



3rd ACPET Study Day 18<sup>th</sup> Sept 2008

Sports Village, Hertfordshire University

**Developing  
Cardiorespiratory Fitness  
in your Patient/Client**

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# Outline

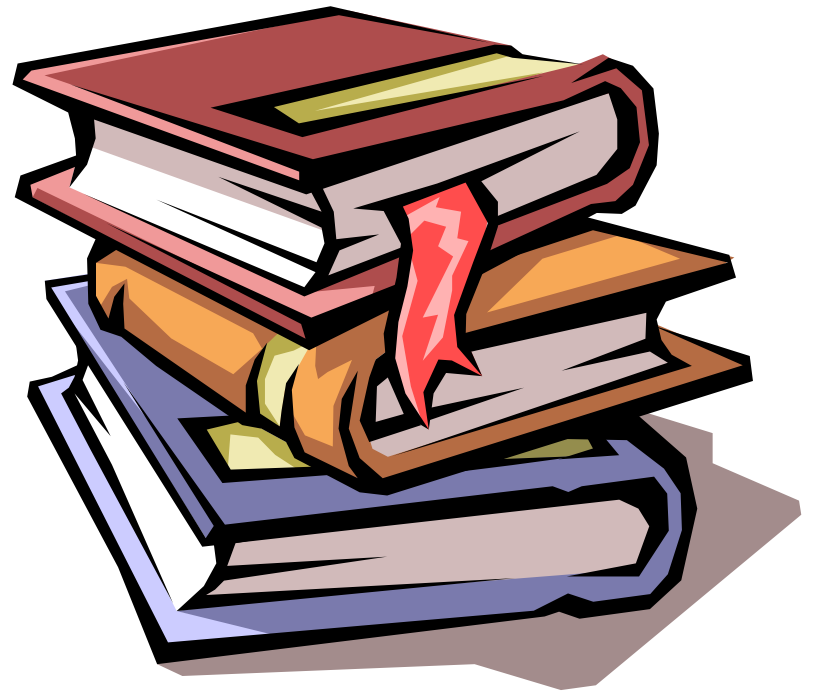
- Brief look at research & current PA recommendations.
- Define CV mode of training.
- Physiological adaptations & training zones.
- Methods of prescribing and monitoring intensity.
- Risk Stratification

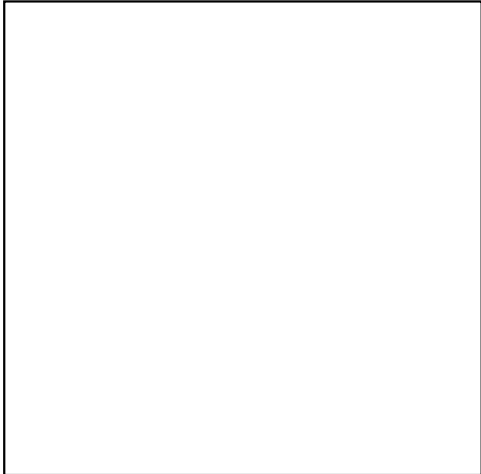


# Afternoon workshop

- Work with HR methods
- Observe a progressive fitness test.
- Overview of commonly used field tests (if time)
- Feedback & discussion

