Cardiorespiratory Fitness (CRF) Evaluation with Muscle Oxygenation

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Cardiorespiratory Fitness (CRF)

- Ability to supply/consume Oxygen
- Measured by VO2max
- Clinical Vital Sign
- Can reduce the risk of heart disease
- Can improve chronic disease management

Traditional CRF Evaluation

Disadvantages

- High cost
- Low availability
- Needs exercise with maximum effort
- Final result only, not showing what limits the performance

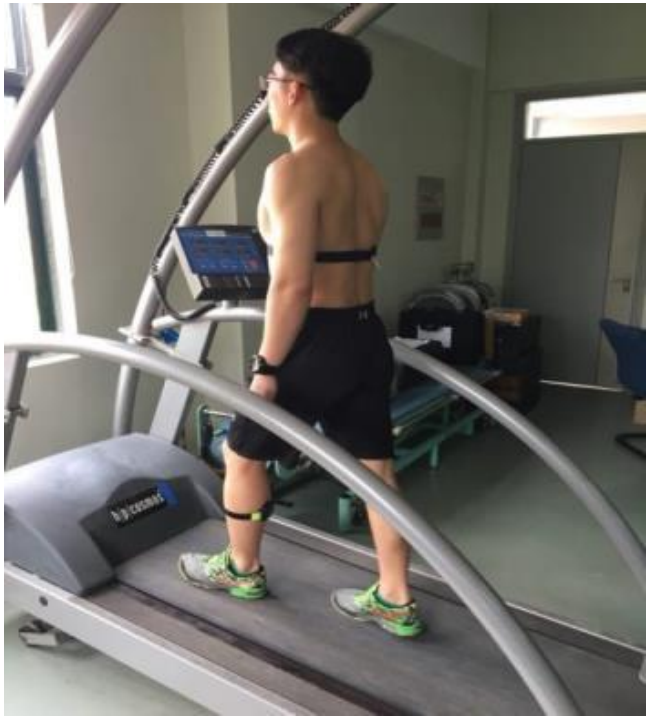
Submaximal Tests

- Low cost
- High availability
- Less accurate
- Not showing the limitations neither

