INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

CARDIORESPIRATORY FITNESS (CRF) ASSESSMENT AND EDUCATION

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DISCLOSURES

- Expert Witness (cardiovascular health and disease, medical evaluations, fitness, heat stress)
- Consultant (medical evaluations, cardiovascular, rhabdomyolysis, FF H&S)
- Member of NFPA Technical Committee on FS Occupational Safety and Health

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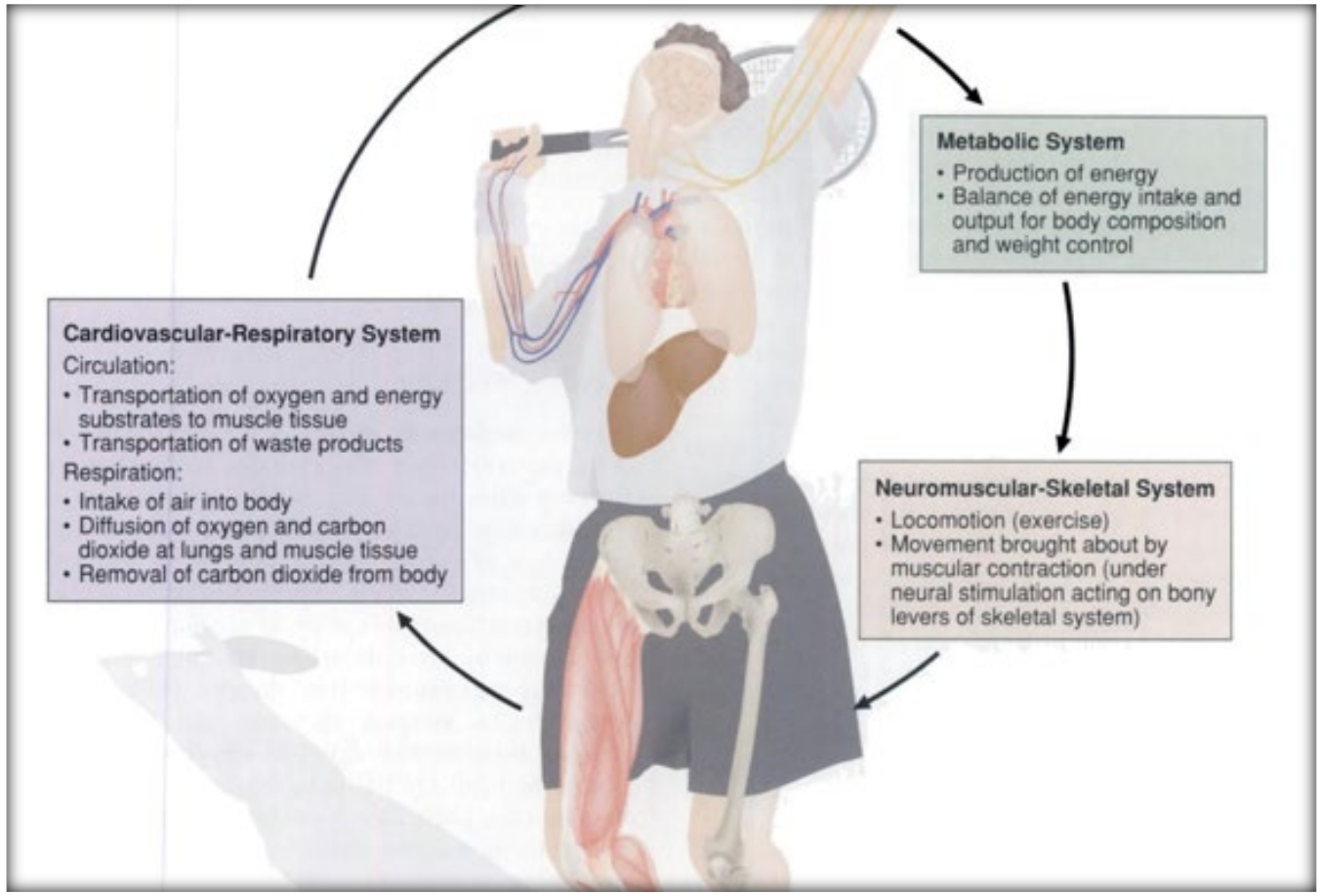
- Consultant (medical evaluations, cardiovascular, FF H&S)
- Member of NFPA Technical Committee on FS Occupational Safety and Health
- Member of IAFF Physicians Advisory Panel
- Member of IAFF WFI SME Panel

- **WHAT IS CRF FITNESS?**
- HOW IS CRF MEASURED/ASSESSED
- WHY IS CRF IMPORTANT
- ROLE OF CRF IN MEDICAL EVALUATION
- WORK EVALUATION VS CRF
- STRATEGIES TO IMPROVE CRF

CARDIORESPIRATORY FITNESS (CRF)



CRF is an objective measure of the integrated ability of respiratory system to take in, the cardiovascular system to deliver, and the muscles to use oxygen to produce energy to support heavy muscular work.

CARDIORESPIRATORY FITNESS (CRF)

- Also called maximal oxygen consumption (VO_2max) or aerobic capacity
- Criterion measure of physical fitness

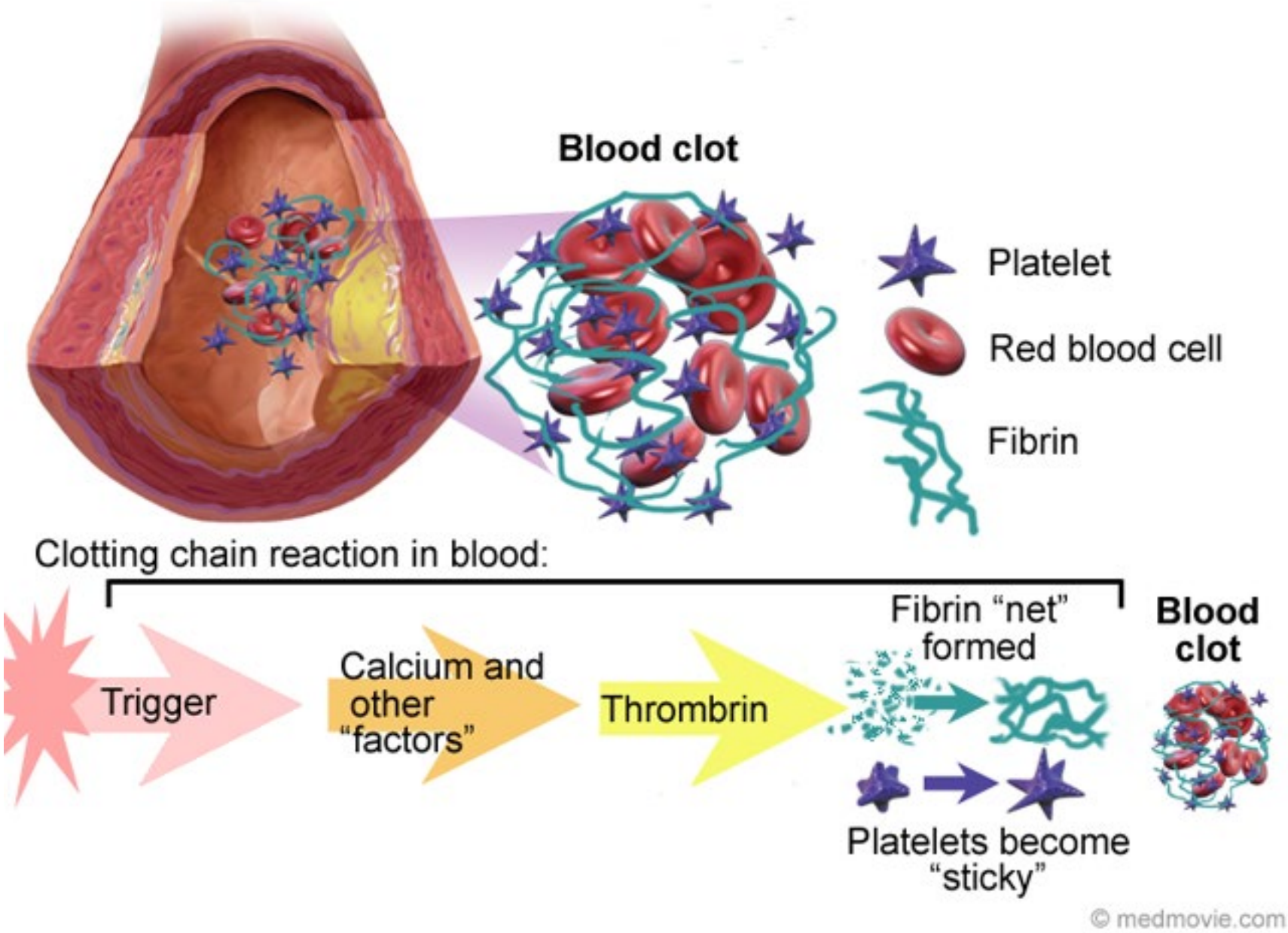
WHAT HAPPENS TO THE BODY

During interior attack:

- Heart rate can hit 85–100% max
- Core temperature rises rapidly
- Blood thickens from dehydration
- Platelets become stickier
- Blood pressure spikes
- Sympathetic nervous system surges

Table 1. Cardiovascular and metabolic responses during strenuous firefighting.