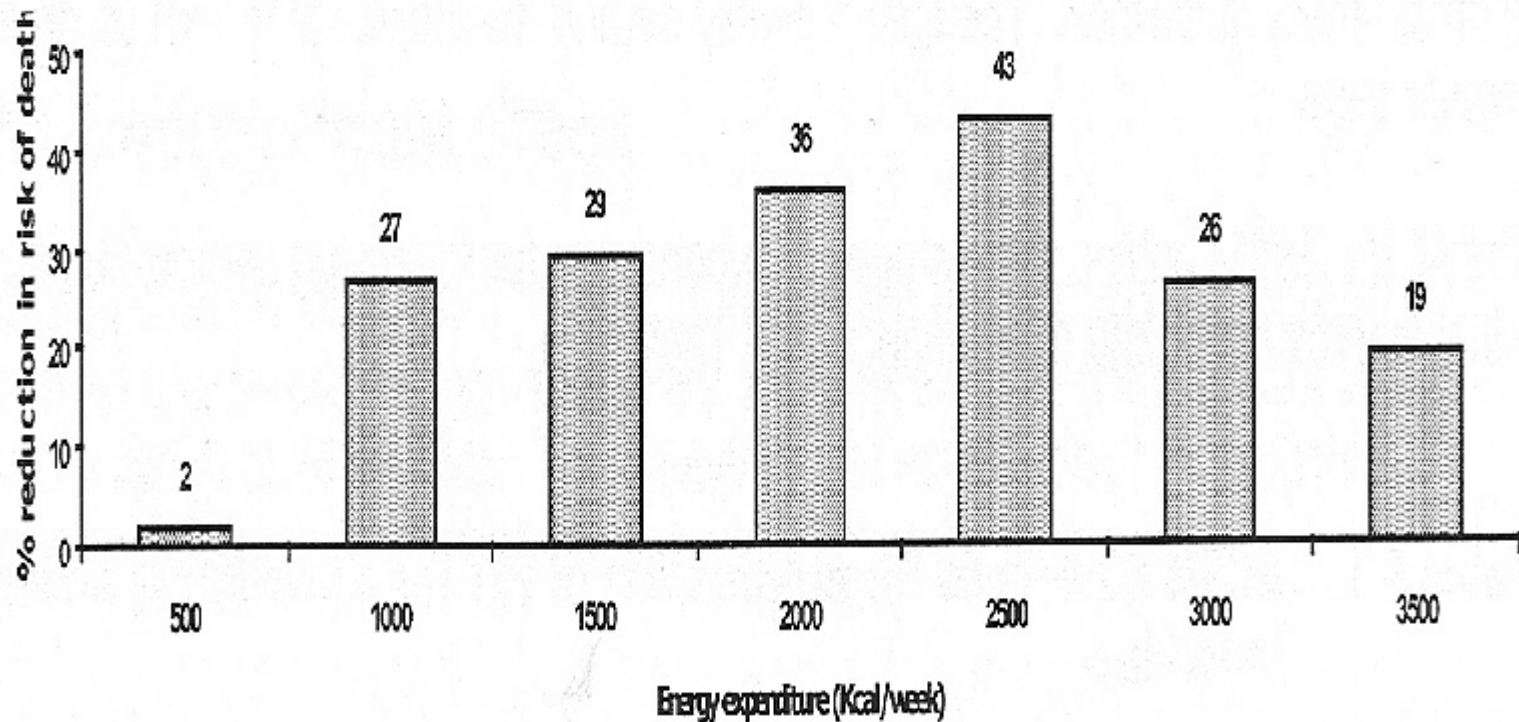
# Research





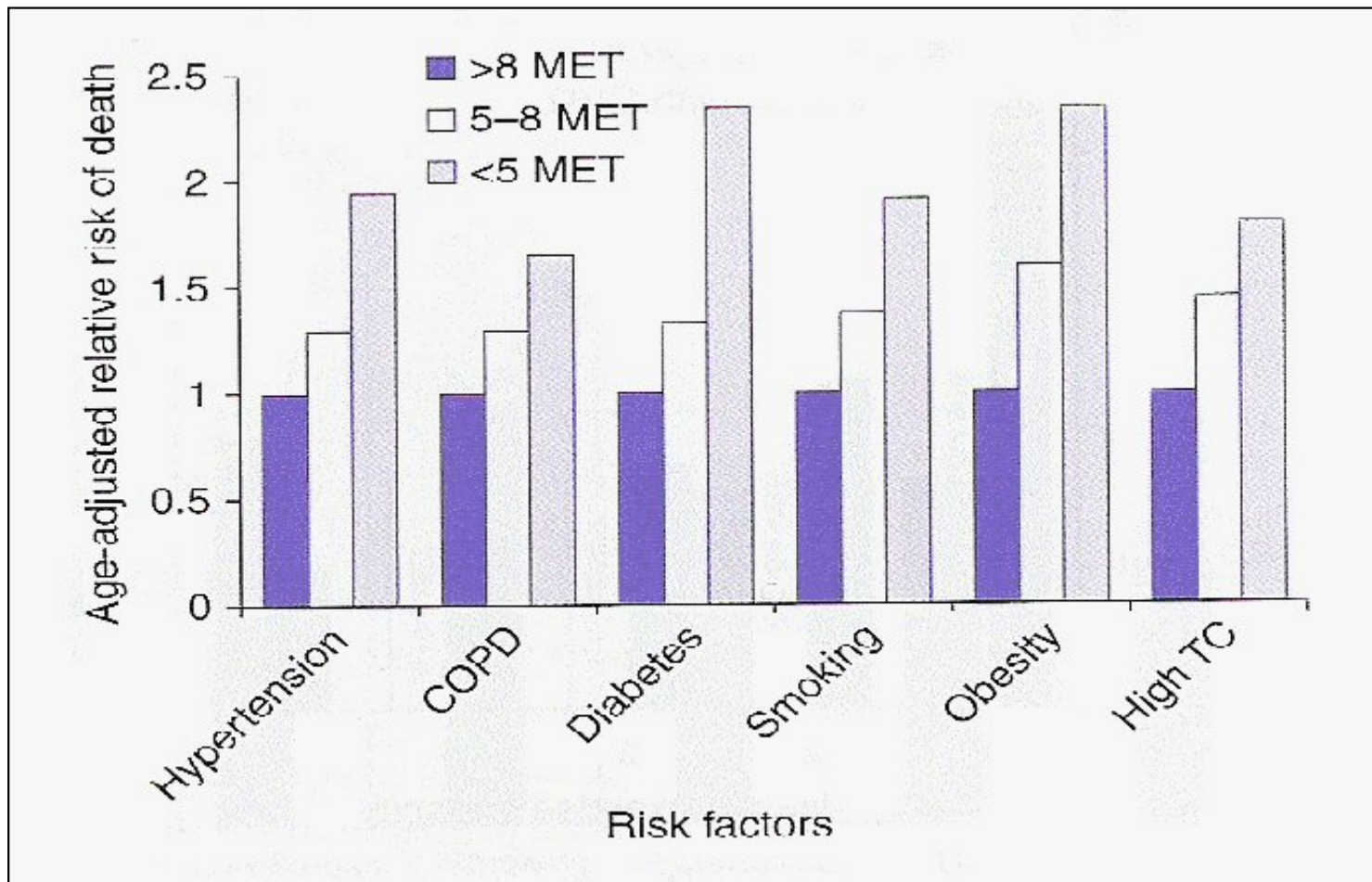
# Reduction in all-cause mortality

**Figure 5.4** The death rates for male Harvard Alumni for the years 1962 to 1978 for various levels of physical activity expenditure



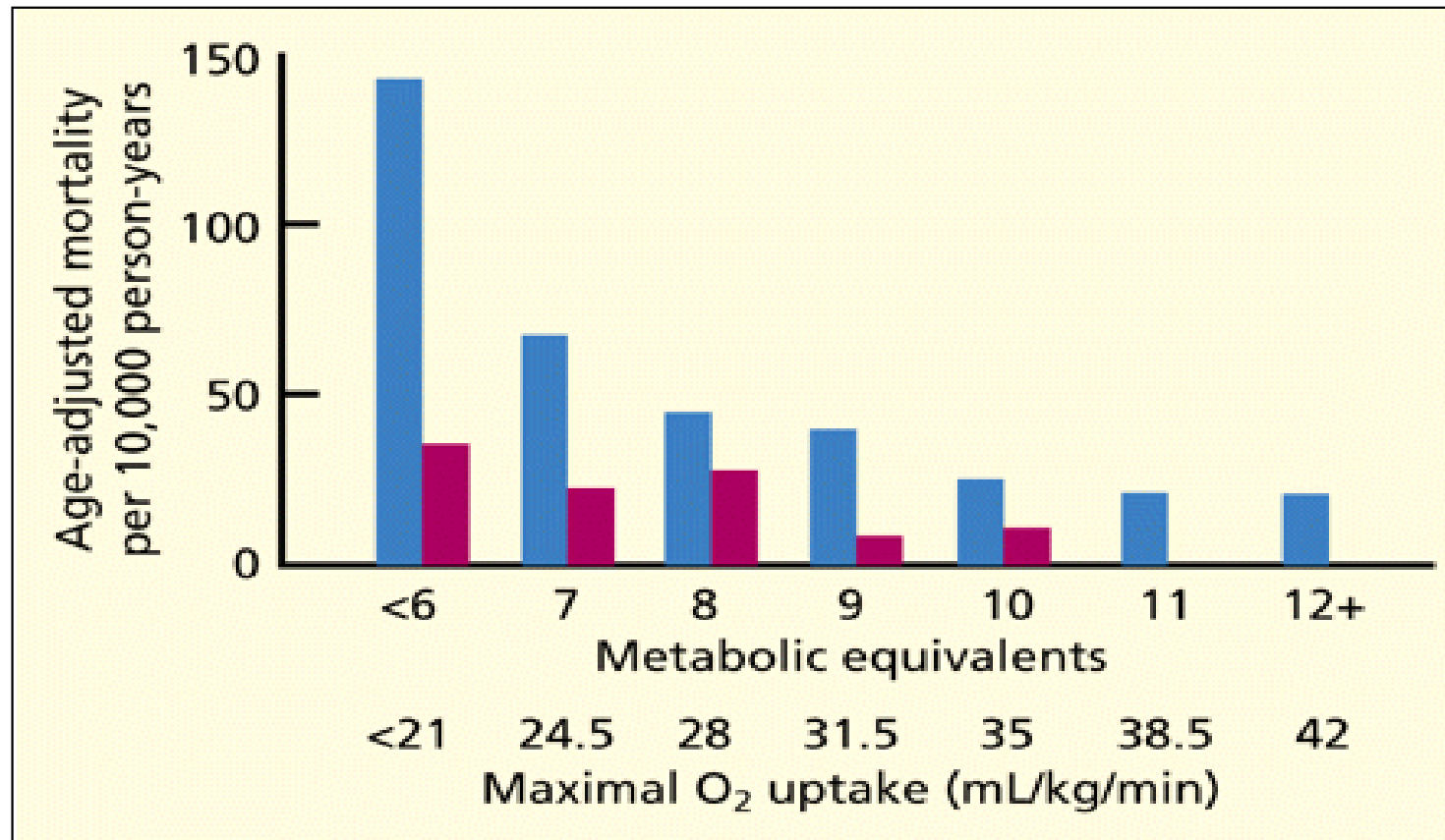
Paffenbarger et al (1986) *New Eng J of Med* 314: 605-613

