Protocolli per la Valutazione Funzionale

Stato del soggetto prima del test

- **A digiuno da almeno 2 ore**
- **Evitare in particolare tè e caffè**
- **Evitare esercizio strenuo e prolungato nelle 72 ore precedenti**
- **Annotare scrupolosamente eventuali farmaci**
- **Sospendere farmaci se necessario**

Protocolli

- Per intensità di esercizio
  - Massimali
  - Sub-massimali
- Per modo di esercizio
  - Laboratorio
  - *outdoor*

Criteri per definire sforzo massimale (VO_{2max})

- Valutazione Diretta
  - RPE ≥ 18/20
  - FC ≥ 85%FCMT
  - FC ≥ FCMT – 10
  - QR (VCO2/VO2) ≥ 1.10
    - ≥ 1.05 (in cardiopatici)
  - Lattato ≥ 8 mMol/L
- Valutazione Indiretta (Stima)
  - Diverse equazioni per diverso protocollo
  - Elevata variabilità fra valutazione diretta e indiretta e fra diversi protocolli…

Monitoraggio & Precauzioni

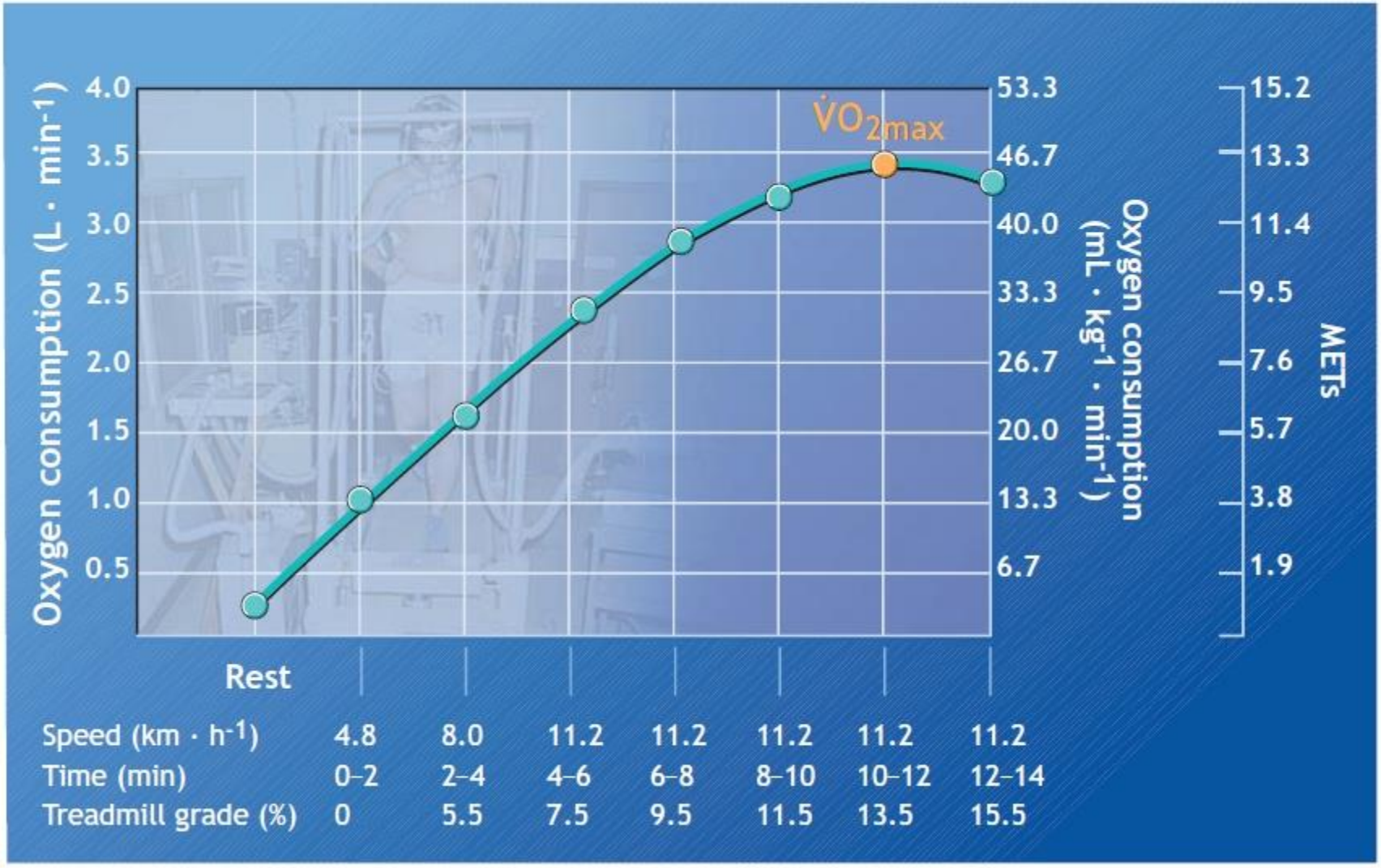
- ECG
- Frequenza cardiaca
- Pressione arteriosa
- Sforzo percepito (Scale di Borg)
- Gas espirati (test cardiopolmonare)
- Lattato
- Segni e sintomi (dispnea, dolore toracico, fatica, vertigini, etc.)