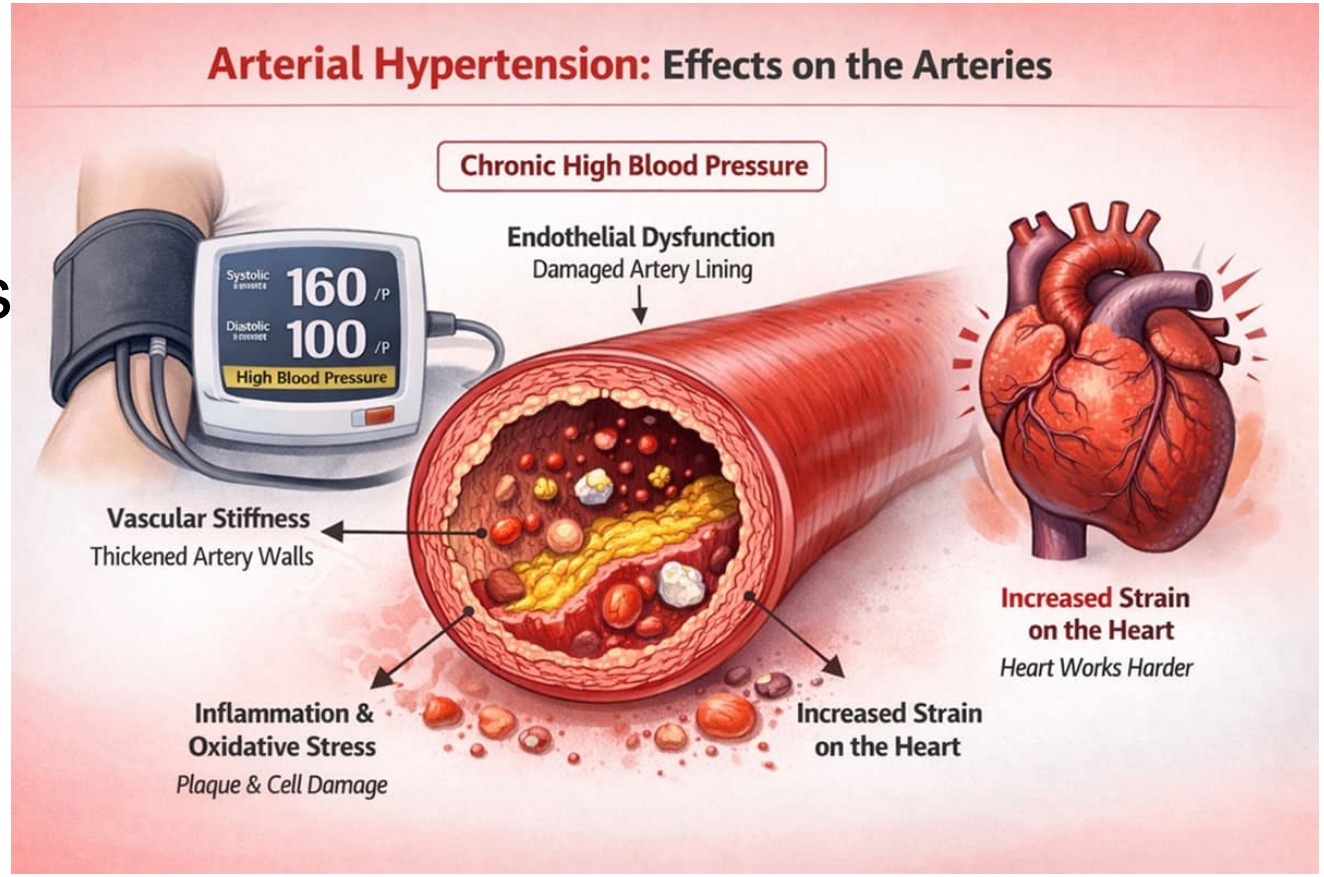
Variable	Rest	Firefighting
Heart rate (bpm)	70	192
Stroke volume (mL/beat)	85	130
Cardiac output (L/min)	5.7	25
Oxygen consumption (mL/kg/min)	3.5	45.5


Blood clot
Platelet
Red blood cell
Fibrin
Clotting chain reaction in blood:
Trigger
Calcium and other "factors"
Thrombrin
Fibrin "net" formed
Platelets become "sticky"
Blood clot
© medmovie.com

TAXING THE HEART AND SYSTEM

If your fitness is low:

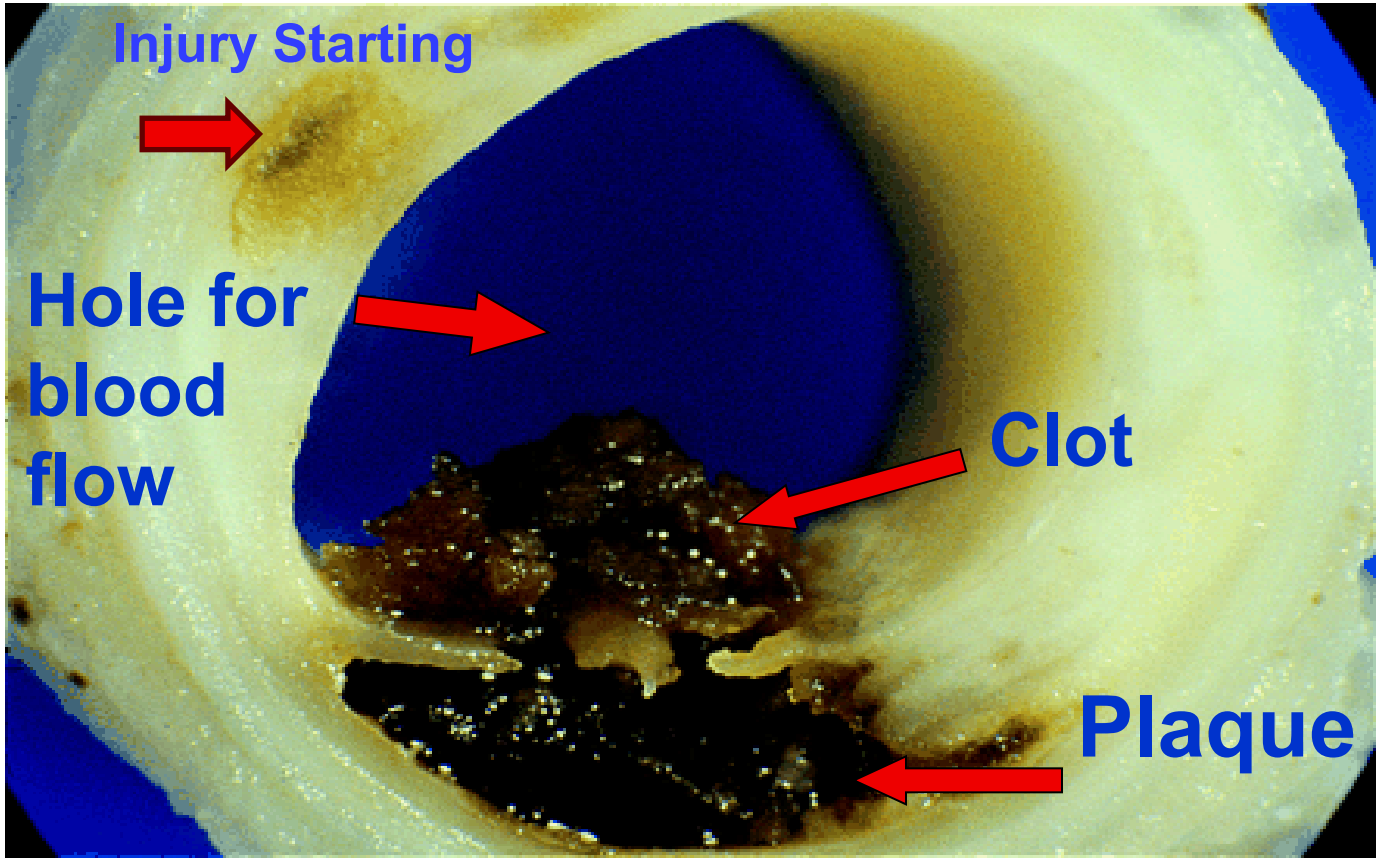
- Your heart works harder
- Your blood pressure spikes higher
- Your recovery is slower
- Your risk of cardiac event increases



CLOT FROM PLAQUE RUPTURE

This is the perfect storm for:

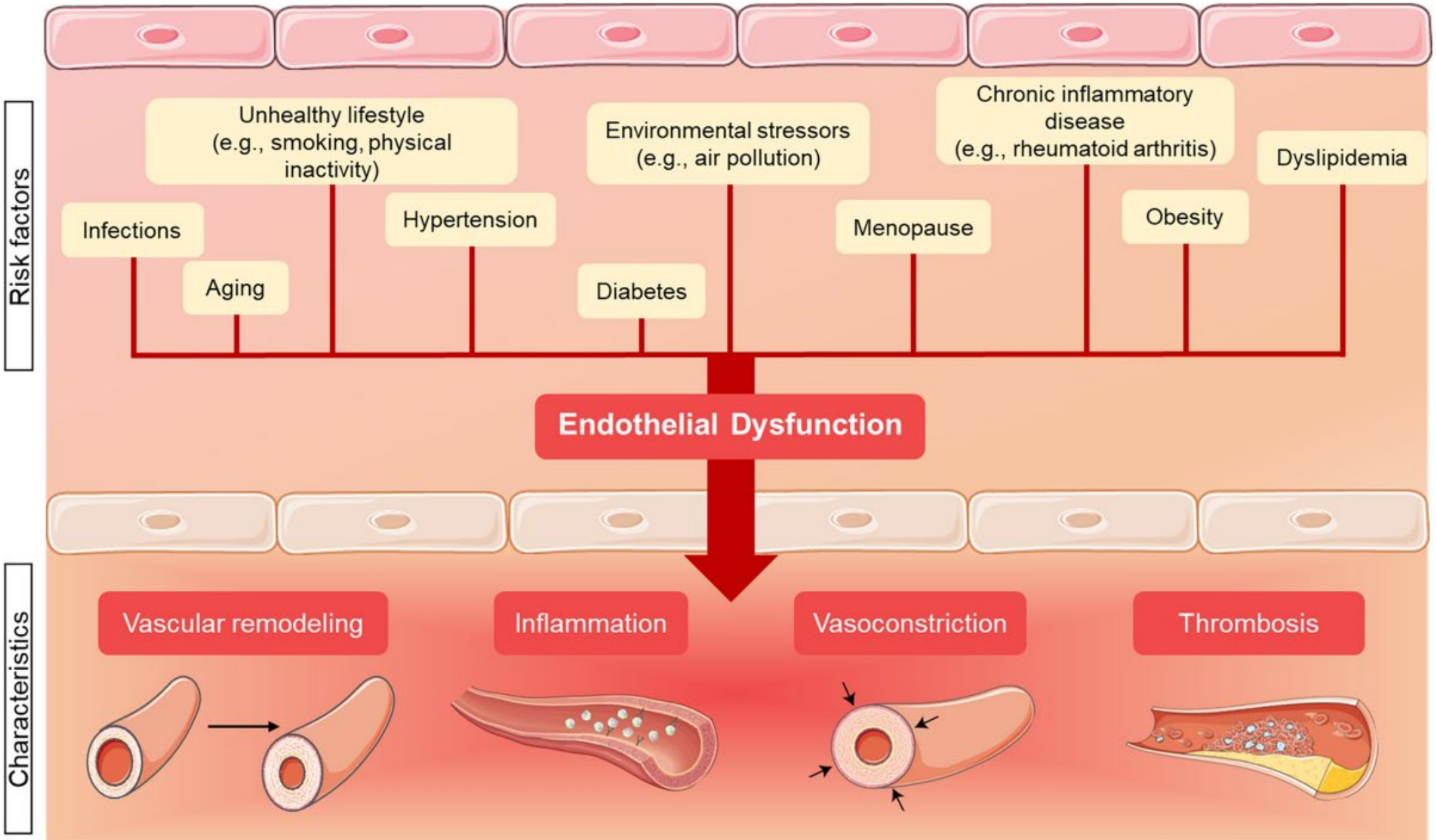
- Plaque rupture
- Arrhythmias
- Sudden cardiac arrest



Identifying the vulnerable plaque: A review of invasive and non-invasive imaging modalities
Jan G. Kips published in ***Artery Research*** *Volume 2, Issue 1 , Pages 21-34, February 2008*

LET'S NOT ADD FUEL TO THE FIRE

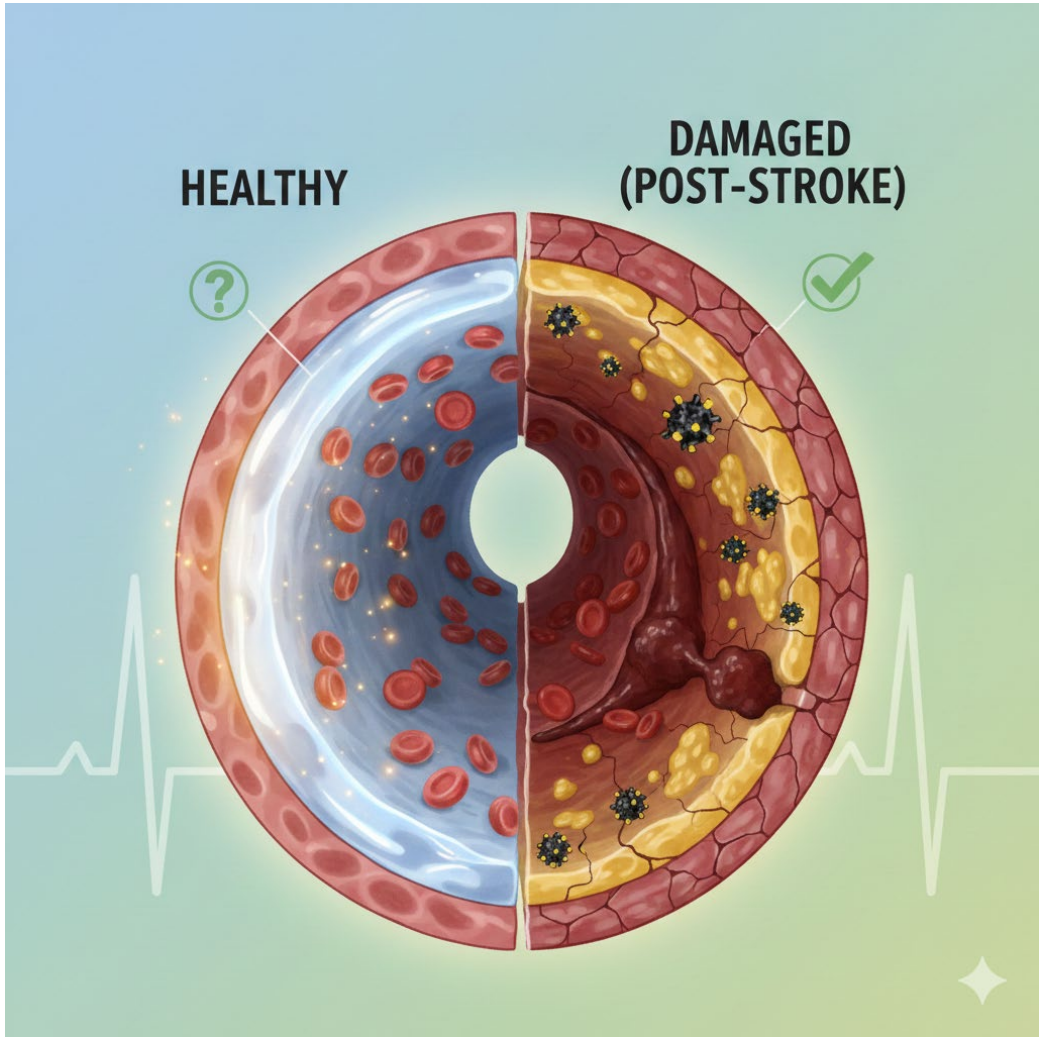
- Full PPE + SCBA = 45–75 extra pounds
- Heat stress = increased cardiac strain
- Adrenaline spike = elevated blood pressure


Risk factors
Unhealthy lifestyle (e.g., smoking, physical inactivity)
Environmental stressors (e.g., air pollution)
Chronic inflammatory disease (e.g., rheumatoid arthritis)
Dyslipidemia
Infections
Aging
Hypertension
Diabetes
Menopause
Obesity
Endothelial Dysfunction
Characteristics
Vascular remodeling
Inflammation
Vasoconstriction
Thrombosis

HOW INCREASED CRF HELPS

Fitness improves:

- Endothelial function
- Stroke volume
- Blood pressure regulation
- Recovery time
- Heat tolerance



- WHAT IS CRF FITNESS
- **HOW IS CRF MEASURED/ASSESSED?**
- WHY IS CRF IMPORTANT
- ROLE OF CRF IN MEDICAL EVALUATION
- WORK EVALUATION VS CRF
- STRATEGIES TO IMPROVE CRF

MEASURING CRF

- VO_2max
- **Measure** *oxygen consumption* (measured in L/minute) during a graded exercise test

- Can be estimated
- Can include ECG

QUANTIFYING CRF

- Maximal oxygen consumption (VO2max) or aerobic capacity
- It is the VOLUME (L) of O_2 taken in, transported and used
- Expressed in L/min or ml/kg/min
  - Can be converted to METs (1 MET = 3.5 ml/kg/min)
  - Dependent on sex and age
  - Interpreted based on
    - %ile
    - % of age-predicted maximum

INTERPRETING CRF

- **Interpreted** based on age and gender

  A VO_2max of 42 ml/kg/min (12 METS) is the 35%ile for 20-29 year old males

  = a Fitness Classification of "**poor**"

  A VO_2max of 42 ml/kg/min (12 METS) is ~85%ile for 50-59 year old males

  = a Fitness Classification of "**excellent**"

WAYS TO ASSESS CRF

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WHY CRF IS IMPORTANT

CRF is important to:

- to do the job
- to do the job safely
- to maintain health and prevent disease

WHY CRF IS IMPORTANT

CRF is an

- Indicator of ability to “do work” (i.e., how much fitness (how many METs) does it take to do certain work

WHY IS CRF IMPORTANT – MEDICAL EVIDENCE

CRF is an overall measure of Health

American Heart Association has proposed CRF as Vital Sign

POWERFUL PREDICTOR OF CVD AND ALL-CAUSE MORTALITY

"CRF was a strong and independent marker of risk for cardiovascular and all-cause mortality. This observation has been made in healthy men and women, those with suspected or known CVD, and those with comorbid conditions, including obesity, T2DM, hypertension, and lipid abnormalities"

BETTER THAN TRADITIONAL RF

CRF has been demonstrated to be a more powerful predictor of mortality risk than traditional risk factors such as hypertension, smoking, obesity, hyperlipidemia, and T2DM.