# Dose-response relationship



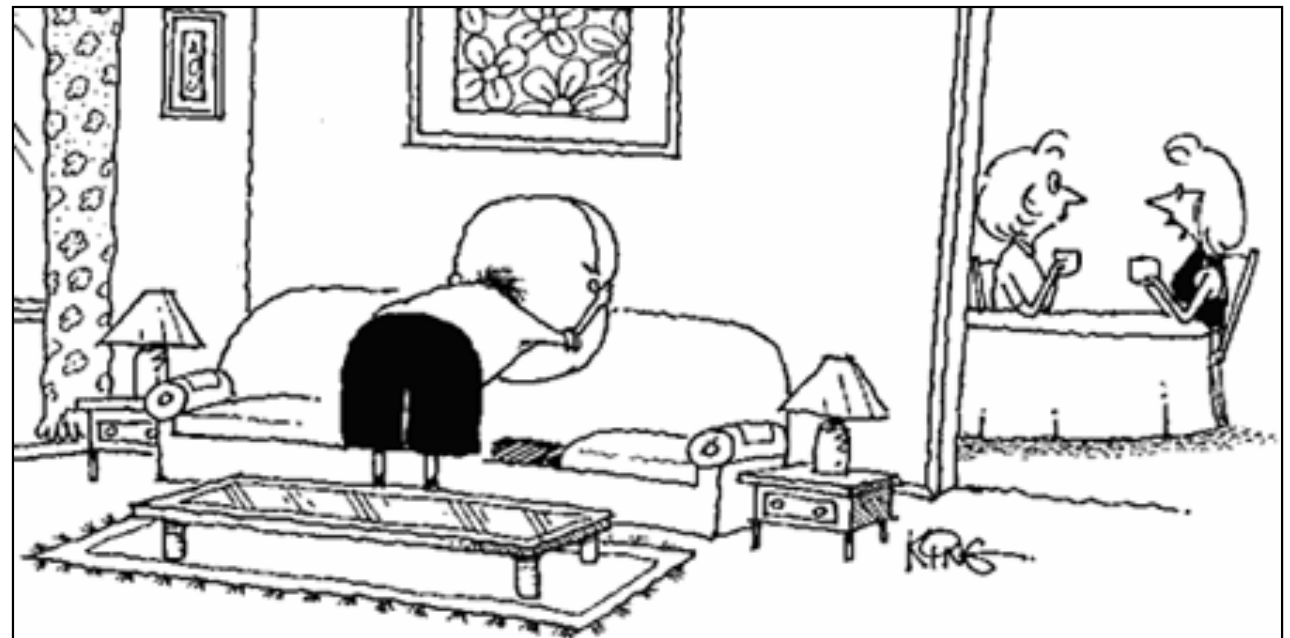
Myers et al (2002) New Eng J of Med 346:793-801

# A small increase in fitness has a big effect



BLAIR et al JAMA 1989; 262:2395–2401.

# Physical Activity Recommendations



The doctor said he needed more activity. So I hide his T.V. remote three times a week.



## Current UK PA recommendations:

“At Least Five a Week” – a report from the Chief Medical Officer on physical activity.  
Department of Health 2004

**Accumulated 30 minutes of moderate intensity exercise on five or more days of the week.**

[www.dh.gov.uk/en/Publicationsandstatistics](http://www.dh.gov.uk/en/Publicationsandstatistics)



## FITT prescription for “five a week”

Frequency: > 5 days a week

Intensity: 3-6 METS or 4-7kcal/min

Time: 1x30, 2x15 or 3x10 mins

Type: Any activity that can be performed at an intensity similar to brisk walking.

Weekly energy expenditure should equal 1000kcal



## Moderate intensity activities which fulfil the 5 a week recommendation:

- Walking 2 miles in 30 mins (4mph)
- Cycling 10mph for 20 mins
- Climbing stairs for 12 mins
- Swimming laps for 20 mins

These activities burn 4-7kcal/min or 150-200 kcal for the given period.  
(5x200kcal=1000kcal/week)



# ACSM / AHA 2007 PA Guidelines for adults under age 65

- Moderate cardio exercise for **30** minutes per day, **five** days a week

OR

- Vigorously intense cardio exercise for **20** minutes on **three** days a week

AND

- 8-10 strength training exercises, 8-12 repetitions twice a week.

