

FF / EMS Musculoskeletal Injury Prevention On-Duty Fitness Best Practices

November 2021

FF / EMS Musculoskeletal Injury Prevention Document Common Terminology

Advanced Training: Several years of consistent resistance or cardiovascular training.

Aerobic Exercise: Any type of cardiovascular conditioning that relies on oxygen for energy production, such as brisk walking, running, or cycling.

American College of Sports Medicine (ACSM): Advances and integrates scientific research to provide educational and practical applications of exercise science and sports medicine.

Anaerobic Exercise: Short length, high intensity, high power version of exercise that relies on muscle glycogen stores for energy production (in addition to underlying oxygen energy production), such as heavy weightlifting, sprints, and high intensity interval training.

Anaerobic Threshold (AT): The threshold where oxygen energy production alone is no longer sufficient, and anaerobic energy production begins to assist.

Beats Per Minute (BPM): Indicates the number of beats in one minute.

Beginner Training: Untrained or several years of no resistance or cardiovascular training.

Candidate Physical Ability Test (CPAT): Recognized standard for measuring an individual's ability to meet the physical demands of being a firefighter.

Carbon Dioxide Output (VCO₂): The amount of carbon dioxide exhaled from the body per unit time. It is expressed in ml/min. A normal value at rest is around 200 ml/min.

Concentric Contraction: Causes muscles to shorten, thereby generating force.

Dynamic Stretching: A large-movement-based type of stretching that uses the muscles themselves to move joints through their active range of motion.

Eccentric Contraction: Causes muscles to elongate in response to a greater opposing force.

Eccentric Training: Type of muscle activation that increases tension on a muscle as it lengthens. Eccentric contractions occur when a muscle opposes a stronger force, which causes the muscle to contract as it lengthens.

Heart Rate (HR): Number of heart beats per minute.

Inbar Formula: If a Submax Treadmill test cannot be performed, this is the next best option for determining Target Heart Rates (THR). An improved modification of the Karvonen Formula to calculate THR for exercise intensity. **See p. 5.**

- a. Max HR (MHR) calculated at $205.8 - 0.685(\text{age})$ instead of $220 - \text{age}$. RHR is Resting Heart Rate.
- b. $(\text{MHR} - \text{RHR}) \times \text{ ______ } \% + \text{RHR} = \text{THR}$
- c. $\{[205.8 - 0.685(\text{age})] - \text{RHR}\} \times \text{ ______ } \% + \text{RHR} = \text{THR}$
- d. High accuracy of + or - 6 bpm
- e. Example: Target heart rate is 70% intensity program for a 40 y.o. who has RHR of 68:
 - i. $\text{MHR} = 205.8 - 0.685(40) = 205.8 - 27.4 = 178.4 \text{ bpm}$
 - ii. $\text{MHR} - \text{RHR} = 178.4 - 68 = 110.4 \text{ bpm}$
 - iii. $(\text{MHR} - \text{RHR}) \times 70\% = 110.4 \times 0.7 = 77 \text{ bpm}$
 - iv. Add RHR back = $77 \text{ bpm} + 68 \text{ bpm} = 145 \text{ bpm} \pm 6 \text{ bpm}$ is the THR for a 70% target intensity.

Intermediate Training: Six months to several years of consistent resistance or cardiovascular training.

International Association of Fire Chiefs (IAFC): Represents the leadership of firefighters and emergency responders worldwide

International Association of Fire Fighters (IAFF): Labor union representing paid full-time firefighters and emergency medical services personnel in the United States and Canada.

Isometric Contraction: Generates force without changing the length of the muscle.

Karvonen Formula: This is a simplistic formula, but more accurate than MHR formula of $220 - \text{age}$. We recommend the Inbar formula (a modification of the Karvonen formula), above and found on p. 4, if a Submax Treadmill test cannot be performed. Target heart rate intensity goal is a percentage of the heart rate reserve (HRR) added back to the resting heart rate. $\text{HRR} = \text{MHR} - \text{RHR}$. % Target Goal calculation: $\text{ ______ } \% (\text{MHR} - \text{RHR}) + \text{RHR} = \text{Target heart rate}$.

Max Heart Rate (MHR): Max Heart Rate (MHR) is the greatest number of beats per minute your heart can possibly reach during all-out strenuous exercise. Therefore, we do not recommend using the overly simplistic formula of $220 - \text{age}$ that is embedded into cardio machines. For example, MHR for a 45 y.o. = $220 - 45 = 175 \text{ bpm}$. This overly simplistic formula does not account for cardiovascular fitness level or circumstances affecting resting heart rate.