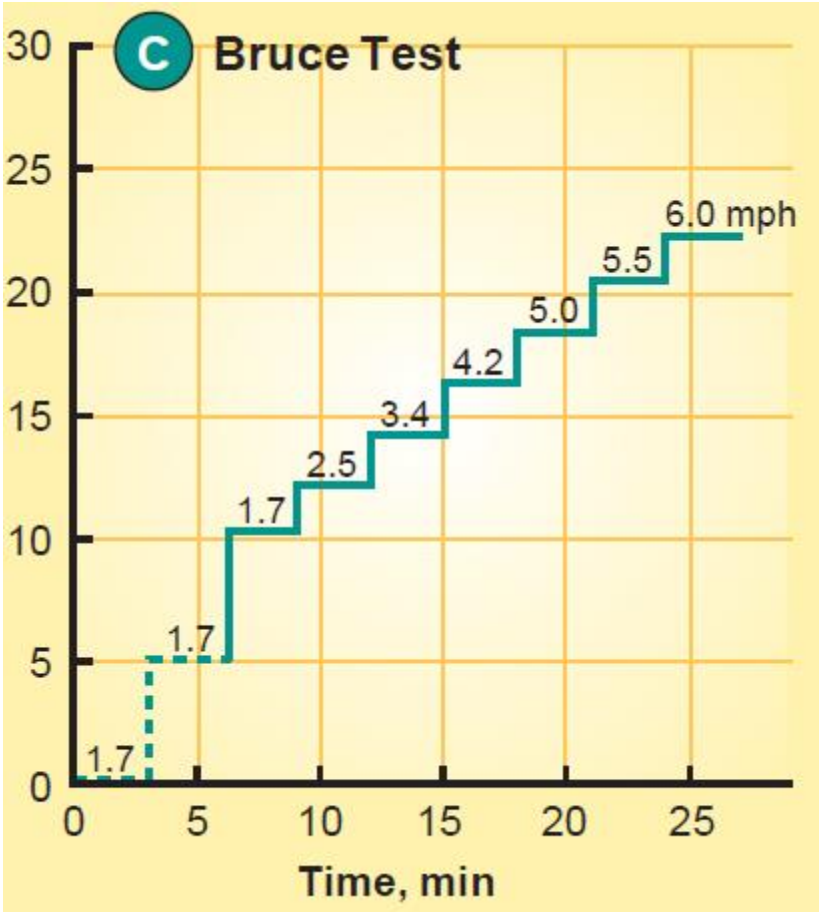
Ragioni per interrompere test

1. Dolori al petto (angina)
2. Ipotensione arteriosa (all'aumentare del carico)
3. Ipertensione arteriosa (>260/115 mmHg)
4. Segni di ridotta perfusione (confusione, vertigini, cefalea, cianosi, etc.)
5. Inadeguato aumento di FC
6. Richiesta del soggetto
7. Fatica severa
8. Altre ragioni mediche
9. Malfunzionamenti strumentali

Protocolli massimali incrementali

- Treadmill


Oxygen consumption (L · min-1)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
V̇O2max
53.3
46.7
40.0
33.3
26.7
20.0
13.3
6.7
Oxygen consumption (mL · kg-1 · min-1)
15.2
13.3
11.4
9.5
7.6
5.7
3.8
1.9
METs
Rest
Speed (km · h-1) 4.8 8.0 11.2 11.2 11.2 11.2 11.2
Time (min) 0–2 2–4 4–6 6–8 8–10 10–12 12–14
Treadmill grade (%) 0 5.5 7.5 9.5 11.5 13.5 15.5


C
Bruce Test
30
25
20
15
10
5
0
1.7
1.7
1.7
2.5
3.4
4.2
5.0
5.5
6.0 mph
0
5
10
15
20
25
Time, min
Pendenza del tappeto (%)


Oxygen consumption
(mL · kg-1 · min-1)
60
50
40
30
20
10
Region of V̇O2max
Grade 6
Grade 5
Grade 4
Grade 3
Grade 2
Grade 1
Level
Hills of successively increasing grade

Bruce modificato

Table 13-2. Bruce Treadmill Protocol

Stage	Speed (miles·hr^{-1})	Speed (km·hr^{-1})	Grade (%)	Duration (min)
0	1.7	2.7	0	3
0.5	1.7	2.7	5	3
1	1.7	2.7	10	3
2	2.5	4.0	12	3
3	3.4	5.4	14	3
4	4.2	6.7	16	3
5	5.0	8.0	18	3
6	5.5	8.8	20	3
7	6.0	9.6	22	3