[www.acsm.org/PA](http://www.acsm.org/PA) & Public Health Guidelines

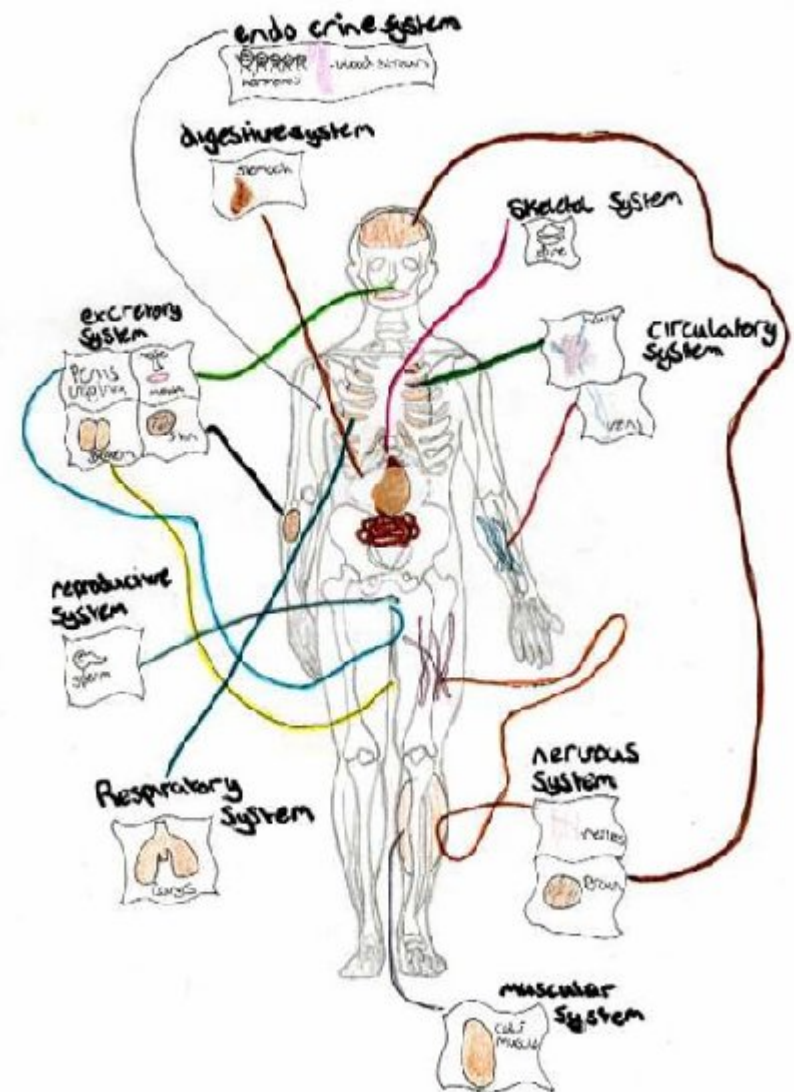


# Mode of CV training

Continuous, rhythmic activity involving large muscle groups under low to moderate tension which stimulates a substantial increase in oxygen consumption over an extended period of time.

e.g. walking, jogging, swimming, cycling, stepping, dancing, housework.  
Gym equipment: treadmill, cross trainer, rower, stepper, arm crank.

# Physiological adaptations to CV training





# Central CV adaptations

Increased stroke volume/cardiac output is achieved by:

- Increased LV mass & chamber size.
- Increase plasma volume.
- Increased venous return (Preload)
- Longer diastole.
- Reduced total peripheral resistance.
- Reduced resting HR & blood pressure.



# Peripheral adaptations in skeletal muscle:

- Increased capillary density
- Increased no. & size of mitochondria
- Increased intramuscular triglyceride storage.
- Increased myoglobin concentration.
- Increased oxidative enzyme activity.

**= Improved  $AVO_2$  difference**



# Endocrine system

- Increased insulin sensitivity.
- Increased utilisation of free fatty acids in the bloodstream & intramuscular fatty acid stores.
- Changes in lipoprotein metabolism leading to reduced LDL & increased HDL.
- Reduced plasma catecholamine concentrations at rest & sub-maximal ex. (adrenaline, nor adrenaline)



# Type 1 diabetes & exercise

- Increasing activity levels can cause hypo- or hyperglycaemia during or up to 36 hours after exercise.
- Pts are advised to closely monitor blood glucose levels before and after each session.

<http://www.diabetes.org.uk>



# Type 1 diabetes & exercise

- Ask if they regularly get hypos and what symptoms they normally experience. Discuss contingencies.
- Have a fast acting carbohydrate to hand (i.e. glucose tablets, isotonic sports drink or squash (not low calorie!))
- Start with low intensity, shorter duration ex & increase gradually.

# Heart Rate Training Zones



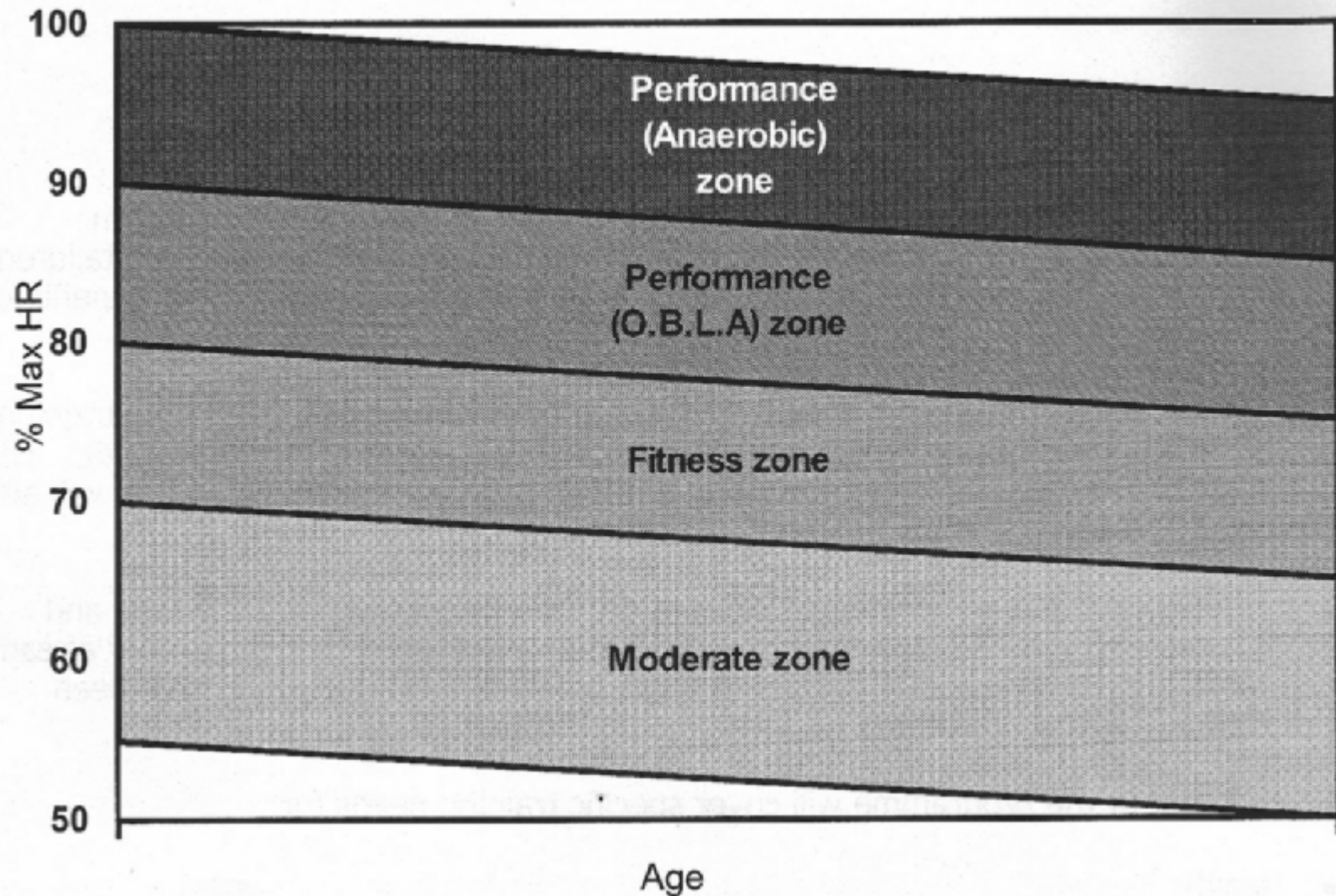


# Measuring CV fitness

- True maximal capacity is determined by a VO<sub>2</sub> max test or treadmill test (TMT).
- VO<sub>2</sub> and HR increase linearly up to the anaerobic threshold.
- Heart rate is therefore a commonly used proxy of training intensity.