Maximum Oxygen Uptake (VO2 Max): The amount of oxygen being taken up at peak exercise (i.e. at the point that the person cannot do any more and has to stop exercising).

Metabolic Equivalent of Task (METs): One MET is defined as the energy you use when you're resting or sitting still and is equal to 3.5 ml O₂ per kg body weight x min. An activity that has a value of 4 METs means you're exerting four times the energy than you would if you were sitting still.

Metabolic Training: Compound exercises with little rest in between in an effort to maximize calorie burn and increase metabolic rate during and after the workout. *Where do we use this term?*

National Fire Protection Association (NFPA): International nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards.

National Strength and Conditioning Association (NSCA): Nonprofit association dedicated to advancing the strength and conditioning and related sport science professions around the world.

Oxygen Uptake (VO₂): How much oxygen the person is taking up and delivering to the tissues per minute. It is measured in ml/min but is often normalized for the subject's weight in kilograms in which case the units are ml/kg/min.

Physical Improvement Plan (PIP): A course of action that outlines the steps that an individual or organization will take to achieve a goal.

Rating of Perceived Exertion (RPE): A way of measuring physical activity intensity level. Perceived exertion is how hard you feel like your body is working.

Recovery: Gentle movements such as dynamic warm up, cool-down, or walking.

Resistance Training: Resistance training (also called strength training or weight training) is the use of resistance to muscular contraction to build the strength, anaerobic endurance and size of skeletal muscles.

Resting Heart Rate (RHR): The resting heart rate refers to the heart rate when a person is lying down or sitting, very relaxed. A *normal resting heart rate* for adults ranges from 60 to 100 beats per minute.

Static Stretching: Muscles are extended and held for a period of time, typically for 10 – 45 seconds.

Submaximal (Submax) Treadmill Test: Test used to assess cardiorespiratory fitness, especially in clinical settings. The test is administered in three-minute stages until the person achieves 85% of his or her age-predicted maximum heart rate.

Target Heart Rate (THR): Target Heart Rate is the heart rate for your desired exercise intensity, e.g. 60%, 70%, 80% intensity. Once you've figured your maximum heart rate (MHR), you can find your target heart rate range by multiplying your Max Heart Rate (MHR) by the desired intensity percent. Typically, use 60 percent (0.6) to find the low end of that range and 85 percent (0.85) to find the high end of the range.

Wellness-Fitness Initiative (WFI): Ensure that uniformed personnel are healthy enough to work safely and effectively during their careers and maintain good health during their retirement.

Work:Rest Ratio: This ratio is the comparison between how much time spent working (lifting weights, high-intensity cardio) and how much time spent resting. Example: if you're doing 10 second sprints and resting for 60 seconds, your work:rest ratio is 1:6.

Annual Testing

Best Practice:

Annual or Every Other Year CPAT for incumbents who do firefighting (FF or FF/EMS), with fitness and nutritional support offered to prepare incumbent to pass CPAT. CPAT represents the minimum physical demands of firefighting.

Next Best:

Annual medical physical that includes cardio sub-maximal fitness assessment with a "pass" if meeting or exceeding IAFF/IAFC's Wellness-Fitness Initiative's (WFI's) output standard of 39.55 ml/kg⁻¹/min⁻¹. or NFPA's 1582 12-MET minimum standard. If a "Pass" is not achieved, a Physical Improvement Plan (PIP) will be

established to help achieve this standard. Treadmill or step test protocols per IAFF/IAFC WFI can be performed by Peer Fitness Trainer, Fitness Trainer, Athletic Trainer, Physical or Occupational Therapist, or medical clinic.

On-Duty Fitness

Daily Expected Essential Movement Training (aka P.T.). This may include cardiovascular, strength, balance, mobility, or dynamic stretching (not static). Professional athletes are required to do physical fitness training to perform their physically demanding jobs. FFs and Paramedics should be as well. *See Exhibit A “FF & EMS Fitness Training Definition”.*

Warm Up & Cool Down (and Recovery)

Best Practice:

Required for both Fire Training Drills and on-duty cardiovascular and strength training.

- Using large full-motion-based movements to **warm up** for 5 minutes prepares the heart, muscles, and joints for exercise by lubricating the joints and pushing blood out to the arms & legs which increases elasticity/motion of muscles and tendons. You can hold end-range movement positions for 1-2 seconds to enhance the dynamic stretch. It is likely of particular benefit to include common movement patterns associated with firefighting and medical rescue.
 - Examples: High-knee marching (step climb, smoke crawl); 1-leg lunge (hose lay, attack line, patient lift); squat (various lifting/lowering); arms overhead (ladder climb, breach, rescue); trunk rotation (almost every task).
 - Without bunker gear is preferred to ensure no restrictions of normal movement patterns, and to reduce exposure to carcinogens.
- A 5-minute upright movement-based **cool-down** is recommended after exercise or strenuous activity (e.g. fire training drills) to safely bring central blood volumes down toward normal.