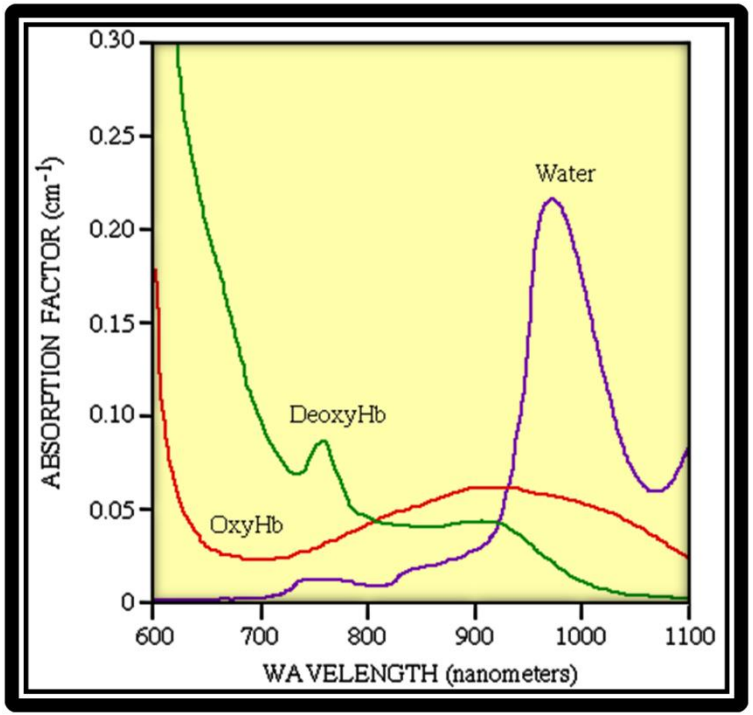
CRF Evaluation with Muscle Oxygenation

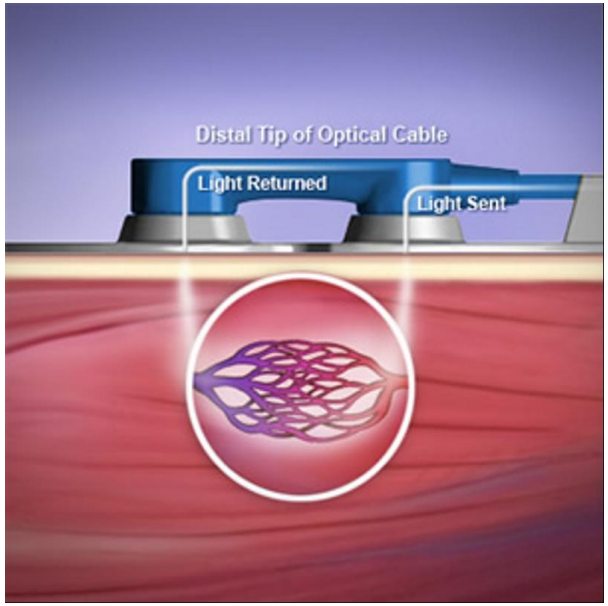
- Submaximal test
- Graded exercise test
- SmO2 monitoring during test
- Improved accuracy
- Physical limitation analysis

SmO2 monitoring device



How SmO2 device works





Exercise design

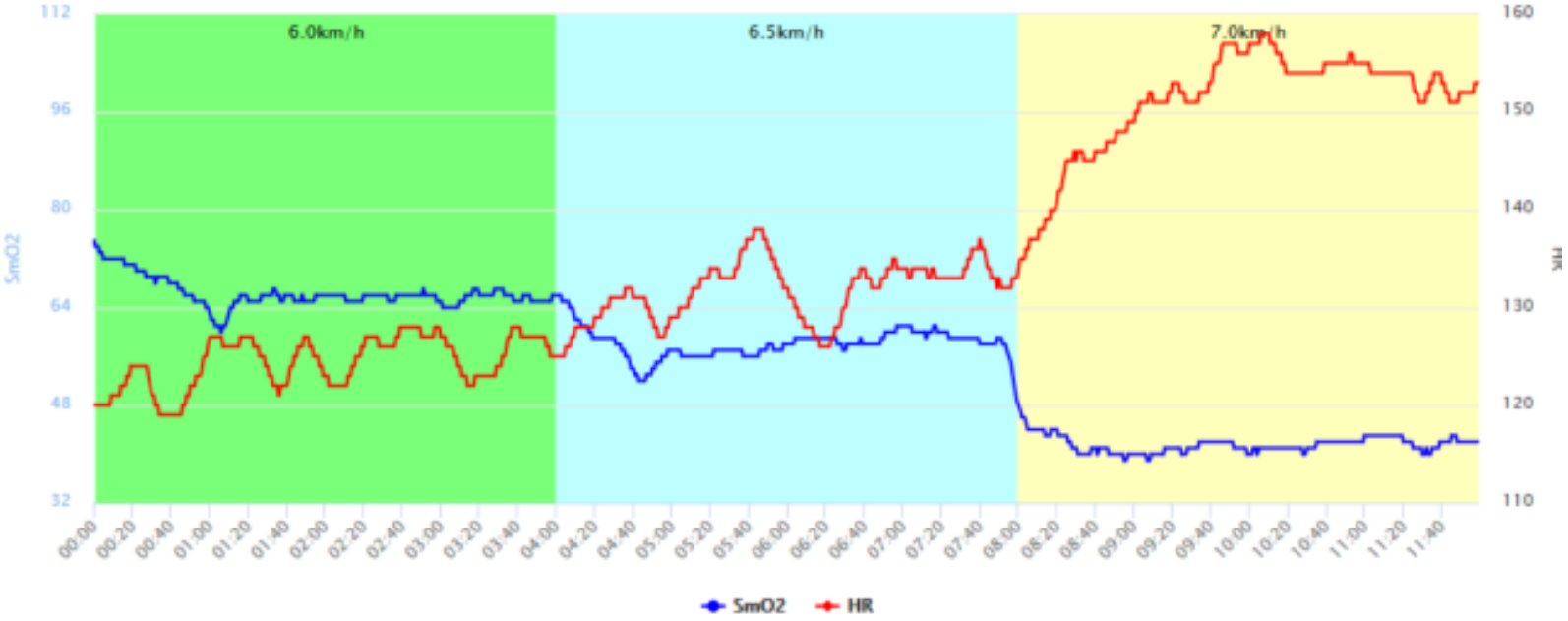
- Heart Rate and SmO2 monitored during the test
- Treadmill at 5% grade
- Warmup 6 minutes with 60%-65% of HRmax
- Rest for 1 minute
- Start test at warmup speed for 4 minutes
- Increase speed for 0.5 km/h to 1 km/h based on subject's performance
- Repeat the 4 minutes incremental 2 more times (4 in total)
- Calculate VO2max based on speed at 6km/h
- SmO2 analysis
- Adjust VO2max if it's not correlated with SmO2 analysis