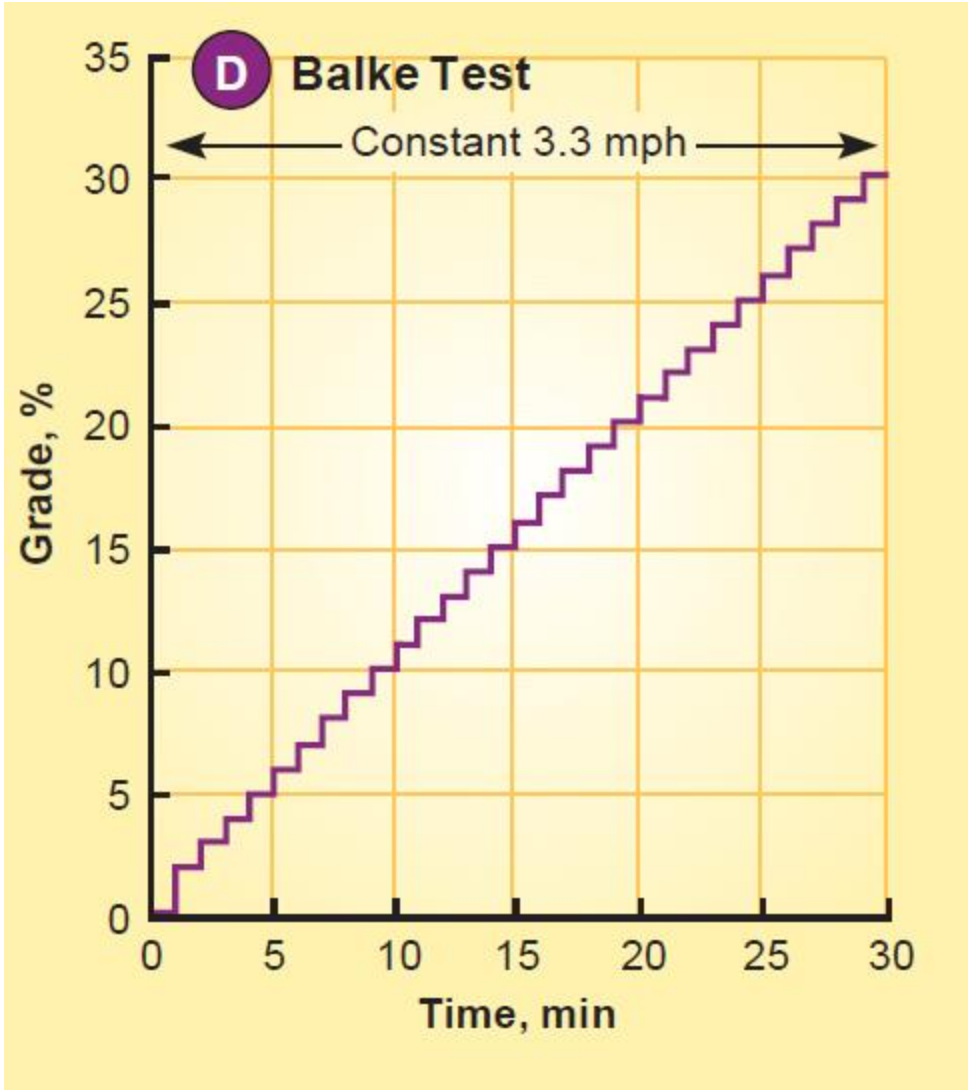
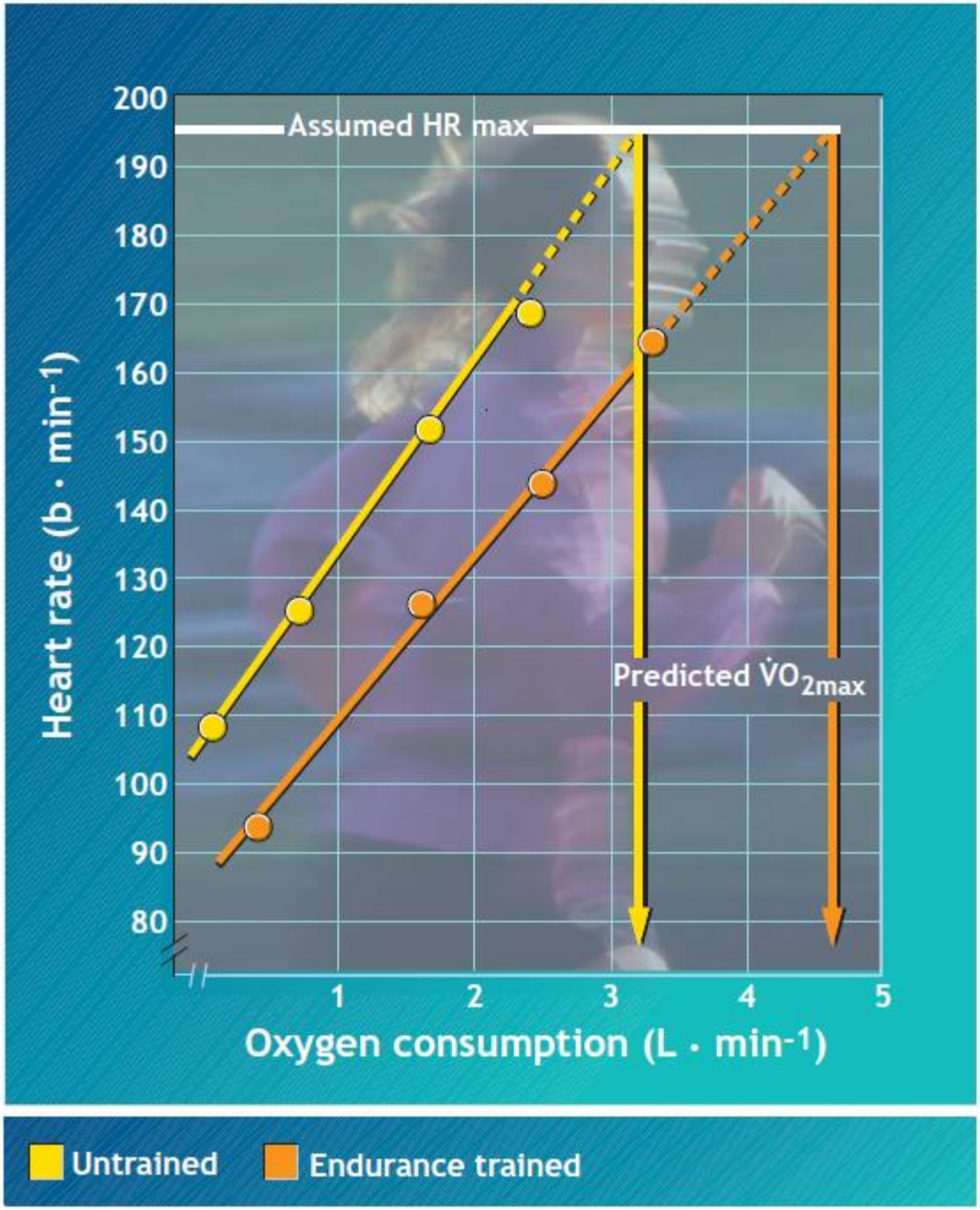

D
Balke Test
Constant 3.3 mph
Grade, %
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
Time, min