Exercise Effort

Best Practice:

HR training. HR-based training is the safest, as it is a truth-teller, and therefore is a best practice. HR determines effort level, not time. And HR determines time for recovery.

Next Best:

RPE (Rating of Perceived Exertion) can be used to help personnel stay within appropriate effort levels for on-duty fitness that allow personnel to respond to a call without having compromised physical capacity. Professional athletes do not have all-out game-day practices because they need a LOT of “gas in the tank” to perform maximally for the game. It is the same for FF & EMS personnel.

See Exhibit B “FF & EMS RPE Ratings”.

Cardiovascular Training Also See Exhibits A, E & F

Best Practices:

1. Warm up & Cool down.
2. Recommend exercise training from Peer Fitness Trainers or Personal Fitness Trainers or Athletic Trainers.
3. All cardiovascular training should be heart-rate-based or RPE-based to avoid overtraining. See Exhibit C “Signs of Overtraining”.
4. Before training, personnel should honestly assess the following and adjust RPE (or HR) goals DOWN for any “yes” answers. See Exhibit B **FF & EMS RPE Ratings**.
 - a. Good quality sleep?
 - b. Getting or are sick?
 - c. Joint pain?
 - d. Stressed?
5. ON-duty cardiovascular training should be aerobic from 10 – 60 min: roughly 60% - 80% of maximum ability, RPE 5 – 8 “Moderate” to “Hard”. Never go all-out on “game-day”. See Exhibit B **FF & EMS RPE Ratings**.
6. Recommend OFF-duty anaerobic threshold training once foundation established. See Exhibit D “Anaerobic Threshold Training”.
7. Mixing up activity type is best.
 - a. Bike, hills, stairs, treadmill, hiking, swimming, in-line skating, etc.
 - b. If using gym equipment, use different ones and always keep it on the manual program.

Max HR & Target HR Calculation

- A. Best Method = VO₂ & VCO₂ gas exchange test.
- B. Better Method = Use your submax treadmill results (estimated VO₂ max) as a guide to determine fitness level (poor, fair, average, meets standard, good, very good) and targeted HR levels for different types of workouts (different zones). See Exhibit G *WFI’s protocols*.
- C. Good Method = Inbar formula
 - a. Karvonen Formula, but with Max HR calculated at 205.8 -- 0.685(age) instead of 220 – age.
 - b. $(MHR - RHR) \times \text{___} \% + RHR = THR$
 - i. MHR = max heart rate
 - ii. RHR = resting heart rate
 - iii. THR = target heart rate
 - c. $\{[(205.8 - 0.685(\text{age})) - RHR] \times \text{_____} \% + RHR = THR$
 - d. + or – 6 bpm

- D. Determine the Target Heart Rate (THR) by taking the % goal you have and multiplying it with your MHR.

Work:Rest for Circuit Training (metabolic + strength)

- Beginner 1: 2
- Intermediate 1:1.5
- Advanced 1:1

Strength Training Also See Exhibits A, E & F

Best Practices:

1. Warm up & Cool down.
2. Recommend exercise training from Peer Fitness Trainers or Personal Fitness Trainers or Athletic Trainers.
3. On-duty strength exercise should be roughly 50%-70% of maximum effort or RPE within 5-7 out of 10. Never go all-out on “game-day”. See Exhibit B “FF & EMS RPE Ratings”.
4. Before training, personnel should honestly assess the following and adjust RPE (or HR) goals DOWN for any “yes” answers. See Exhibit B “FF & EMS RPE Ratings”.
 - a. Good quality sleep?
 - b. Getting or are sick?
 - c. Joint pain?
 - d. Stressed?