BETTER THAN TRADITIONAL RF

In addition, CRF has been shown to be a more powerful predictor of risk than other exercise test variables, including ST-segment depression, symptoms, and hemodynamic responses.

DEMONSTRABLE IMPROVEMENT IN SURVIVABILITY

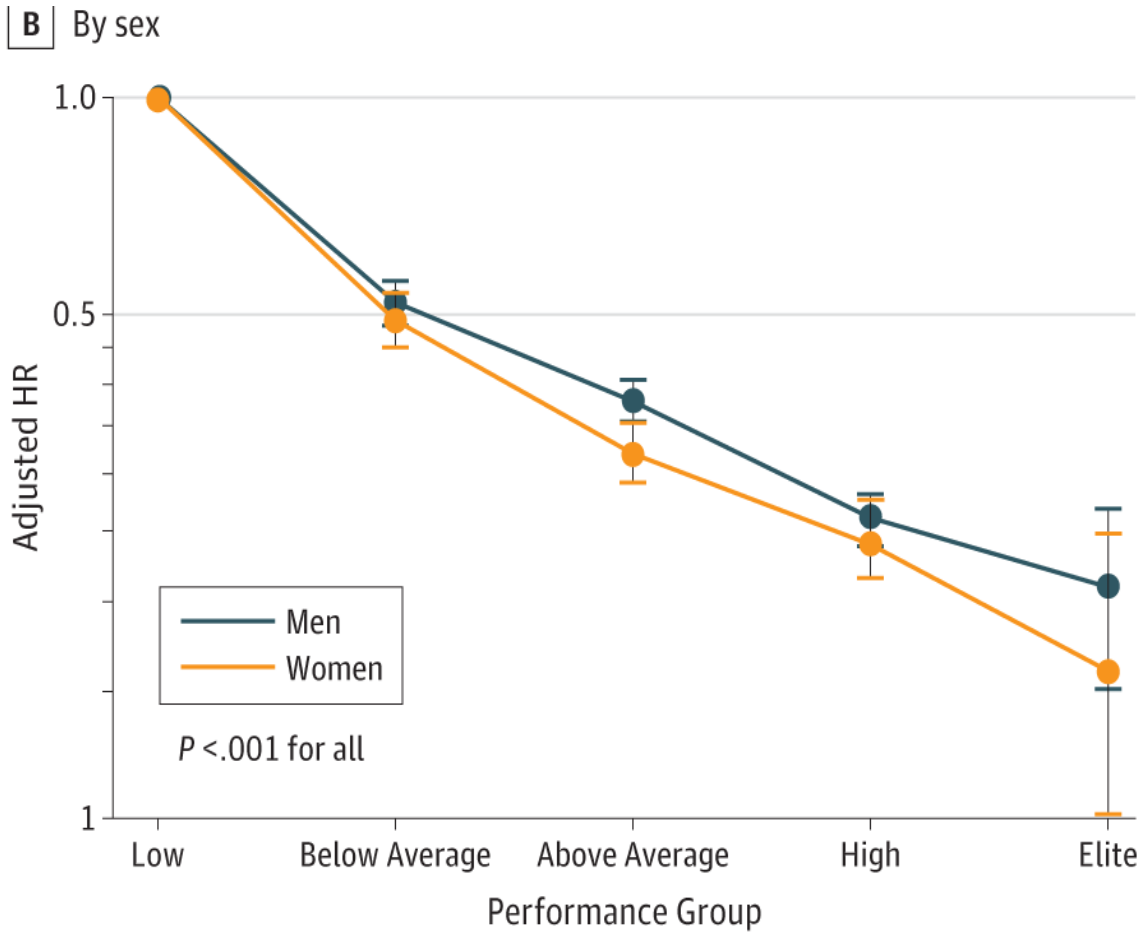
Increasing CRF by 1 MET is associated

with 10%–25% improvement in survival.

SUMMARY: MAJOR BENEFITS OF CRF

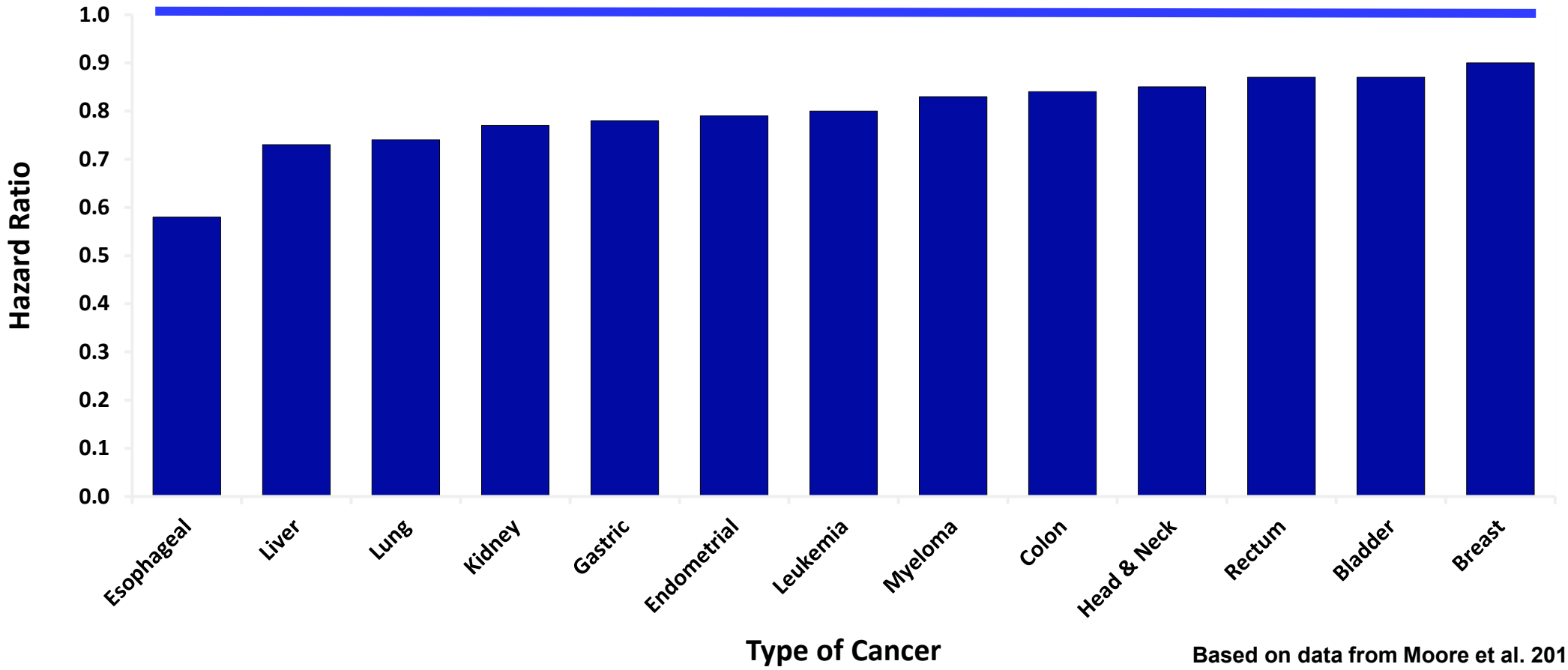
- Improved Work Performance
- Improved Thermal Tolerance (decreased physiological strain)
- Decreased Injury
- Decreased All-cause mortality
- Decreased CV mortality
- Decreased Cancer Mortality
- Decreased Anxiety and Depression

CRF VS MORTALITY



KEY FINDING:
Cardiorespiratory fitness is a modifiable indicator of long-term mortality, and health care professionals should encourage patients to achieve and maintain high levels of fitness.

CANCER RISK AND PHYSICAL ACTIVITY



Based on data from Moore et al. 2016..

THE VITAL SIGN WE ARE MISSING

You measure:

- Blood pressure
- Cholesterol
- Glucose

But CRF is:

- A stronger predictor of mortality than smoking, hypertension, or diabetes in many studies.

Fire fighters deserve to know:

Cardiorespiratory fitness isn’t optional.
It’s protective gear you can’t see.