Table 13-1. Balke Treadmill Protocol

Stage	Speed (miles·hr^{-1})	Speed (km·hr^{-1})	Grade (%)	Duration (min)
1	3.3	5.3	0	1
2	3.3	5.3	2	1
3–25	3.3	5.3	Increase 1%/min	1 at each % grade
26	3.5	5.62	25	1
27 and higher	Increase 0.2 each stage	Increase 0.32 each stage	25	1 at each speed increase

Equazioni per stimare VO_{2max}

		VO2max	R
Balke 1	Maschi	1.444(tempo in min) + 14.99	0.92
Balke 2	Femmine	1.38 (tempo in min) + 5.22	0.94
Bruce 1	Maschi	14.76 - 1.379 (tempo in min) + 0.451 (tempo in min x tempo in min) - 0.012(tempo in min x tempo in min x tempo in min)	0.98
Bruce 2	Femmine	4.38 (tempo in min)	0.91
Bruce 3	Cardiopatici maschi	2.282 (tempo in min) + 8.545	0.82


Assumed HR max
Predicted $\dot{V}O_{2max}$
Heart rate (b · min-1)
200
190
180
170
160
150
140
130
120
110
100
90
80
1
2
3
4
5
Oxygen consumption (L · min-1)
Untrained
Endurance trained

Protocolli massimali incrementali

- Cicloergometro

Al cicloergometro, test submax
(cadenza 50rpm)

Stadio 1 3min	25 watt	25 watt	25 watt	25 watt
FC (bpm)	**<80**	**80-90**	**90-100**	**>100**
Stadio 2 3min	125	100	75	50
Stadio 3 3min	150	125	100	75
Stadio 4 3min	300	150	125	100

Esempio

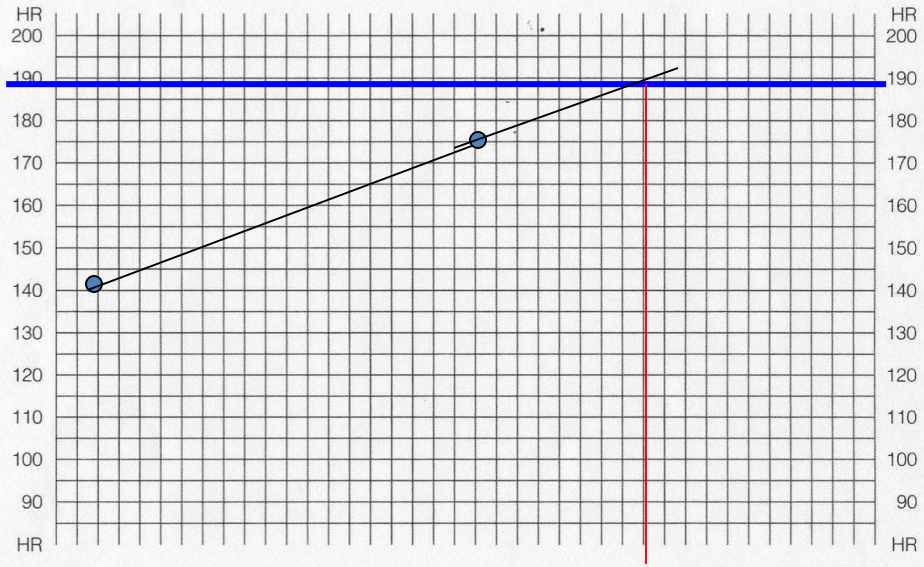
Anni 30	FCMT 220-30= 190/min
300 kgm/min (50 watt)	140/min
1200 kgm/min (200watt)	175/min

Name _____ Age _____ Weight _____ Lb _____ Kg Seat Height _____ Predicted Max HR _____

	Date	1st Workload HR Used	2nd Workload HR Used	Max Workload	Max O_2 (L/min)	Max O_2 (mL/kg)
TEST 1						
TEST 2						
TEST 3						

Directions

1. Plot the HR of the 2 workloads versus the work (kgm/min).
2. Determine the subject's max HR line by subtracting subject's age from 220 and draw a line across the graph at this value.
3. Draw a line through both points and extend to the max HR line for age.
4. Drop a line from this point to the baseline and read the predicted max workload and O_2 uptake.



Workload (kgm/min)	150	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100
Max O_2 Uptake (L/m)	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.8	3.2	3.5	3.8	4.2	4.6	5.0
KCal Used (kcal/m)	3.0	4.5	6.0	7.5	9.0	10.5	12.0	14.0	16.0	17.5	19.0	21.0	23.0	25.0
Approx Met Level (for 132 lb)	3.3	4.7	6.0	7.3	8.7	10.0	11.3	12.7	14.0	15.3	16.7	18.0	19.3	20.7
Approx Met Level (for 176 lb)	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0

Figure 4.15 Graph for determining $\dot{V}O_{2max}$ from submaximal heart rates obtained during the YMCA's submaximal cycle test. Source: Reprinted form *Y's Way to Physical Fitness* (3rd ed.), with permission of the YMCA of the U.S.A., 101 N. Wacker Drive, Chicago, IL 60606.

Età	Fattore di correzione (moltiplicare per)
15	1.10
25	1.00
35	0.87
40	0.83
45	0.78
50	0.75
55	0.71
60	0.68
65	0.65

- Anni 30
- VO2max stimato: 3.5 L/min
- Correzione x età:
  - 3.5 x 0.87 = **3.04 L/min**

Stima da test incrementale cicloergometro

- Cadenza 60-70 rpm (almeno)
- Incrementi: +10-15 watt/min
- VO_{2max} = (watt/peso, kg)*10,8+3,5

- Esempio
  - Watt max: 100
  - Peso: 80 kg

  VO2max= (100/80) *10,8+3,5=(1.25x10.8)+3.5

  13.5+3.5= **17.0 ml/kg/min**

Valutazione dopo test cicloergometro

TABLE 2 Exercise durations subdivided into 10-yr age categories

Age yrs	Exercise duration min	Subjects n
25–34	11.02±3.36	92
35–44	11.29±3.43	145
45–54	9.31±2.86	115
55–64	9.08±2.73	120
65–74	7.81±2.23	55
⩾75	7.98±1.16	7
Total	9.92±3.24	534

Data are presented as mean±SD, unless otherwise stated.