# CV training zones by HR

Figure 1.1 The four cardiovascular training zones



ACSM Position Stand on Cardiorespiratory Fitness (1998)



# Moderate zone

## (55-69%MHR / 40-59%HRR)

- Safe for unfit clients/ new exercisers.
- “Fairly light” intensity = improved compliance.
- Engages Type 1 slow oxidative fibres which use intramuscular triglyceride stores and free fatty acids as energy source.
- In *sufficient quantity* will improve health status.
- Low intensity = longer duration required to achieve required calorie consumption.

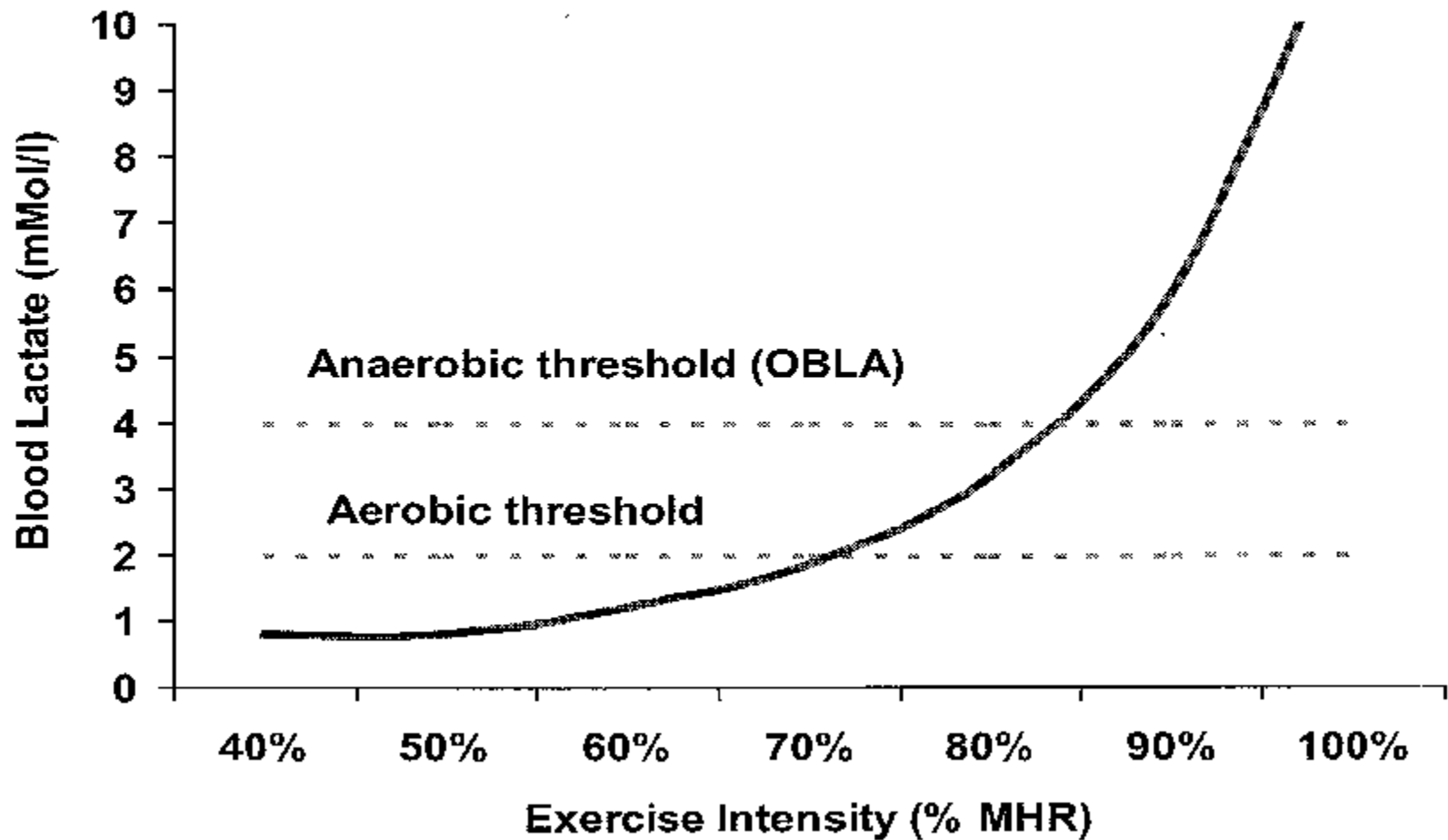


# Fitness (Training) Zone (70-79%MHR / 60-73%HRR)

- “Somewhat hard” to “hard” intensity:  
“Challenging but sustainable”
- Will elicit improvements in aerobic capacity.
- Burns more calories than moderate zone.
- Below anaerobic threshold.
- Can be maintained for 20-60 minutes max.

# Onset Blood Lactate Accumulation (OBLA)

The Lactate Curve





## OBLA zone

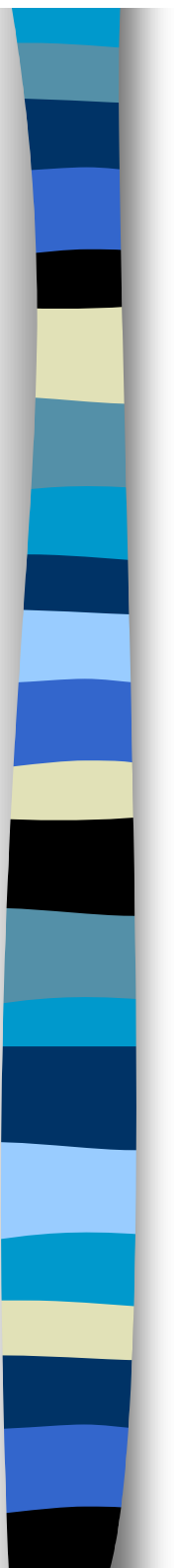
(80-89%MHR / 73-85%HRR)

- **Tempo training:** Exercising just below OBLA. Can only be sustained for 20 minutes max.
- **Cruise intervals:** Alternating work periods of 3-5 minutes just above and below OBLA.