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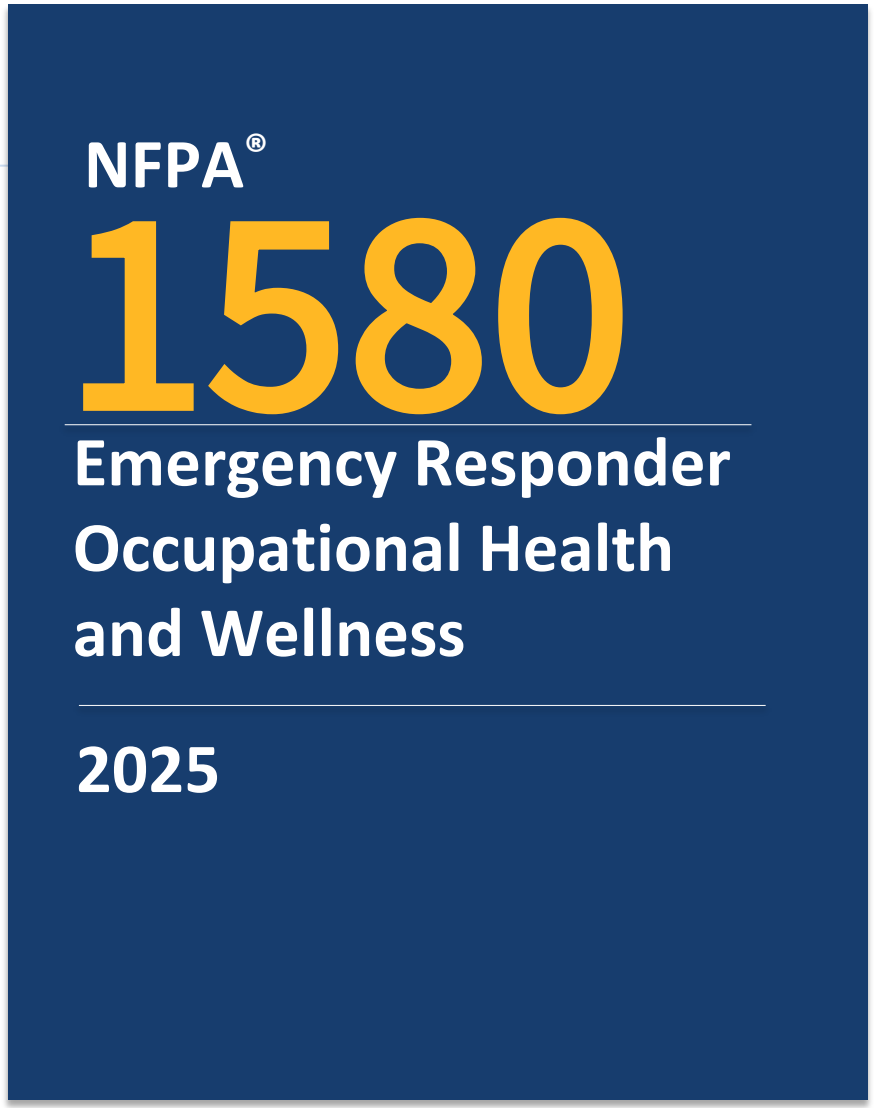
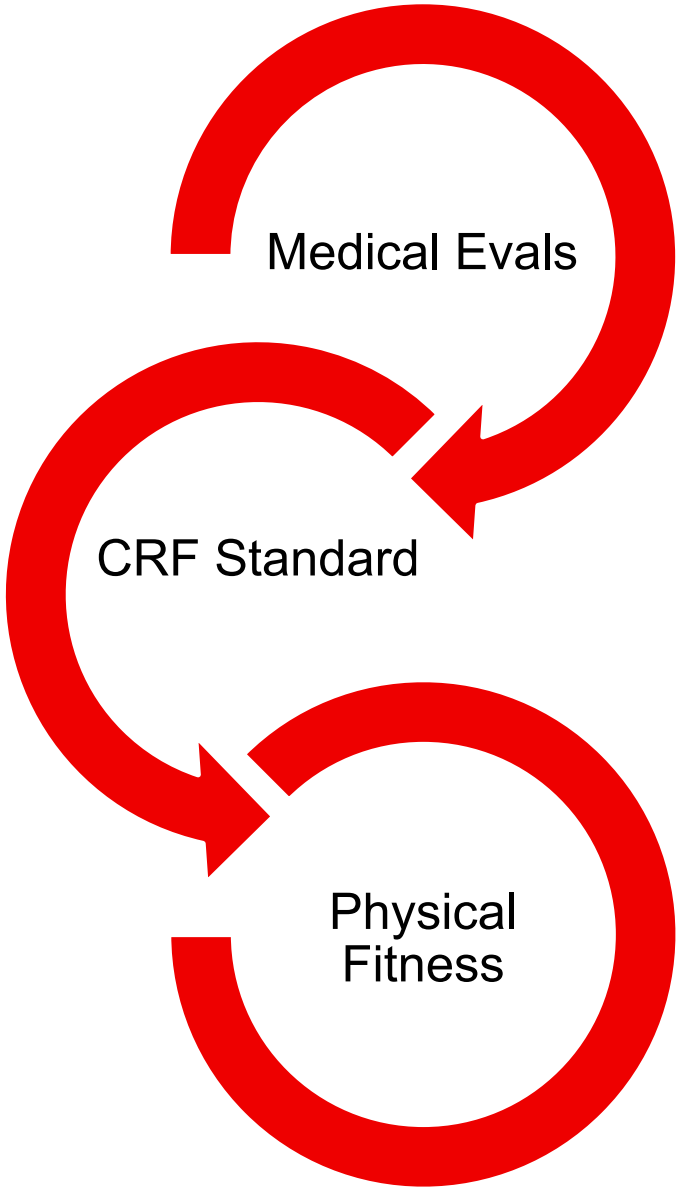
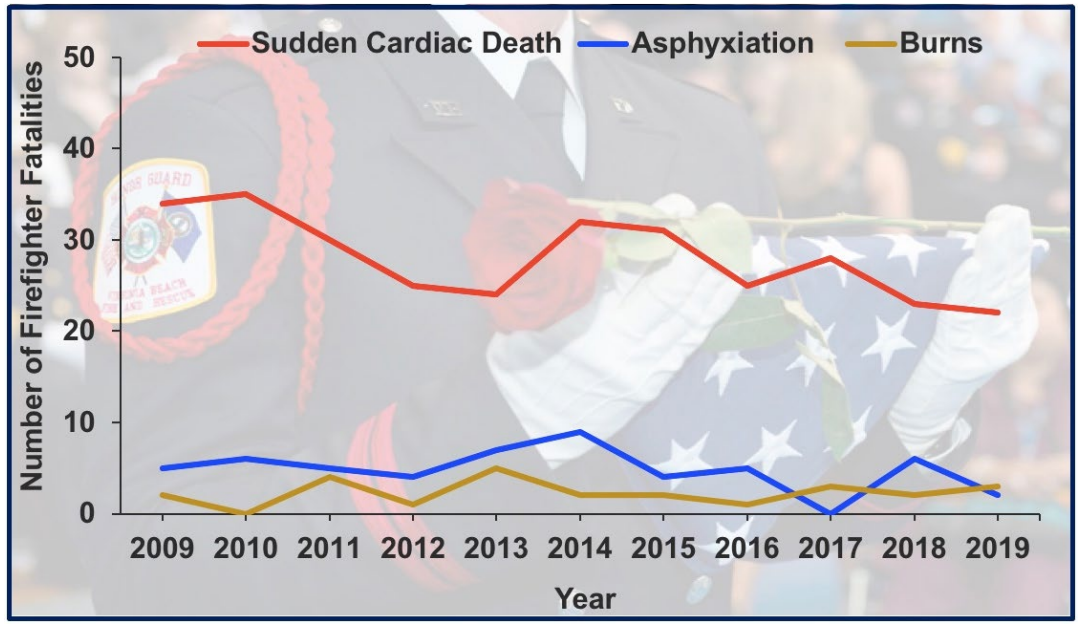
www.NFPA.org/1580next