Valutazione dopo test cicloergometro

Maschi

Femmine

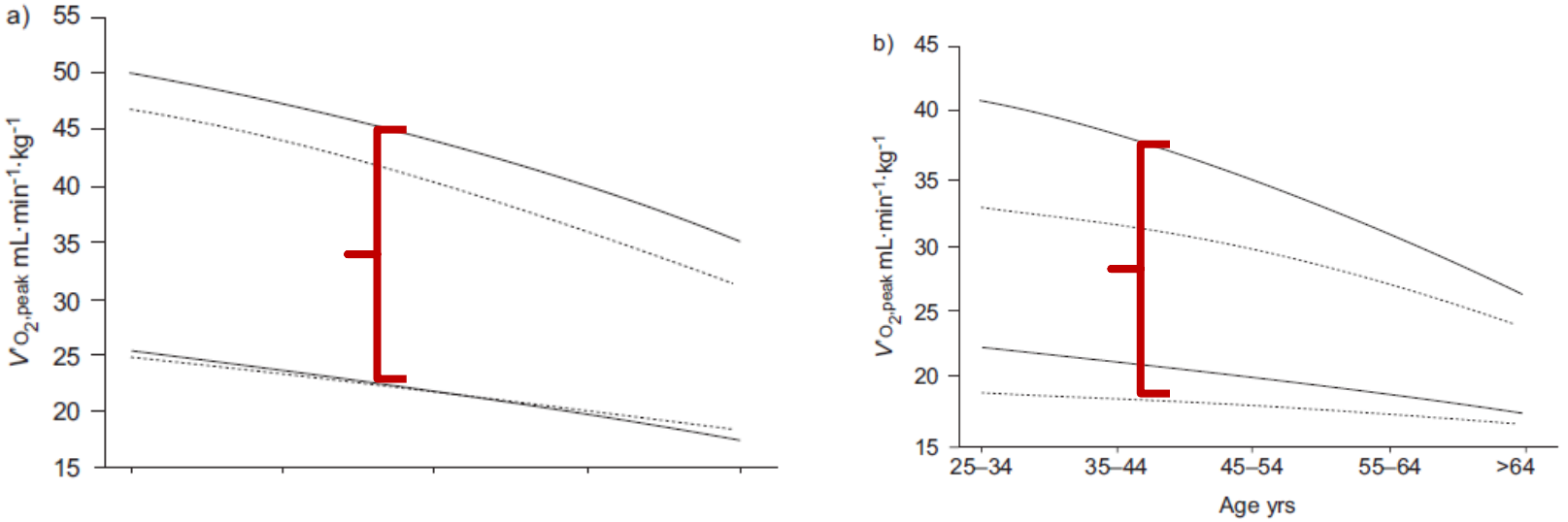


FIGURE 2. Normal ranges for peak oxygen uptake ($V'O_{2,peak}$) for a) males and b) females, with relation to age and subdivided according to body mass index (BMI) groups. ——: BMI ⩽25 kg·m^{-2}; ·····: BMI >25 kg·m^{-2}. Lower and upper lines represent the 5th and 95th percentiles, respectively.

Stima del VO2max da test di cammino

Stima di VO_{2max} (1mile walking test – *track&field*)

Rockport test

- Cammina più velocemente che puoi per 1miglio

- VO_{2max} (L/min)

  = 6.9652 + (0.0091 x peso, lb*) – (0.0257 x età) – (0.5955 x sesso) – (0.2240 x tempo in min) – (0.0115 x FC fine test)

  Maschi = 1; Femmmine = 0

*** 1lb = 0.454 kg**

1mile walking test - esempio

- Sesso:Maschio
- Età: 30 anni
- Peso: 150 lb
- Tempo impiegato: 12 min
- FC finale: 120/min

- VO_{2max} L/min

  = 6.9652 + (0.0091 x 150) – (0.0257 x 30) – (0.5955 x 1) – (0.2240 x 12) – (0.0115 x 120)

  = 4.09 L/min = 60.1 ml/kg/min

  Note: Questa equazione può sovrastimare VO_{2max} in soggetti giovani o ben allenati. In questi casi meglio usare altri protocolli tipo Bruce o Balke.

1mile *treadmill* walking test*

VO2peak =

92.08-0.10xpeso corporeo – 0.34xetà + 9.72x sesso – 1.0xwalking time -0.13x FCfinale + 0.86xactivity status

Dove:
Peso corporeo in pounds (1kg = 2.2 pounds)
Sesso: maschio = 1, femmina = 0
Walking time: in min e centesimi di minuto
Activity status: da 0 – 7**

**: da 0=sedentario assoluto a 7=corre > 10 miglia/sett o > 3H/sett in af comparabile

Memo 10 miglia = ~16km = 1kcal/kg/km = se 70kg = 1120kcal/sett
Potete dividere in 7 fasce da 0 a 1120kcal/sett. Per standardizzare l'errore.