# Anaerobic zone (90-100%MHR / 86-100%HRR)

- **Explosive training:** All out sprints of 10-60 sec duration with longer recovery periods.



# Prescribing & monitoring intensity of training





# Methods of prescribing & monitoring exercise intensity

- % Maximum Heart Rate (Age adjusted)
- Heart Rate Reserve 'Karvonen formula'
- Rate Perceived Exertion (Borg 6-20 Scale)
- Talk test
- MET values
- Observation



## % Maximum Heart Rate (%MHR) age adjusted

- $220 - \text{age} \pm 10\text{BPM}$
- Simple and quick to calculate.
- Underestimates target HR if pt has high resting HR.
- Only a rough guideline: use in conjunction with RPE.



# % Heart Rate Reserve (%HRR) (Karvonen Formula)

- Takes into account resting heart rate.
- Is equivalent to %VO<sub>2</sub> reserve.  
(previously V<sub>O</sub>2max)
- Is more accurate at lower intensities.
- Should ideally be used with an accurate MHR.
- Resting HR should be recorded after 5 minutes of quiet sitting.



# Heart Rate Reserve (Karvonen Formula)

Target heart rate by % HRR Method:

Target HR =

$$(MHR - RHR) (\text{intensity fraction}) + RHR^*$$

\*Resting HR should be recorded after 5 minutes of quiet sitting. The client should not be excited or stressed as this will cause an elevated HR.

# RPE Borg 6-20 Scale

6

7 **Very, very light**

8

9 **Very light**

10

11 **Fairly light**

11 = aerobic threshold

12

13 **Somewhat hard**

12 – 14 = preferred  
exertion (70-75%MHR)

14

15 **Hard**

16

17 **Very hard**

16-18 Anaerobic threshold

18

19 **Very, very hard**

20

Borg, G. 1982 Psychosocial bases of perceived exertion. *Medicine & Science in Sports & Exercise* 14: 377-381



# Talk Test

- Simple tool to determine aerobic & anaerobic thresholds.
- Patient should be aware of breathing harder than normal but able to talk in short sentences without gasping for breath.
- When sentences become interrupted by the need to take a breath they are reaching the anaerobic threshold.
- “Challenging but sustainable”

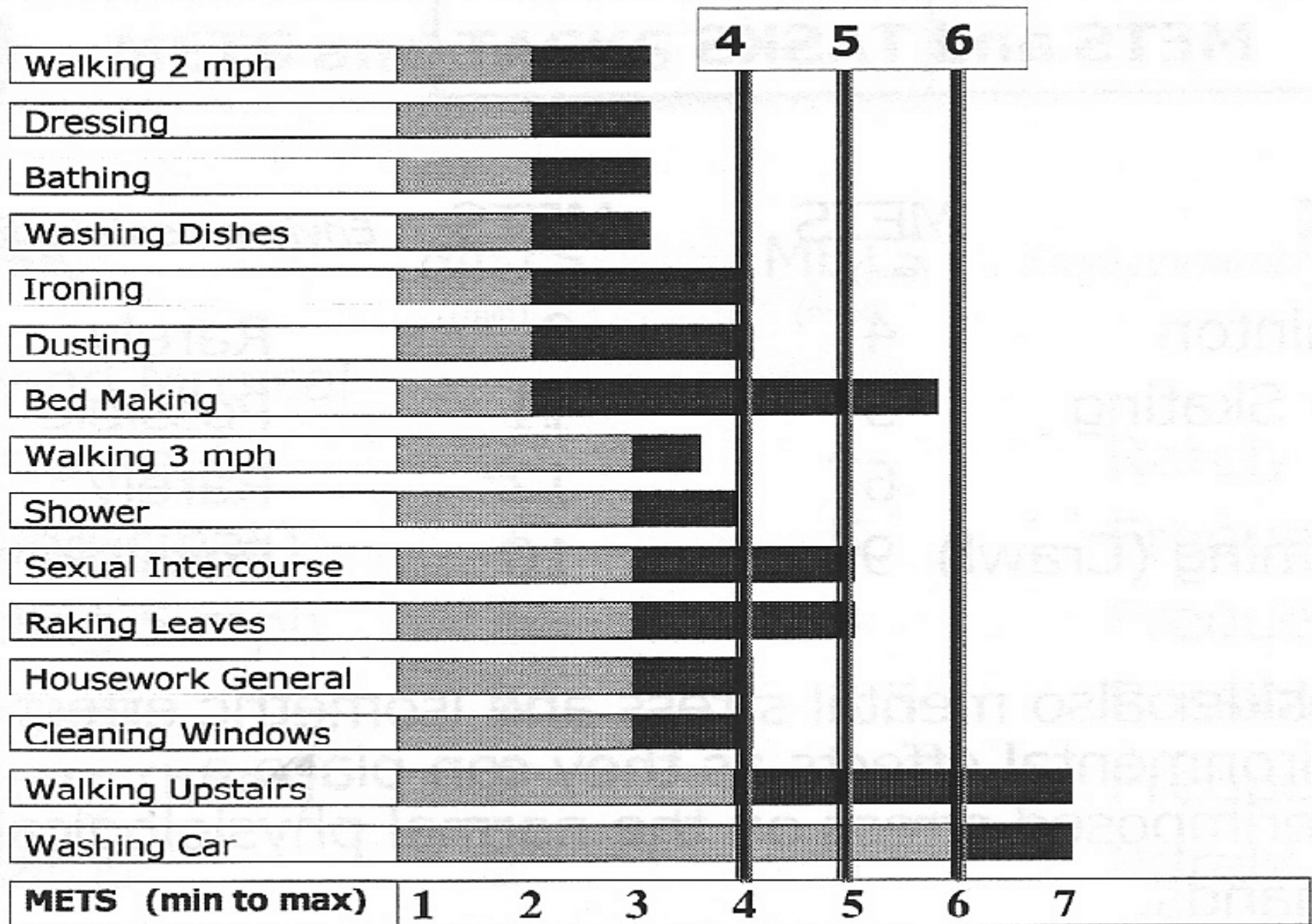
Persinger et al (2004) Consistency of the talk test for exercise prescription. MSSE 36 (9) 1632-1636



# Metabolic Equivalents (METS)

- Multiple of resting oxygen metabolism: corresponds with  $V_{O_2}$
- 1 MET = 3.5ml/kg/min of oxygen
- MET tables have been produced by ACSM
- Limited value as most activities vary in intensity.
- Useful in advising cardiac patients re activities

# MET values: some examples





# Observation

- Shortness of breath
- Facial expression
- Posture
- Quality of movement
- Skin colour (flushed / pallor / cyanosis)
- Sweating
  
- Also bear in mind medical history



# Summary of 1998 ACSM training guidelines

- Incorporate a 5-15 min warm-up @ 50% training stimulus.
- FITT: 3-5/week, 50-85%MHR (60-80% HRR) 20-60 mins, aerobic type activities.
- Progress by increasing duration first, then intensity.
- Cool down until HR is within 20BPM of starting HR to prevent venous pooling.
- Find an enjoyable activity= better adherence
- More volume of ex (2000kcal/week) required for weight loss



# Reference for ACSM training guidelines

“The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults”.