VO2max Calculation

- VO2max (ml/kg.min) = 15.1 + (21.8 × Speed in mph)
  - (0.327 × HR)
  - (0.263 × Speed × Age)
  + (5 .98 × Sex)
  + (0.00504 × HR × Age) [1]

Sex: Male 1, Female 0

HR and SmO2


6.0km/h
6.5km/h
7.0km/h
SmO2
HR
112
96
80
64
48
32
160
150
140
130
120
110
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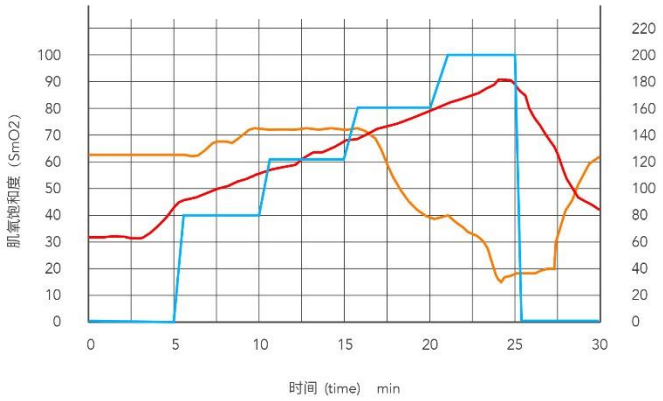
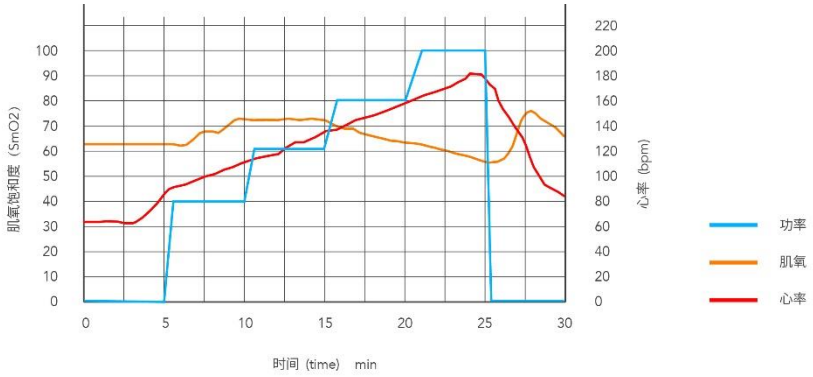
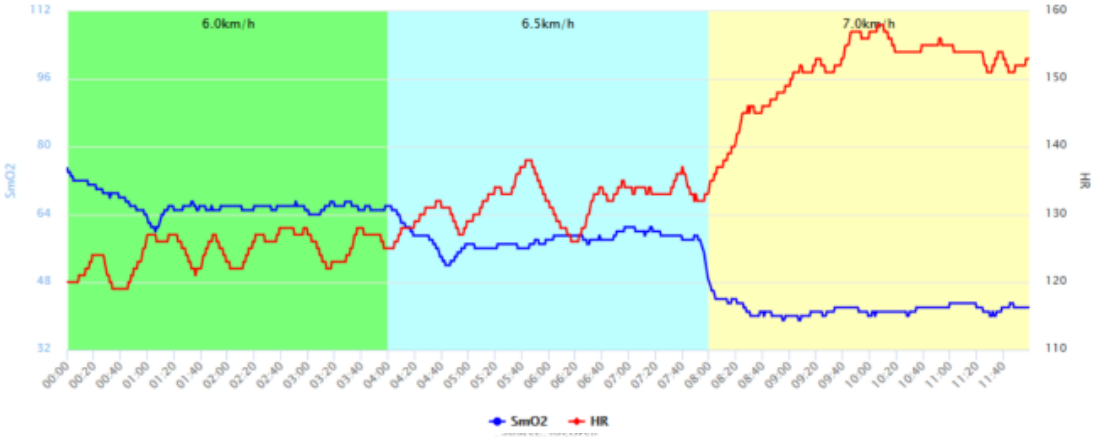
SmO2
HR