*Pober et al, CJAP 2002; Heil et al, MSSE 1995; Matthews et al, MSSE 2000

Activity status rating

0	Sedentario assoluto.
1	Si muove nelle attività quotidiane: cammina per spostarsi, usa le scale … occasionalmente esercizio che causa respiro aumentato e sudorazione
2	Attività moderata* per 10-60 minuti/settimana in aggiunta a stile di vita attivo, non necessariamente “strutturato” (hobby vari…)
3	Attività moderata per > 60min/sett
4	Attività da moderata a vigorosa per < 30min/sett
5	Attività da moderata a vigorosa per 30-60 min/sett
6	Attività da moderata a vigorosa per 1-3 h/sett
7	Attività da moderata a vigorosa per > 3 h/sett

*: si veda classificazione intensità di esercizio

Test di marcia di 1-km su treadmill (1k-TWT)

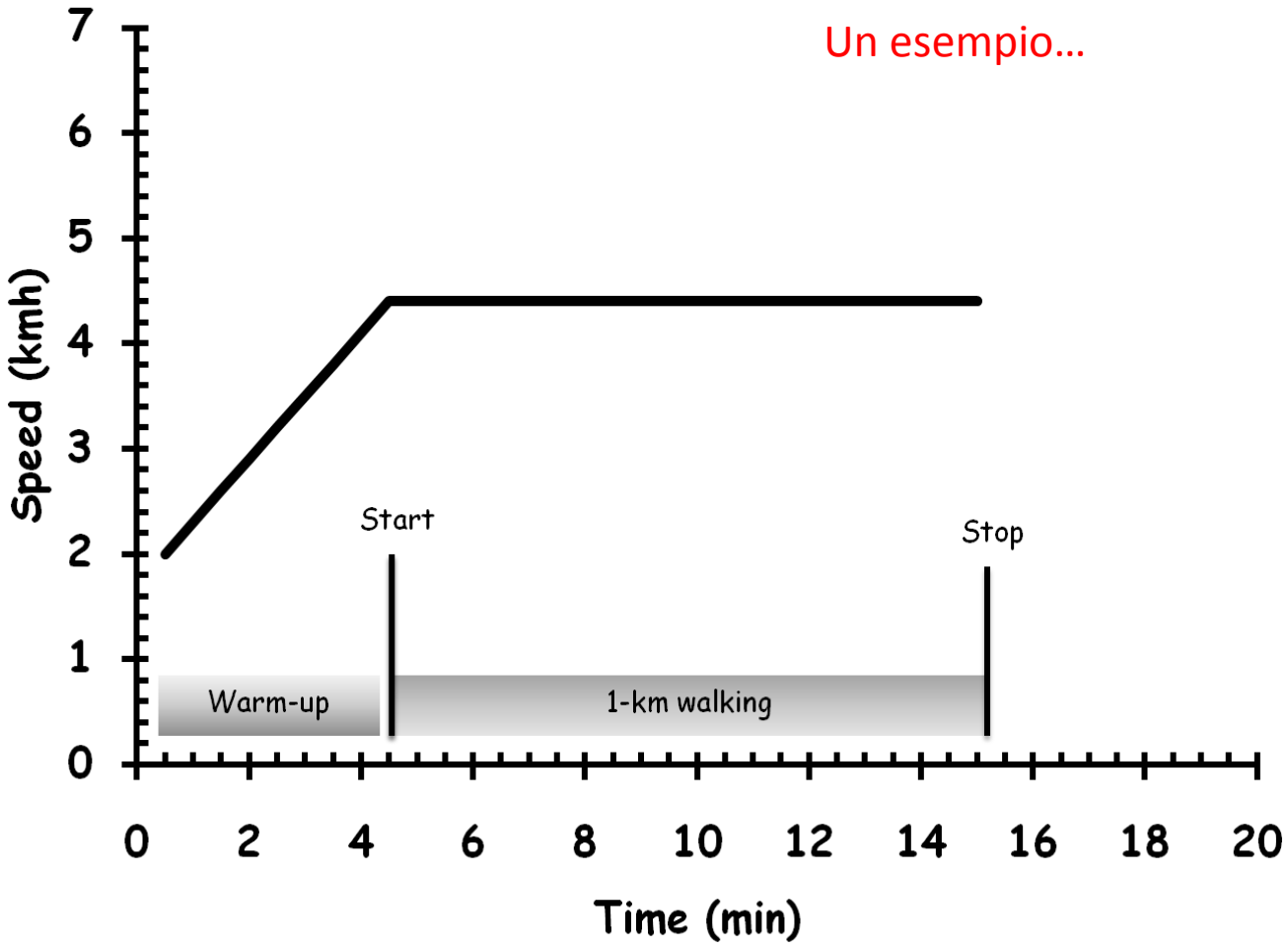
- Per soggetti cardiopatici clinicamente stabili
  - FE>40%
  - No ridotta riserva coronarica da sforzo
  - No aritmie complesse da sforzo
- Su tappeto rotante
- Ad intensità moderata percepita

Test di marcia di 1-km su treadmill (1k-TWT)

- Si parte a 2.0kmh, pendenza 0%
- Si aumenta +0.2kmh/30 secondi
- Fino a quando lo sforzo viene percepito come 11-12/20 (Scala di Borg)
- A quel punto inizia il 1-km (cronometraggio)
- Ogni 2min valutare sforzo percepito e adeguare la velocità di cammino

Test di marcia di 1-km su treadmill (1k-TWT)

Un esempio…



Test di marcia di 1-km su treadmill (1k-TWT)

- Equazioni predittive per stimare VO_{2max}:
  - NBB (no terapia beta-bloccante)
    - 46.11 + (4.41 x mean speed) – (0.40 x BMI) – (0.30 x age) – (0.11 x HRmax)
  - BB (in terapia beta-bloccante)
    - 33.42 + (2.79 x mean speed) - (0.49 x BMI) – (0.14 x age)

Valutazione dello sforzo percepito

Table A1*

15-Grade Scale		10-Grade Scale	
6		0	Nothing
7	Very, very light	0.5	Very, very weak (just noticeable)
8		1	Very weak
9	Very light	2	Weak (light)
10		3	Moderate
11	Fairly light	4	Somewhat strong
12		5	Strong (heavy)
13	Somewhat hard	6	
14		7	Very strong
15	Hard	8	
16		9	
17	Very hard	10	Very, very strong (almost maximum)
18			
19	Very, very hard		Maximum
20			

*From Borg GA. *Med Sci Sports Exerc.* 1982;14:377–381. Reproduced with permission.