Position Stand 1998 Medicine & Science in Sports & Exercise Vol 30 (6)

# Risk Stratification





# Risk stratification

- Vigorous exercise is 10 times more likely to trigger an ischaemic cardiac event in someone with CV disease than a healthy person.
- Screening for CV and other known risk factors is therefore recommended.



# Pre-exercise screening

- **PAR Q (used in gyms)**
- **ACSM Risk Stratification (2006)**



# ACSM screening questions

## 1: Cardiac risk factors:

1. Family history of early CV disease? Relative must have been <55 male, <65 female.
2. Smoked within last 6 months?
3. Hypertension (>140/90) or on BP medication?
4. Hypercholesterolaemia (on statins?)
5. Diabetic or raised fasting glucose >100?
6. BMI >30 or waist circumference >88cm/34.6" female or >102cm/40" male?
7. Sedentary i.e. not meeting current PA guidelines)?



# ACSM screening cont.

## 2: Symptoms

1. Chest pain or discomfort?
2. Dizzy spells or fainting?
3. Breathing difficulty in lying/sleeping?
4. Swollen ankles?
5. Palpitations/heart murmur?
6. Leg pain/cramping?
7. Breathing difficulties or unusual fatigue with usual activities?



# ACSM screening cont.

## 3: Other

1. Are you 45 or over (man) or 55 (woman)?
2. Any h/o: CHD, PVD, chronic respiratory disease, asthma, diabetes, thyroid disorder, renal or liver disease?
3. Any bone or joint problems that may worsen with exercise?
4. Do you have a cold or other infection?
5. Are you pregnant?
6. Any other problem that might make it difficult to do strenuous exercise?



## Low risk

Younger (<44 men, <54 women)

- No more than one coronary disease factor.
- No symptoms or known disease.
- **Can do maximal testing and enter a vigorous exercise programme.**



## Moderate Risk

- Age: >45 men >55 women.
- Two or more coronary risk factors.

**Can do sub-maximal testing  
or enter a moderate exercise  
programme.**



## High risk

- One or more symptom of cardiopulmonary disease (hypertension, dyslipidaemia)
- Known CV, pulmonary or metabolic disease.

**Written authorisation from specialist is advisable before starting a progressive exercise programme.**

# Questions





# Bibliography

- AE Hardman & DJ Stensel 2003 *Physical Activity & Health: The Evidence Explained* Routledge.
- 2006 *ACSM's Guidelines for Exercise Testing and Prescription*, 7<sup>th</sup> ed. Lippincott Williams & Wilkins.
- Brian J. Sharkey *Fitness & Health* 5<sup>th</sup> ed. 2002 Human Kinetics.
- *Exercise Prescription* 2<sup>nd</sup> Ed 2007 A Case Study Approach to the ACSM Guidelines. D Swain & B Leuthotz. Human Kinetics

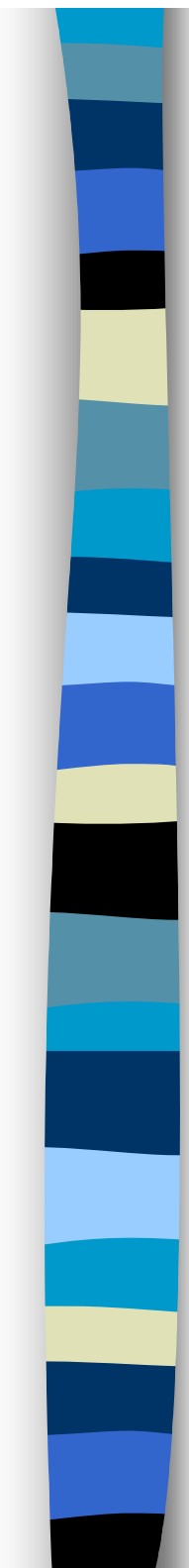


# Afternoon session

# Quiz

## Questions

## Answers

- 
- 1/ How much moderate intensity activity is required to meet current UK guidelines?
  - 2/ What is the required sub-maximal exercise intensity range (in %MHR) to improve cardiorespiratory fitness? What is this called?
  - 3/ Give another name for the anaerobic threshold.
  - 4/ According to ACSM guidelines, what should be the length (range) of the warm-up? What should determine the duration?
  - 5/ What does the cool down help to prevent? What is the target HR?
  - 6/ What is the predominant fuel source utilised during moderate intensity exercise?
  - 7/ Give a definition and the value of 1 MET.
  - 8/ What are the limitations of using heart rate in monitoring exercise intensity?



# % Maximum Heart Rate (%MHR) age adjusted

Target heart rate by % MHR method:

$$\text{MHR} = 220 - \text{age}^*$$

$$\text{Target HR} = (\text{intensity fraction})(\text{MHR})$$

\* Standard deviation of  $\pm 20$  bpm



# WORKSHEET

## HEART RATE TRAINING ZONES

**% Max Heart Rate (MHR) (age adjusted)**

**MHR = (220 – age)**

**55%      MHR x 0.55 =**

**70%      MHR x 0.7 =**

**80%      MHR x 0.8 =**

**90%      MHR x 0.9 =**



# Percentage Heart Rate Reserve

- Take your pulse for 15 seconds & multiply by 4 to obtain resting heart rate (RHR). Write this on the worksheet.
- Work out HRR (**MHR-RHR**) and use to calculate the following training intensities:

**40%     $HRR \times 0.4 + RHR =$**

**60%     $HRR \times 0.6 + RHR =$**

**73%     $HRR \times 0.73 + RHR =$**

**85%     $HRR \times 0.85 + RHR =$**



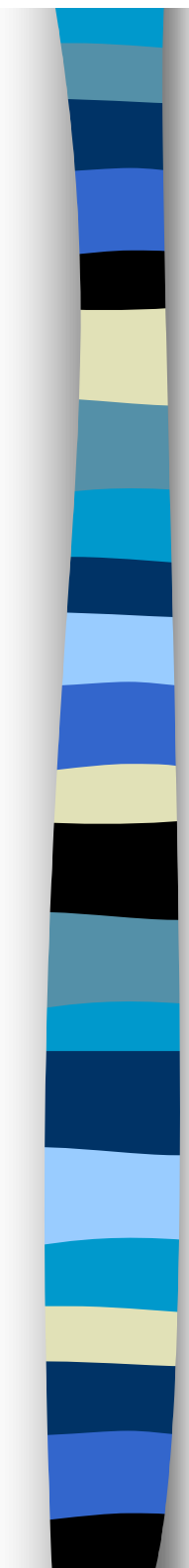
# Heart Rate Reserve (Karvonen Formula)