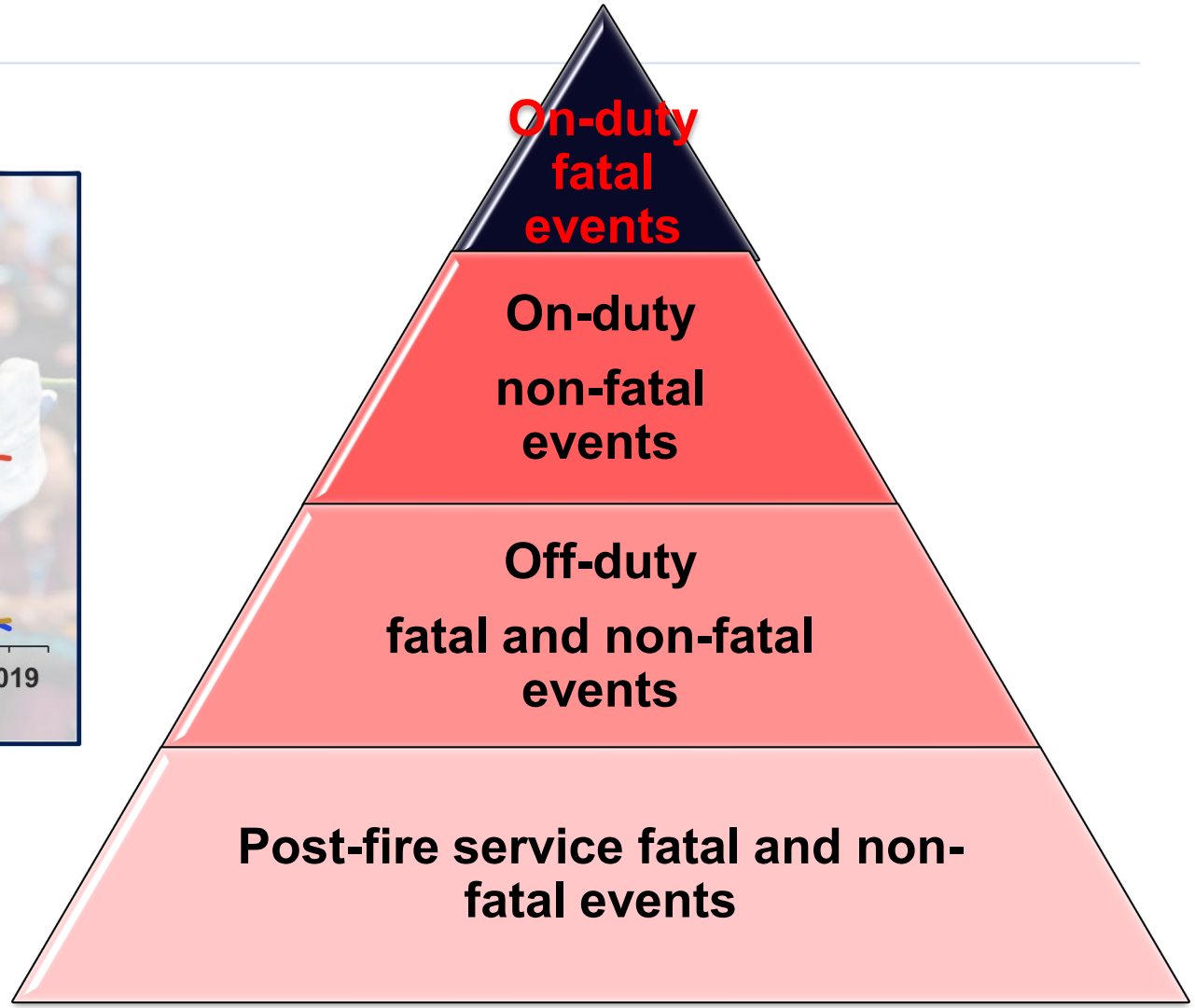




CRF is a strong and independent marker of risk for cardiovascular and all-cause mortality.

BURDEN OF CARDIOVASCULAR DISEASE IN FIRE SERVICE





MULTIPLE BENEFITS OF PHYSICAL FITNESS

- Increased work capacity (faster, more endurance)
- Decreased risk of all-cause mortality
- Improved thermotolerance (heat acclimation)
- Decreased risk of SCE
- Increased likelihood of surviving SCE
- ***Decreases blood pressure, weight, blood sugar, and triglycerides***
- Increases HDL-C
- **Decreases inflammation**
- Improves immune function
- Decreases cancer risk
- Decreases anxiety and depression

***Relative Risk* of Cardiovascular Outcome by Risk Factor**	
Risk Factor	**On-duty CHD Fatalities**
Age ≥ 45 years old	18.0 (8.5–40)
Current Smoking	8.6 (4.2–17)
Hypertension	**12.0 (5.8–25)**
Obesity, BMI ≥ 30 $kg \cdot m^{-2}$	3.1 (1.5–6.6)
Cholesterol ≥ 5.18 $mmol \cdot L^{-1}$	4.4 (1.5–13)
Diabetes mellitus	10.2 (3.7–28)
Prior diagnosis of CHD	35.0 (9.5–128)

Source: Soteraides et al., Cardiovascular Disease in US Firefighters, *Cardiology in Review,* 2011.

IS HTN AN ISSUE IN THE FIRE SERVICE

- Study of 5063 males and 274 females
  - Arizona, Indiana, Illinois, Virginia
- 20–29 years old
  - female FF was 11%
  - male FF was 45%
- 50–59 years old
  - female FF was 79%
  - Male FF was 77%

50th PERCENTILE THRESHOLDS (No Restrictions-fitness programming req'd)

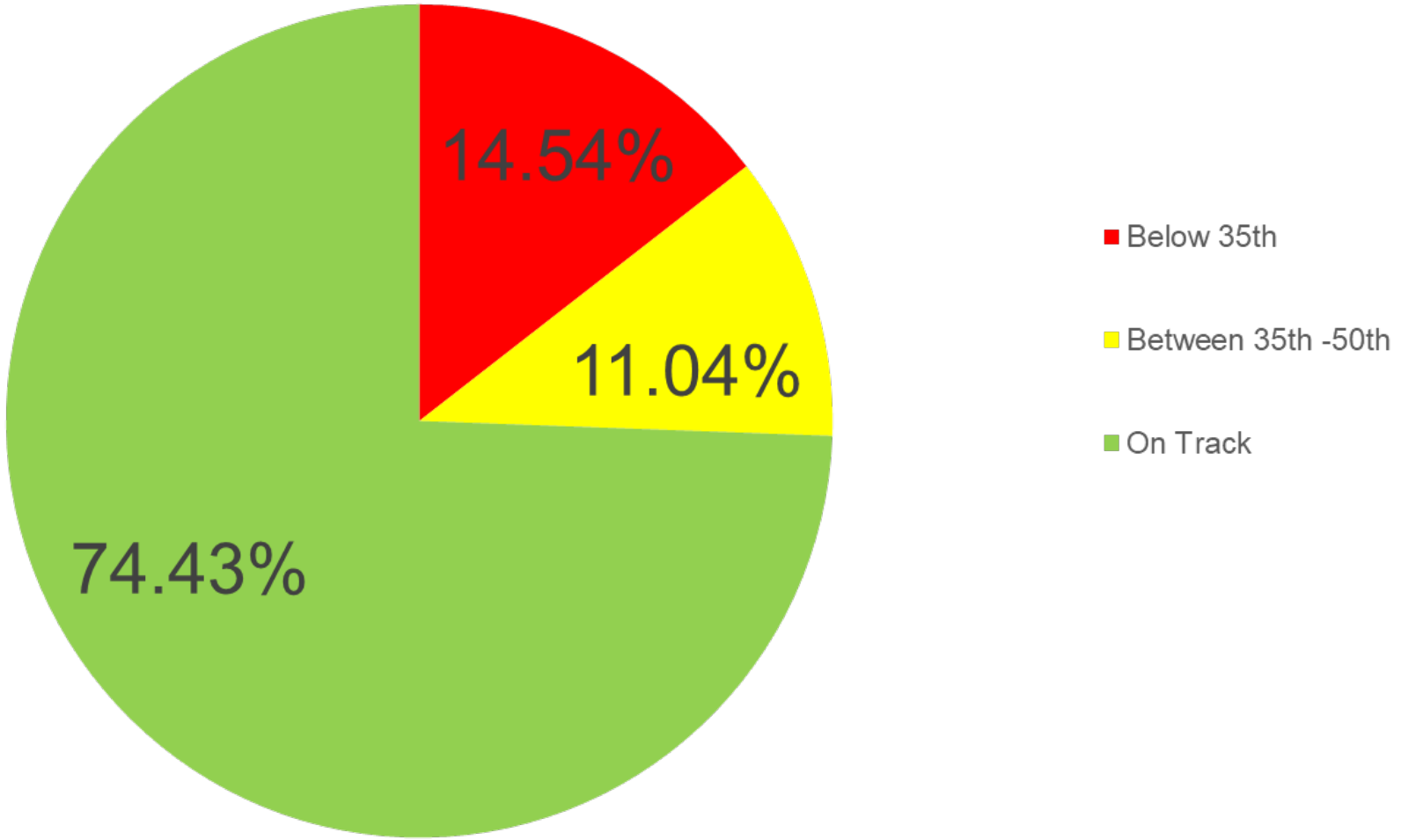
Age	Male METs	Female METs
20–29	12.0	8.9
30–39	8.6	6.2
40–49	7.7	5.5
50–59	7.1	4.9
60–69	6.4	4.6

This is using a cycle ergometer-treadmill numbers are different.