Valutazione dello sforzo percepito

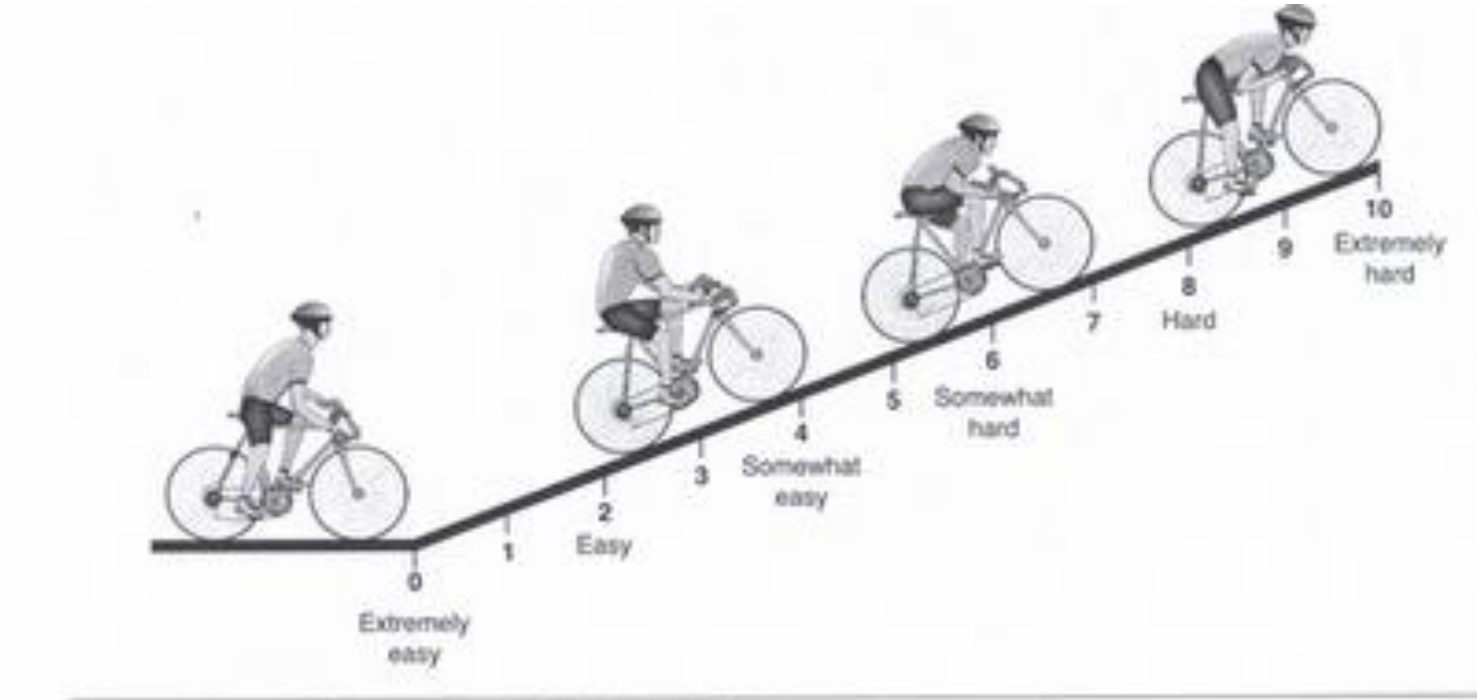
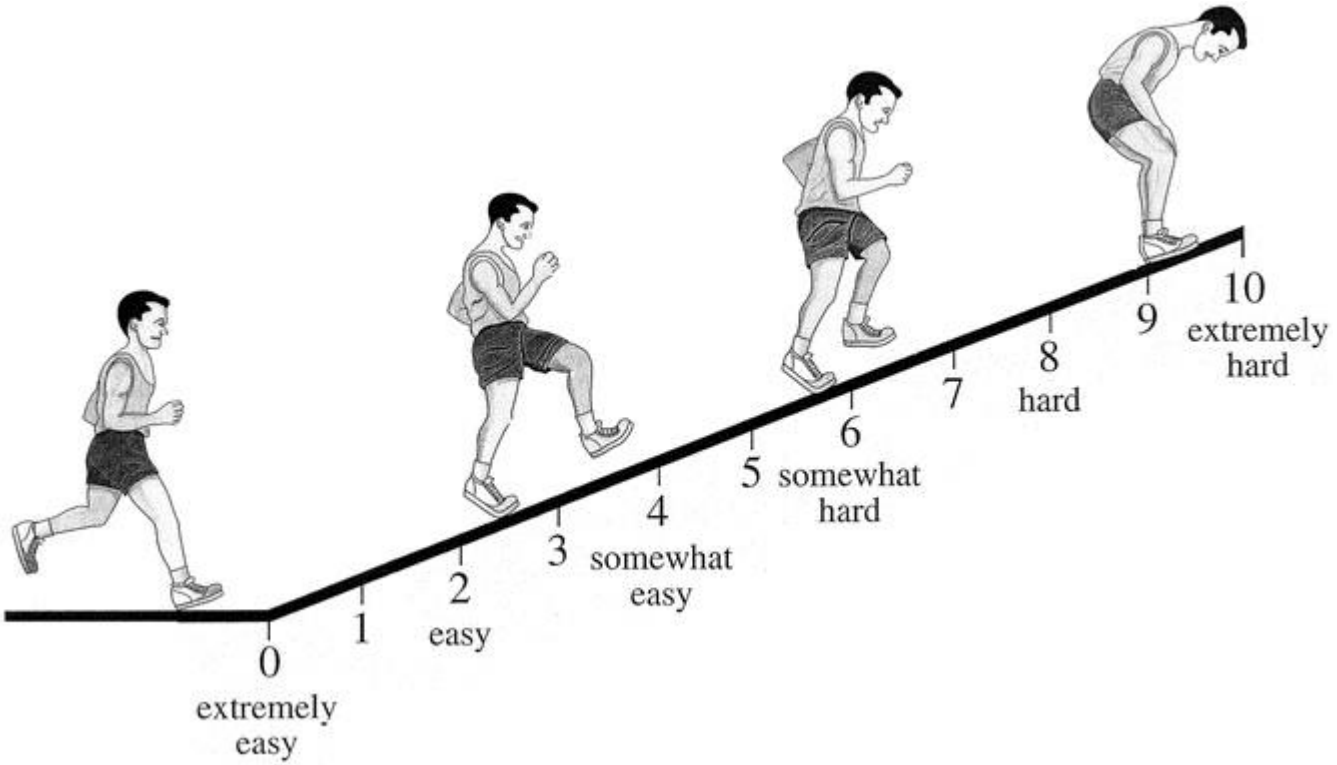