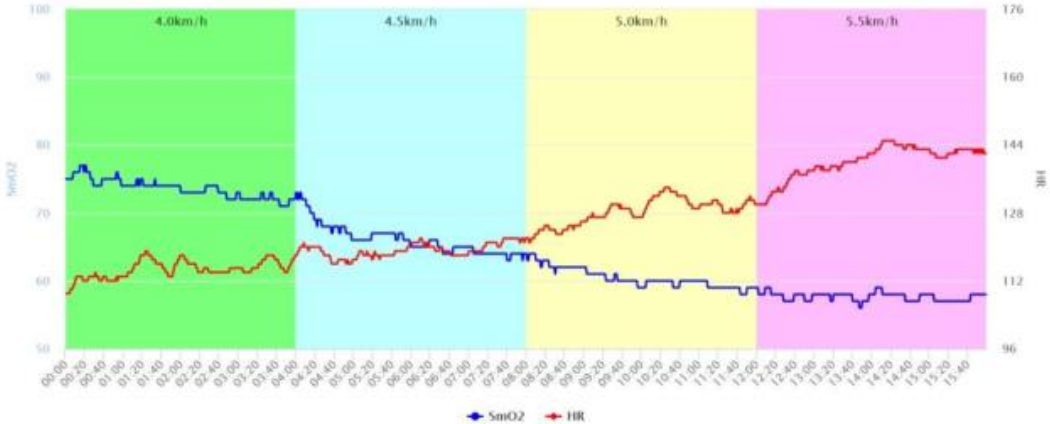
Understand the physical limitation





SmO2 performance comparison





SmO2 analysis- overall

- Total SmO2 decline shows the ability of muscle to consume oxygen in general.

- The ratio of SmO2 decline over the first minute in all stages show the ability to quickly consume oxygen and reach the balance.

SmO2 analysis - Stage

- The slope for the first minute after speed increase shows the ability of muscle to quickly consume more oxygen. The lower the better. (negative value)

- The slope for the 3 – 4 minutes after speed increase shows the ability to keep muscle oxygen supply. The higher the better.

