

Oxygen uptake efficiency slope is not a valid submaximal measure of aerobic capacity in paediatric cystic fibrosis patients

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Introduction

- Patients with cystic fibrosis (CF) with higher maximal oxygen consumption ($VO_{2\text{ peak}}$) have significantly higher survival rates.¹
- Aerobic fitness testing based on maximal effort - patients with CF may be unable or unwilling to reach volitional exhaustion - submaximal measures could be more practical.²
- Oxygen uptake efficiency slope (OUES) is a submaximal parameter showing the relationship between oxygen uptake (VO_2) and the common logarithm of minute ventilation (Log VE)³
- OUES at 80% duration is valid in adults with CF⁴ but not in a paediatric population as only moderately correlated with $VO_{2\text{ peak}}$ ⁵
- Standardisation of OUES to %duration of the test is flawed as not representative of each individual's exercise intensity relative to their metabolic boundaries.
- Oxygen uptake efficiency (OUE) is the ratio of VO_2 to VE ⁶ other submaximal indicators include gaseous exchange threshold (GET), respiratory compensation point (RCP) and the plateau of highest consecutive values (OUEP).

The aim of the study was to investigate the validity of submaximal exercise measures in the paediatric CF patients.

Methods

- Cardiopulmonary exercise test (CPET) data collected from 79 patients with CF and 31 healthy controls (13.1 ± 2.9 y, 156.0 ± 14.7 cm, 50.6 ± 16.2 kg) was retrospectively analysed.
- OUE was determined at GET and RCP using a 60 s average, and OUEP with a 90 s average. Six of the 79 patients with CF did not have a detectable GET so were not included in any further analyses.
- OUES was calculated at 50%, 75% and 100% of test duration and $VO_{2\text{ peak}}$, GET and RCP. Values standardised for body surface area (BSA).
- Pearson's correlation coefficient was calculated between OUES/BSA measures and $VO_{2\text{ peak}}$ relative to body mass ($\text{mL.kg}^{-1}.\text{min}^{-1}$), and independent t-tests were conducted between CF and healthy groups.

Results

- Descriptive statistics for participants included in the study are shown in Table 1.

Table 1. Characteristics of 104 subjects (mean ± SD)

	Adolescents with CF n=73	Healthy adolescents n=31	p-value
Gender (m/f)	46/27	10/21	
Age (y)	13.16 ± 2.88	12.94 ± 3.02	p=0.169
Stature (cm)	156.0 ± 15.5	155.9 ± 13.1	p=0.981
Body mass (kg)	52.31 ± 17.55	46.58 ± 11.96	p=0.100
BMI (kg.m^{-2})	20.84 ± 3.72	18.83 ± 2.43 *	p=0.007
BSA (m^2)	1.50 ± 0.33	1.41 ± 0.24	p=0.193
FVC	3.10 ± 1.17	n=72	
FVC % predicted	97.74 ± 16.82	n=71	
FEV1	2.80 ± 1.00	n=72	
FEV1 % predicted	95.10 ± 14.45	n=71	

BMI= body mass index; BSA= body surface area; FVC= Forced vital capacity; FEV1= Forced expiratory volume in 1 s

- $VO_{2\text{ peak}}$ ($\text{mL.kg}^{-1}.\text{min}^{-1}$) and OUE/BSA at GET, RCP and plateau were significantly lower in adolescents with CF than healthy adolescents (Table 2).

Table 2. CPET Exercise Variables (mean ± SD)

	Adolescents with CF n=73	Healthy adolescents n=31	p-value
WR_{peak} (W)	162 ± 73	154 ± 60	p=0.522
$VO_{2\text{ peak}}$ (L.min^{-1})	1.86 ± 0.68	1.91 ± 0.82	p=0.748
$VO_{2\text{ peak}}$ ($\text{mL.kg}^{-1}.\text{min}^{-1}$)	37.03 ± 6.88	41.05 ± 10.55 *	p=0.023
GET (L.min^{-1})	0.96 ± 0.34	1.06 ± 0.47	p=0.295
GET (% $VO_{2\text{ peak}}$)	53.27 ± 9.57	55.91 ± 7.37	p=0.133
VE_{peak}	78.26 ± 33.81	60.42 ± 30.03 *	p=0.010
OUE@GET/BSA	24.62 ± 6.73	31.60 ± 5.16 *	p=0.000
OUE@RCP/BSA	20.58 ± 5.86	26.07 ± 4.92 * n=27	p=0.000
OUEP/BSA	25.25 ± 6.42	33.03 ± 6.16 *	p=0.000