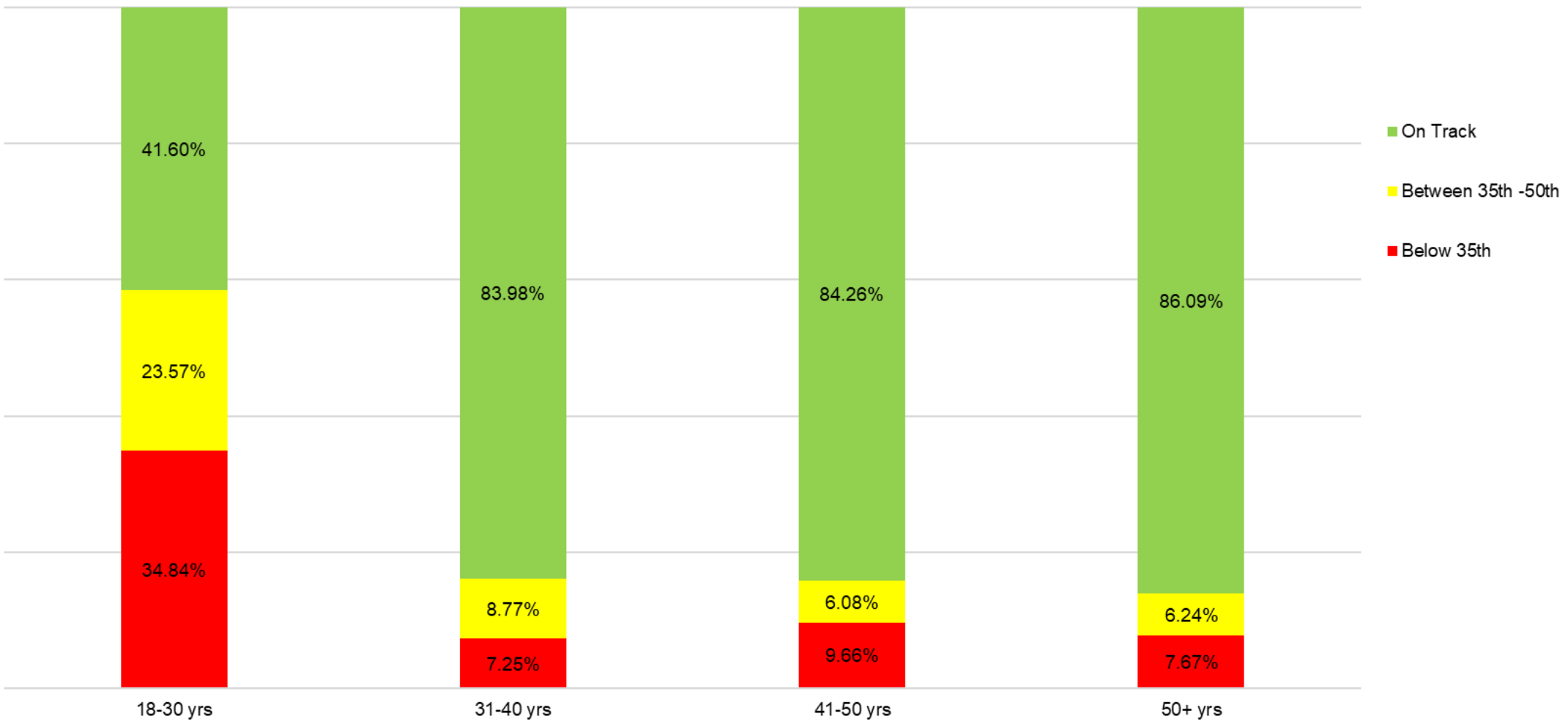
35TH PERCENTILE THRESHOLDS (Restrictions- fitness programming req'd)

Age	Male METs	Female METs
20–29	10.7	7.6
30–39	7.9	5.6
40–49	7.1	5.1
50–59	6.6	4.6
60–69	6.0	4.3

CURRENT MET DATA 3,500 FIRE FIGHTERS



MET DATA BY AGE GROUP



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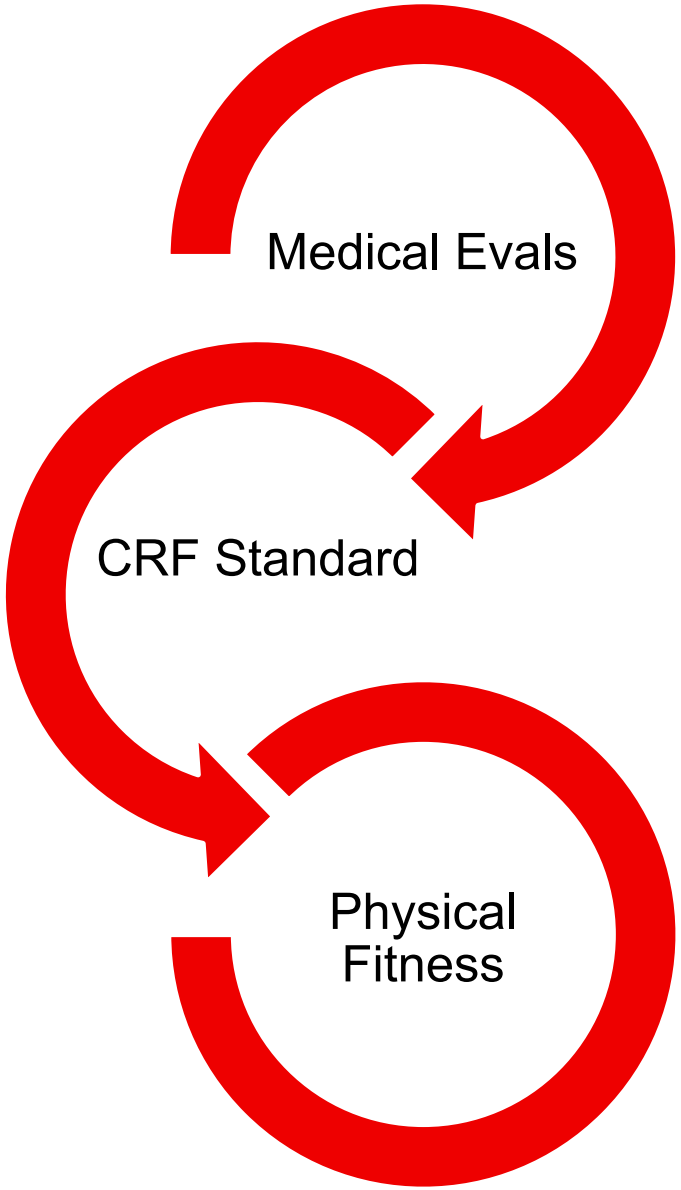
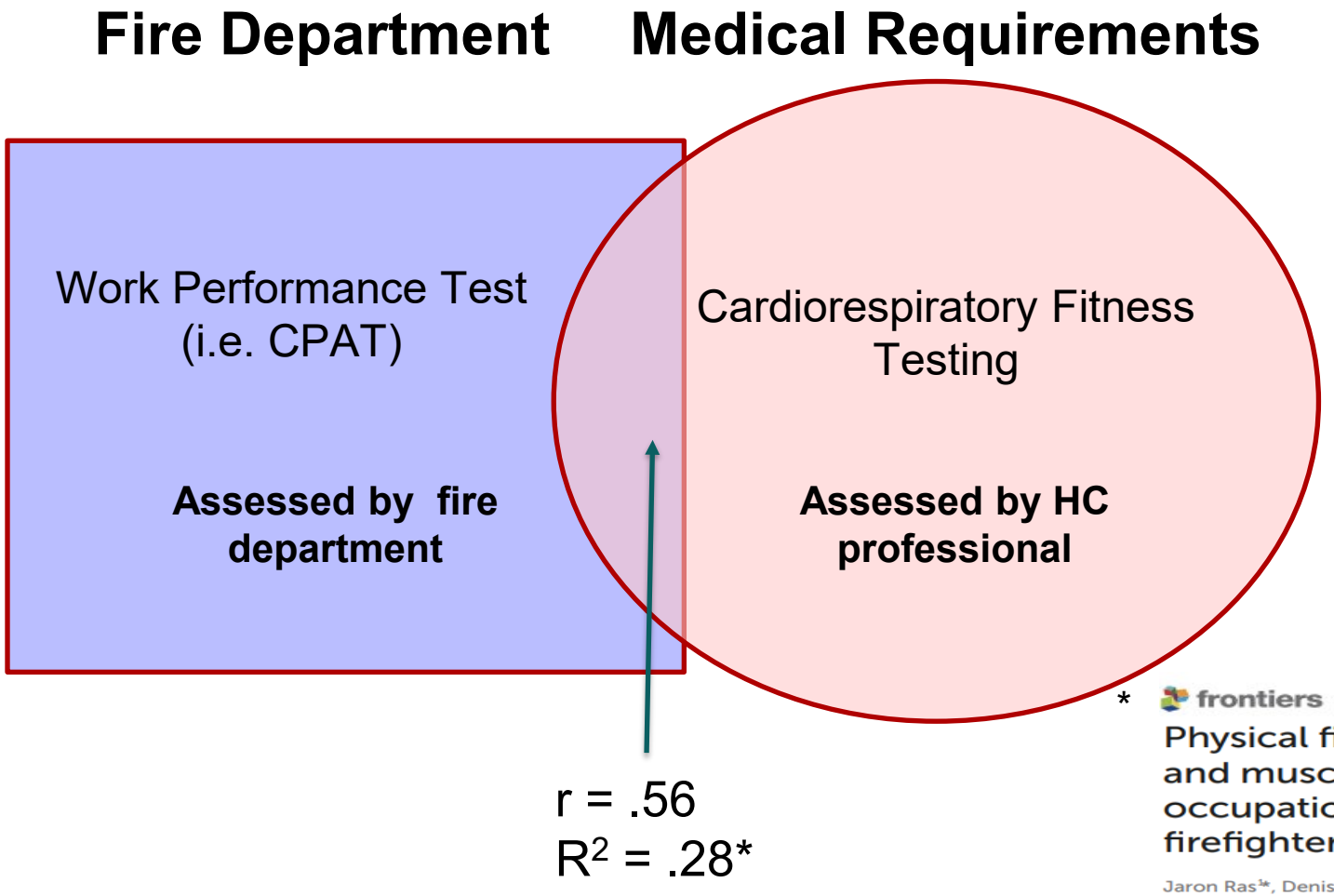


CRF is a strong and independent marker of risk for cardiovascular and all-cause mortality…….