Figure 2.1 OMNI Picture System of Perceived Exertion for adult bicycle exercise.


0
extremely
easy
1
2
easy
3
4
somewhat
easy
5
6
somewhat
hard
7
8
hard
9
10
extremely
hard

Scala RPE e parametri fisiologici

RPE Scale	% Maximal Heart Rate	% $\dot{V}O_{2max}$	Blood Lactate ($mmol \cdot L^{-1}$)
6			
7 Very, very light			
8			
9 Very light			
10			
11 Fairly light	35–54	25–44	
12			
13 Somewhat hard	55–69	45–59	
14			
15 Hard	70–89	60–84	2.5
16			
17 Very hard	>90	≥85	
18			4.0
19 Very, very hard			
20	100	100	

Scala di Borg e training

Scala CR-10

Rating of Perceived Exertion Scale

Rating	0	1	2	3	4	5	6	7	8	9	10
Exertion	No exertion at all	Extremely low	Very low	Relatively low	Low	Moderate	High	Relatively high	Very high	Extremely high	Maximal exertion
	Warm-up stage				Training stage				Critical stage		

Rating of Perceived Exertion Scale

Rating	0	1	2	3	4	5	6	7	8	9	10
Exertion	No exertion at all	Extremely low	Very low	Relatively low	Low	Moderate	High	Relatively high	Very high	Extremely high	Maximal exertion
	Warm-up stage				Training stage				Critical stage		

According to the'Rating of Perceived Exertion Scale', intensity of exercise should be maintained within the range of Rating 4 to 7. If you have doubts about your health condition, you may consult your doctor before doing exercise.

Scala di Borg e training

Scala RPE 6-20/20

Rating of Perceived Exertion (RPE) Scale

Borg Scale 6-20)	Intensity	Breathing Scale	Distance Scale
6	No exertion at all		
7		Can sing full songs	Could continue all day
8	Extremely light		Could continue 4–6 hours
9	Very light	Can sing partial verses	Could continue 3–4 hours
10			Could continue 2–3 hours
11	Light	Can talk in full sentences	Could continue 1–2 hours
12			Could continue 45–60 minutes
13	Somewhat hard	Can talk in short sentences	Could continue 30–45 minutes
14			Could continue 20–30 minutes
15	Hard (heavy)	Breathing hard, thinking clearly	Could continue 15–20 minutes
16			Could continue 10–15 minutes
17	Very hard	Breakaway ventilation	Could continue 5–10 minutes
18			Could continue 2–5 minutes
19	Extremely hard		Could continue 1–2 minutes
20	Maximal exertion		Could continue <1 minute

Al variare del protocollo cambiano i risultati

Table 7.2 Average Maximal Oxygen Uptakes for 15 College Students During Continuous (Cont.) and Discontinuous (Discont.) Tests on the Bicycle and Treadmill

VARIABLE	BIKE, DISCONT.	BIKE, CONT.	TREADMILL, DISCONT. WALK-RUN	TREADMILL, CONT. WALK	TREADMILL, DISCONT. RUN	TREADMILL, CONT. RUN
$\dot{V}O_{2max}$, $mL \cdot min^{-1}$	3691 ± 453	3683 ± 448	4145 ± 401	3944 ± 395	4157 ± 445	4109 ± 424
$\dot{V}O_{2max}$, $mL \cdot kg^{-1} \cdot min^{-1}$	50.0 ± 6.9	49.9 ± 7.0	56.6 ± 7.3	56.6 ± 7.6	55.5 ± 7.6	55.5 ± 6.8

Si può stimare senza esercizio

Equations to Predict $\dot{V}O_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) from Age

GROUP	EQUATION	CORRELATION
1. Sedentary[a]	Predicted $\dot{V}O_{2max} = 54.2 - 0.40$ (age, y)	r = 0.88
2. Moderately Active[b]	Predicted $\dot{V}O_{2max} = 61.4 - 0.39$ (age, y)	r = 0.80
3. Endurance Trained[c]	Predicted $\dot{V}O_{2max} = 77.2 - 0.46$ (age, y)	r = 0.89
4. Alternate equations (independent of relative fitness status		
Males: Predicted $\dot{V}O_{2max} = 59.48 - 0.46$ (age, y)		
Females: Predicted $\dot{V}O_{2max} = 53.7 - 0.537$ (age, y)		

[a]No physical activity.
[b]Occasional physical activity, about 2 $d \cdot wk^{-1}$.
[c]Physical activity = 3 $d \cdot wk^{-1}$ for at least 1 full year.