SmO2 analysis - Final

- Overall score + average stage score
- Final score will be categorized as poor, fair, good
- VO2max will be adjusted if VO2max category is different with SmO2 category

Normative data for VO2max

Normative data for VO2max
Female (values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<25.0	25.0 - 30.9	31.0 - 34.9	35.0 - 38.9	39.0 - 41.9	>41.9
20-29	<23.6	23.6 - 28.9	29.0 - 32.9	33.0 - 36.9	37.0 - 41.0	>41.0
30-39	<22.8	22.8 - 26.9	27.0 - 31.4	31.5 - 35.6	35.7 - 40.0	>40.0
40-49	<21.0	21.0 - 24.4	24.5 - 28.9	29.0 - 32.8	32.9 - 36.9	>36.9
50-59	<20.2	20.2 - 22.7	22.8 - 26.9	27.0 - 31.4	31.5 - 35.7	>35.7
60+	<17.5	17.5 - 20.1	20.2 - 24.4	24.5 - 30.2	30.3 - 31.4	>31.4

Male (values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35.0	35.0 - 38.3	38.4 - 45.1	45.2 - 50.9	51.0 - 55.9	>55.9
20-29	<33.0	33.0 - 36.4	36.5 - 42.4	42.5 - 46.4	46.5 - 52.4	>52.4
30-39	<31.5	31.5 - 35.4	35.5 - 40.9	41.0 - 44.9	45.0 - 49.4	>49.4
40-49	<30.2	30.2 - 33.5	33.6 - 38.9	39.0 - 43.7	43.8 - 48.0	>48.0
50-59	<26.1	26.1 - 30.9	31.0 - 35.7	35.8 - 40.9	41.0 - 45.3	>45.3
60+	<20.5	20.5 - 26.0	26.1 - 32.2	32.3 - 36.4	36.5 - 44.2	>44.2

Table Reference: The Physical Fitness Specialist Certification Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 1997 printed in Advance Fitness Assessment & Exercise Prescription, 3rd Edition, Vivian H. Heyward, 1998.p48

VO2max validation

- A comparison has been done among traditional method, Submaximal test and proposed test
- 35 subjects are included in the comparison
- The average accuracy has been increased from 87.3% to 90.1%

Descriptive data.

n = 35	Submaximal test	after adjusted
difference from measured VO2max (ml/kg.min)	-15.3 to 6.6	-12.1 to 6.05
number of 90% accuracy tests	19	22
average difference from measured VO2max	3.9	3.2
SD	5.6	5.2

Physical limitation validation

- 45 subjects are involved in the validation test
- Intervention group gets instruction on how to exercise based on SmO2 analysis
- Control group did not get any instruction
- The validation test last 3 months
- VO2max and SmO2 are used to analyze the exercise outcome

Subject Summary

	Sex	Count	Age (average± SD)	Height	Weight
Intervention	Female	10	47±6.3	160.1±5.4	59.9±6.5
	Male	23	46.4±9.6	172.2±6.1	73.3±11
Control	Female	7	39.3±15.3	157±8.1	63.7±13.3
	Male	5	38.6±9	172.8±7.6	81.2±18.3

Validation Result

	Sex	Count	VO2max Increase	Increased Subject	Ratio	SmO2 Increase	Increase Subject	Ratio
Intervention	Female	10	1.3±2.00	9	0.90	0.4±0.4	7	0.70
	Male	23	0.9±1.65	18	0.78	0.2±0.5	13	0.57
Control	Female	7	0.1±1.9	3	0.43	-0.1±1.0	2	0.29
	Male	5	0.2±1	3	0.60	0±0.2	2	0.40

CRF Evaluation with Muscle Oxygenation

- Low Cost
- High Availability
- More Complete Model for Evaluation
- Improved accuracy
- Physical limitation detection
- Reliable analysis for exercise instruction

References

1. Ebbeling CB1, Ward A, Puleo EM, Widrick J, Rippe JM. Development of a single-stage submaximal tre admill walking test. *Med Sci Sports Exerc*. 1991 270
Aug;23(8):966-73. PLOS 7/8.

Questions??