But it is not a work performance test or a physical ability test

CRF IS ASSOCIATED WITH PERFORMANCE



* frontiers | Frontiers in Public Health

Physical fitness, cardiovascular and musculoskeletal health, and occupational performance in firefighters

Jaron Ras[1]*, Denise L. Smith[2], Andre P. Kengne[3], Elpidoforos S. Soteriades[4,5] and Lloyd Leach[1]

TYPE Original Research
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DOI 10.3389/fpubh.2023.1241250

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CRF is improved by doing more “endurance” exercise.

Optimizing CRF improvements is dependent on following key exercise physiology principles:

Overload **– if you want to get better – do more.**
Manipulate - frequency, intensity, time

Specificity **– train for what is important (for VO2max – train for intensity)**

Progression **– once you can do the same amount of work with less strain, increase the work (increase distance, or decrease time)**

Recovery **– positive adaptations occur when the muscles and body systems adapt to stress of training. So, must include adequate recovery**

MOST EFFECTIVE TRAINING STIMULI

1. Moderate-Intensity Continuous Training (MICT/Zone 2) – 60-75% VO2max
    * Builds foundation or base for high-intensity work
    * 150-300 min/week

2. Threshold Training– 80-90% VO2max
    * Increase ability to sustain high-intensity work
    * 20-40 min continuous or 2-3 intervals x 10-15 min

3. High-Intensity Interval Training (HIIT) – 90-100% VO2max
    * Increases VO2max
    * 4x4 min at 90-95% HRmax

Efficient Weekly Structure

- 2 sessions of Zone 2 (MICT) – 45 min
- 1 session Threshold Training 30-40 min
- 1 session High-Intensity Interval Training (HIIT) – 15-20 min
- 1 longer aerobic (low intensity) session – optional – 60+ min

SUPPORT AND CONTEXT

- Rate of improvements depend on initial fitness level, training program, recovery and consistency.

- *To support training adaptations*
  - *Get adequate sleep*
  - *Get good nutrition*
  - *Stay hydrated*
  - *Avoid overtraining*
  - *Attend to injuries early*

RECOVERY MATTERS

Fitness doesn’t just affect performance — it affects:

- Post-call recovery
- Sleep quality
- Hormonal balance
- Inflammation levels

AND WE ALL KNOW...

POOR SLEEP + HIGH STRESS + LOW FITNESS = DISASTER RECIPE.

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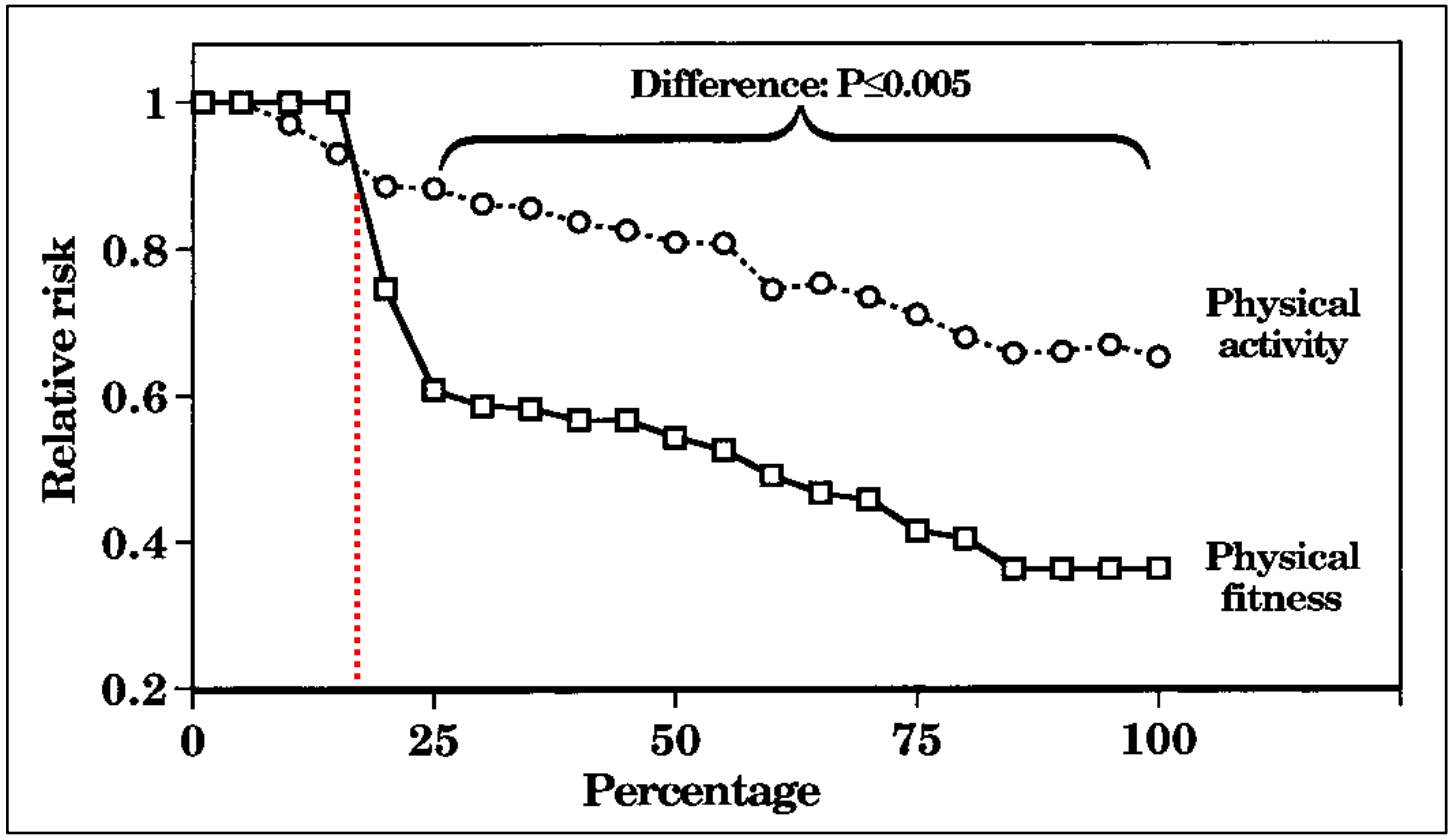
CVD RISK AND PHYSICAL ACTIVITY AND FITNESS

- Much lower risk with being more physically active or fit.
- Greatest benefits seen when low fit person begins exercise.



Williams 2001, *MSSE*.

THE HARD TRUTH

- Sudden cardiac events remain the leading cause of line-of-duty deaths.
- Fire fighters who suffer events had underlying cardiovascular disease and risk factors.
- Lower CRF is strongly associated with higher mortality — regardless of weight.

You can be strong and still be at risk if your aerobic capacity is poor.


GLASBERGEN
"What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?"

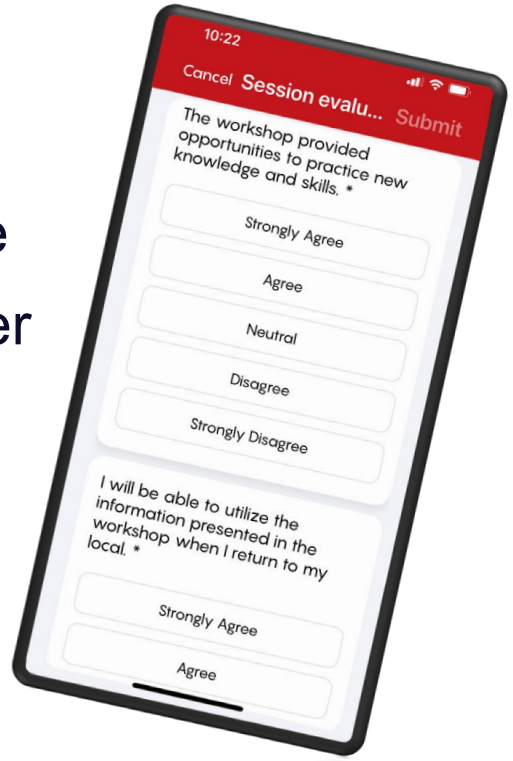
Denise Smith
dsmith@skidmore.edu

Kepra Jack
kepra@heartfitforduty.org

THANK YOU!
ANY QUESTIONS?

EVALUATION AND WIN AN IPAD!

- **Submit your workshop and overall evaluations to be automatically entered in two drawings for a new iPad!**
- **Complete your evaluations using the IAFF app:**
  1. Download the IAFF app and sign in with your iaff.org username
  2. Tap the 2026 Strive for Excellence Summit event image to enter the event's dashboard
  3. Tap "Sessions" and tap on the workshops you attended
  4. Tap "Evaluation" and complete the evaluation
  5. Tap "Submit"



For the event's overall evaluation, follow steps 1 and 2, then tap "Event Evaluation" located in the event's Dashboard.