Target heart rate by % HRR Method:

Target HR =

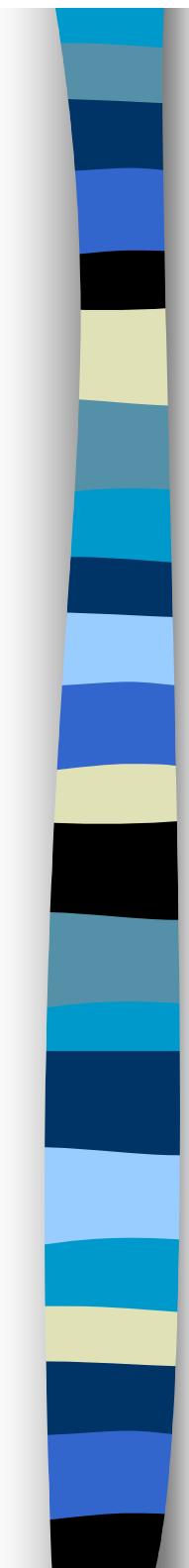
$$(MHR - RHR) (\text{intensity fraction}) + RHR^*$$

\*Resting HR should be recorded after 5 minutes of quiet sitting. The client should not be excited or stressed as this will cause an elevated HR.



## Now recalculate %HRR using a hypothetical higher or lower heart rate $\pm 20$ BPM

- Fill out the table at the bottom of the worksheet and observe the different values.
- Remember that in the absence of an *actual* maximum heart rate, HRR has the same potential for error and should be used in conjunction with other methods.



## Table 3: Compare values from MHR and HRR methods.

- Write values in the bottom table on worksheet

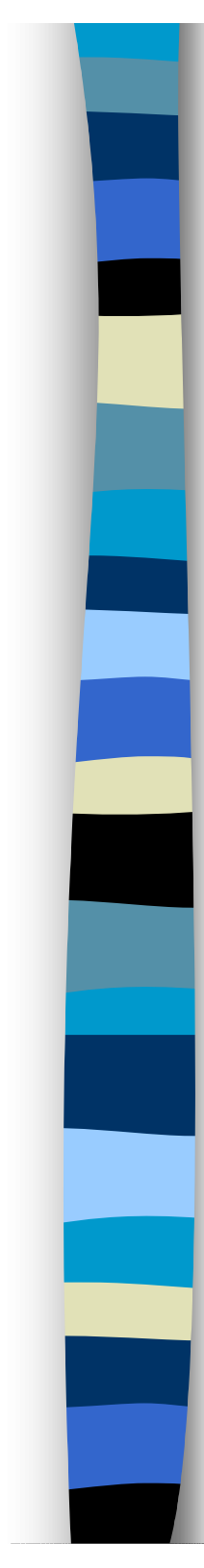
# Julie's table

**Age: 43**

**MHR: 177**

**RHR: 57**

% HR	MHR method	HRR method RHR: 57BPM HRR = 120	HRR method RHR:77BPM HRR =100
55 MHR 40 HRR	97	105	117
70 MHR 60 HRR	124	129	137
80 MHR 73 HRR	142	145	150
90 MHR 85 HRR	159	159	162



# Observation of an incremental exercise test (treadmill)

- Observe methods of monitoring exercise intensity (Heart rate, respiratory rate, RPE & talk test)
- Observe effects of exercising at different intensities on the exerciser.
- It is not advisable to attempt  $> 80\%MHR$  with your client!  
(see risk stratification criteria)



# Field tests for CV fitness

- Incremental Shuttle Walk Test (ISWT)
- Six minute walk test (6MWD)
- YMCA 3 minute step test.
- Chester step test (incremental)



# Incremental Shuttle Walk Test

- 10m shuttles with externally paced bleep increasing in speed each minute.
- Correlates with TMT & V02 peak
- Not suitable if mobility is impaired by LL musculoskeletal problems or claudication.
- Requires a practice test and use of standardised instructions.
- Can be used in conjunction with the Endurance Shuttle Walk Test.

Singh SJ, Morgan MDL, Hardman AE (1994) Eur Respir J vol 7: pp 2016-20



# Six minute walk test

- Self-paced walk test with standardised instructions. Patient can stop & rest in (standing) as required.
- Measures walking tolerance which is a proxy of functional capacity.
- Is more suitable than the ISWT for slow walkers and mobility-impaired patients.
- Practice is not required.



## Six minute walk test cont.

- 30m course recommended but 10m shuttles are commonly used.
- Contraindications: unstable angina or MI in the last month / BP >180/100 resting HR>120.

ATS Guidelines for the 6MWT(2002) Am J Resp Crit Care Med 166: pp111-117



# YMCA 3 minute step test

- Simple & quick to administer.
- Requires a 12" step and metronome.
- Patient steps at the rate of 24 complete steps up & down /min
- Stop at 3 minutes, rest in a chair and take the pulse after exactly 1 min.
- Not suitable for patients unable to manage steps or the required speed!

[http://www.health.harvard.edu/newsweek/Aerobic\\_Fitness\\_Test\\_The\\_Step\\_Method.htm](http://www.health.harvard.edu/newsweek/Aerobic_Fitness_Test_The_Step_Method.htm)



# Chester Step test

- Requires the Chester Test CD, heart rate monitor & BORG scale.
- Stepping rate increases incrementally after every 2 minutes until 80% MHR is reached.



## If none of these are suitable...

- Find a mode of exercise which the patient can manage which provokes a CV response.
- After a short practice (warm-up intensity), ask them to exercise for as long as possible at their preferred exertion.
- Record length of time, heart rate & RPE immediately on completion and time to recovery.
- This can be used as a benchmark for changes.



# Learning objectives: practical

- To observe a progressive fitness test and the use of exercise intensity monitoring.
- To learn how to assess the patient's risk level through the use of a risk stratification tool and how this affects exercise prescription.
- To increase confidence in prescribing effective CV exercise taking into account known risk factors & physical limitations.



# Learning objectives

- To be appraised of some of the research evidence for the benefits of regular cardiovascular exercise.
- To become aware of current physical activity guidelines and CV training recommendations.
- To understand physiological adaptations to CV training & how this relates to training intensity.
- To be able to prescribe and monitor CV exercise at different intensities.
- To understand the importance of risk stratification.
- To gain an overview of selected field tests in evaluating CV fitness.