaO}_2 \%), arterial oxygen saturation; \( \text{RPE} \), end-exercise rating of perceived exertion; \( \text{RPD} \), end-exercise rating of perceived dyspnoea; ramp; incremental ramp test; \( \text{GET} \), non-invasive estimate of the lactate threshold which was verified by the ventilatory threshold; \( \text{MRT} \), mean response time; \( \dot{V}O_2 \) gain, oxygen cost of exercise; \( \text{OUES}_{100} \), oxygen uptake efficiency slope for the entire duration of the ramp test; \( \text{OUES}_{\text{GET}} \), \( \text{OUES} \) to the \( \text{GET} \); \( \dot{V}_E/\dot{V}CO_2 \)-slope, ventilatory drive; \( \dot{V}_E/\dot{V}O_2 \), ventilatory equivalent for oxygen uptake; \( \dot{V}_E/\dot{V}CO_2 \), ventilatory equivalent for carbon dioxide.
VO$_2$ peak and VO$_2$ peak recovery profile during and following maximal exercise in a young CF patient and control.
Peak VO₂: high > 45, medium = 32–45, low < 32

Cumulative survival

Time (months)

28 patients (8-17 yrs) Maximal ETT

Pianosi, P et al. Thorax 2005;60:50-54
Demonstrated CPET as part of annual review in children aged >7 years is feasible

In mild disease, there is no significant correlation between Vo2peak and FEV1 or body mass index.

A decline in fitness can be used as a trigger for more intensive physiotherapy intervention.
Conclusions: Exercise in CF

**TREATMENT**
- Exercise is good.
- Individualised.
- Improves outcomes, QoL & Self esteem.
- Needs nutritional support.

**TESTS**
- Need Standardisation
- Tell us additional information (to FEV1 and imaging)
- CPET measures are an independent prognostic indicator.
- Will be useful in monitoring and determining response to intervention.
Questions?

SO WE NEED YOU!

FRONT LINE ENGLISH VILLAGE
EDITED BY ARTHUR WILSON M.A.

WALMINGTON-ON-SEA
WANTS YOU
Motivation, Maintenance?

- One-off one-to-one counselling or advice.
- Self-directed or unsupervised participation in a prescribed physical activity programme.
- Supervised physical activity session in the home.
- Supervised physical activity session in a facility.
- On-going face-to-face counselling or advice.
- Telephone support.
- Written material.
- **Internet-based or tele-health advice and motivation.**
- Monitoring device for motivation, e.g. pedometer.
OUTCOME MEASURES USED FOLLOWING EXERCISE INTERVENTIONS

1. Exercise capacity (either maximal or submaximal where measured directly or by a standard field test)
2. Pulmonary function tests (change in per cent predicted or absolute measures from baseline, or rate of decline)
   i) forced expiratory volume in one second (FEV1)
   ii) forced vital capacity (FVC)
   iii) forced expiratory flows between 25% and 75% of expired volume (FEF25–75)
3. Adverse outcomes (e.g. musculoskeletal injuries)
4. Body composition in terms of body mass index (BMI) and lean body mass
5. Bone mineral density (defined on dual energy X-ray absorptiometry (DXA) scans)
6. Adherence to the intervention programme
7. Compliance with other CF treatments, e.g. airway clearance techniques and nebulised medication; any measure of compliance such as pill counts, self-report diaries, electronic monitoring
9. Health-related QoL measures (generic +/- disease specific)
10. Cost evaluation
A protocol to determine valid $\text{VO}_2\text{max}$ in young cystic fibrosis patients

Zoe L. Saynor$^{a,b}$, Alan R. Barker$^a$, Patrick J. Oades$^b$, Craig A. Williams$^{b,*}$

$^a$ Children’s Health and Exercise Research Centre, Sport and Health Sciences, University of Exeter, UK
$^b$ Royal Devon and Exeter NHS Foundation Trust Hospital, UK
Interventions for promoting physical activity in people with cystic fibrosis

Narelle S Cox, Jennifer A Alison, Anne E Holland

2011 Cochrane Database Systematic Reviews