WR=work rate, HR= heart rate, RER= respiratory exchange threshold; * p<0.05

Results

- Significant moderate correlations between OUES/BSA and peak VO_2 adjusted to body mass for adolescents with CF and healthy controls, at all intensities, durations and thresholds (p< 0.01), shown in Table 3. Correlations were moderate (0.332 - 0.601) in adolescents with CF, but moderate to strong in healthy adolescents (0.497 - 0.800).

Table 3. Correlations between OUES/BSA and Peak VO_2 ($\text{mL.kg}^{-1}.\text{min}^{-1}$) at the different thresholds

OUES/BSA threshold	CF	Healthy
50% $VO_{2\text{ peak}}$	0.398**	0.497**
75% $VO_{2\text{ peak}}$	0.487**	0.710**
100%	0.601**	0.800**
GET	0.332**	0.524**
RCP	0.557**	0.800**

** p< 0.01

- No significant difference in OUES/BSA between healthy adolescents and adolescents with CF at any of the thresholds of the CPET (see Figure 1).

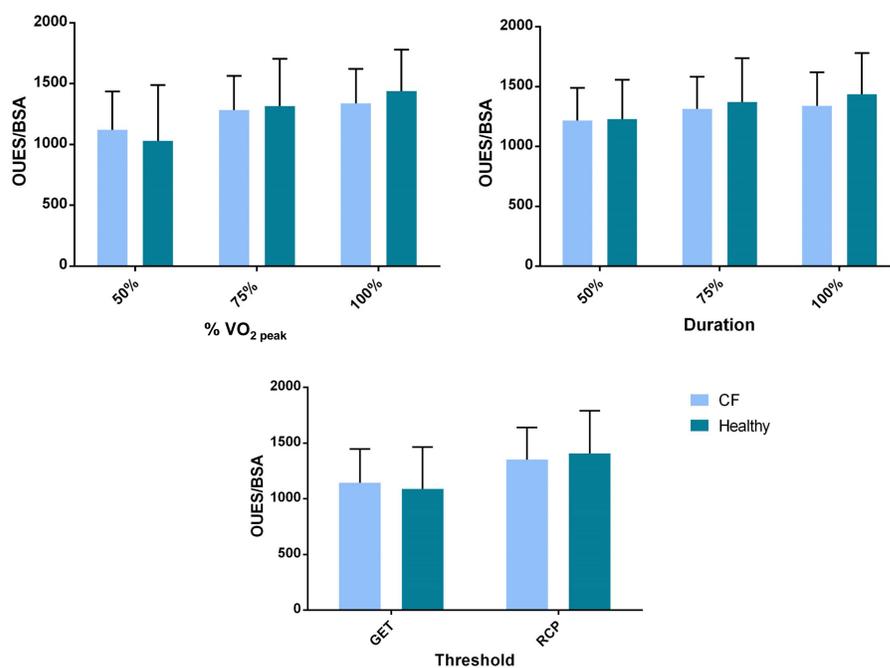


Figure 1. Comparison of OUES/BSA values between adolescents with CF and healthy adolescents at different exercise thresholds.

Discussion

- Despite significant correlations between OUES/BSA and $VO_{2\text{ peak}}$ at all thresholds, OUES/BSA was not significantly different between healthy adolescents and those with CF at any threshold point, supporting Bongers *et al.*⁵ that OUES is not a valid submaximal measure in adolescents with CF.
- A novel finding was adolescents with CF had significantly lower values than healthy adolescents for OUE@GET/BSA, OUE@RCP/BSA and OUEP/BSA
- GET occurred at 53% of $VO_{2\text{ peak}}$ in this sample of 73, so OUE at this threshold could be more representative of the individual's ability to cope with sub-threshold activity demands compared to exercise above the threshold point.
- OUE & OUEP could provide alternative measure for adolescents unable to reach volitional maximum.

Conclusion:

OUES is not a valid submaximal measure of aerobic capacity in adolescents with CF, however OUE & OUEP as alternative measures should be investigated.

References

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