Strength Training Recommendations:

1. Mixing up Equipment: Body weight, Dumbbells, resistive tubing, body weight, cable machines, stability balls, kettlebells
2. [ACSM stand for progression models of resistance training in healthy individuals.](#)
3. Resistance training should include the use of concentric, eccentric and isometric muscle contractions and incorporate a variety of multi-joint exercises, focused on both unilateral and bilateral movements.
4. Include regressive and progressive eccentric training (deceleration or resisting gravity) and joint stabilization training (to resist rotational injuries and increase the foundation for optimal strength and power) that supports fire service job demands such as:
 - a. Lowering patient
 - b. Resisting hose PSI
 - c. Stepping off apparatus/unit

Work:Rest for Circuit Training (metabolic + strength)

Beginner 1:2-4

Intermediate 1:1.5

Advanced 1:1

What to Avoid

Avoid the following:

1. Avoid competitions between personnel. Competition with oneself if appropriate.
2. Avoid basketball and volleyball games (or similar), as this leads to many injuries on-duty.
3. Avoid barbells overhead. Dumbbells are safer than barbells because they allow for differences between right and left side of one's body.
4. Academy Recruits – avoid any additional workouts outside Academy. Use those days for recovery which will improve performance.

Caution: Static stretching > 15 seconds prior to exercise ON-duty

1. Instead, consider dynamic stretching before and after exercise, or as a gentle recovery session.
2. Static stretching can safely be performed after exercise for 8 – 15 seconds only while on-duty.
3. Off-duty static stretches can be held for up to 60 seconds each maximum.

Exhibit A

Fitness Training Definition

Training Pillars

- You have a goal (or goals) that you are working toward achieving.
- Your sessions are structured in order to help you progress toward your goal(s).
- You apply the concepts of regression (to perfect movement & technique) and progression (to increase capacity) to your sessions. Regression and progression is achieved through adjustments down or up in any one of the following: volume, intensity, frequency, and/or time.
- You Seek out Peer Fitness Trainers or Professionals to help develop a sound program.

Why Training instead of Working Out?

In the Fire Service, structure exists in all aspects of the job. Structure provides a framework for best achieving a positive result in all the hazards we encounter. When examining physical fitness amongst response personnel there should be no difference. Without structure, physical training at the firehouse just becomes “working out.” Each individual FF should have a specific goal(s) related to their personal physical fitness that improves their ability to perform the physical demands of the job without injury. This is where “training” becomes different than just “working out” in the words of Stephen Covey, “Begin with the end in mind.”

Definition of Training

Unlike “working out”, training revolves around achieving a specific goal. This goal could be improving physical movement patterns [instead of “literacy (developing proper movement patterns)”] and strength to perform fireground tasks (e.g. lifting patients, pulling hose, raising ladders, breaching roof, lifting cutters or fans, etc.), improving cardiovascular fitness, or mobility or reducing injury. Training is performing specific exercises structured around what needs to be done in order to achieve each that goal — the exercises performed during training sessions are selected as a means of working toward what you ultimately want to achieve. Unlike “workouts,” training sessions are substantive and meaningful, and they are much more effective.

Any training program should be designed to allow the individual to train in a sequential and progressive manner, and even regressing when needed. A well-designed training program should incorporate biomechanically safe movement patterns, loading/de-loading phases, and micro/macro training cycles and achieving physical literacy. The program should also take into account daily or weekly fluctuations in stress. The inherent nature of a career in firefighting and EMS is stressful. Paying attention to how much stress is being added based on the intensity and volume of your training session should be accounted for in order to maximize resiliency.

Cardiovascular training programs in the fire service should stay in the aerobic “Moderate” effort zone while ON-duty, and go into the “Hard” anaerobic zone while OFF-duty. *See Exhibit D for “Anaerobic Zone and the Fire Service” and Exhibit F for “Work:Rest Ratios and Frequency”.*

- ACSM recommends adults should engage in moderate intensity cardiorespiratory training for a minimum of 30 min, for a minimum of 5 days per week or vigorous intensity exercise for 20 min per day for a minimum of 3 days per week.
 - [NSCA recommendations for cardiorespiratory aerobic training progressions.](#)

Resistance training programs in the fire service should stay in the “Moderate” effort zone and utilize movement patterns that include variations of (regressions and progressions) the below. *See Exhibit E for “Regressions and Progressions” and Exhibit F for “Work:Rest Ratios and Frequency”.*

- squat
- lunge
- push-pull
- carry
- rotation
- joint stability

[ACSM stand for progression models of resistance training in healthy individuals.](#)

- Resistance training should include the use of concentric, eccentric and isometric muscle contractions and incorporate a variety of multi-joint exercises, focused on both unilateral and bilateral movements.
- During strength training, exercise selection and order of performance should move from large muscle groups early in the session to smaller muscle groups later in the session.
- Powerful, multi-joint movements should be performed earlier in a training session than slower, less powerful, single-joint movements. Power is a combination of force and velocity.
- Higher intensity exercises should be performed earlier in a training session than lower intensity exercises.

Mixing it up is best to prevent plateaus:

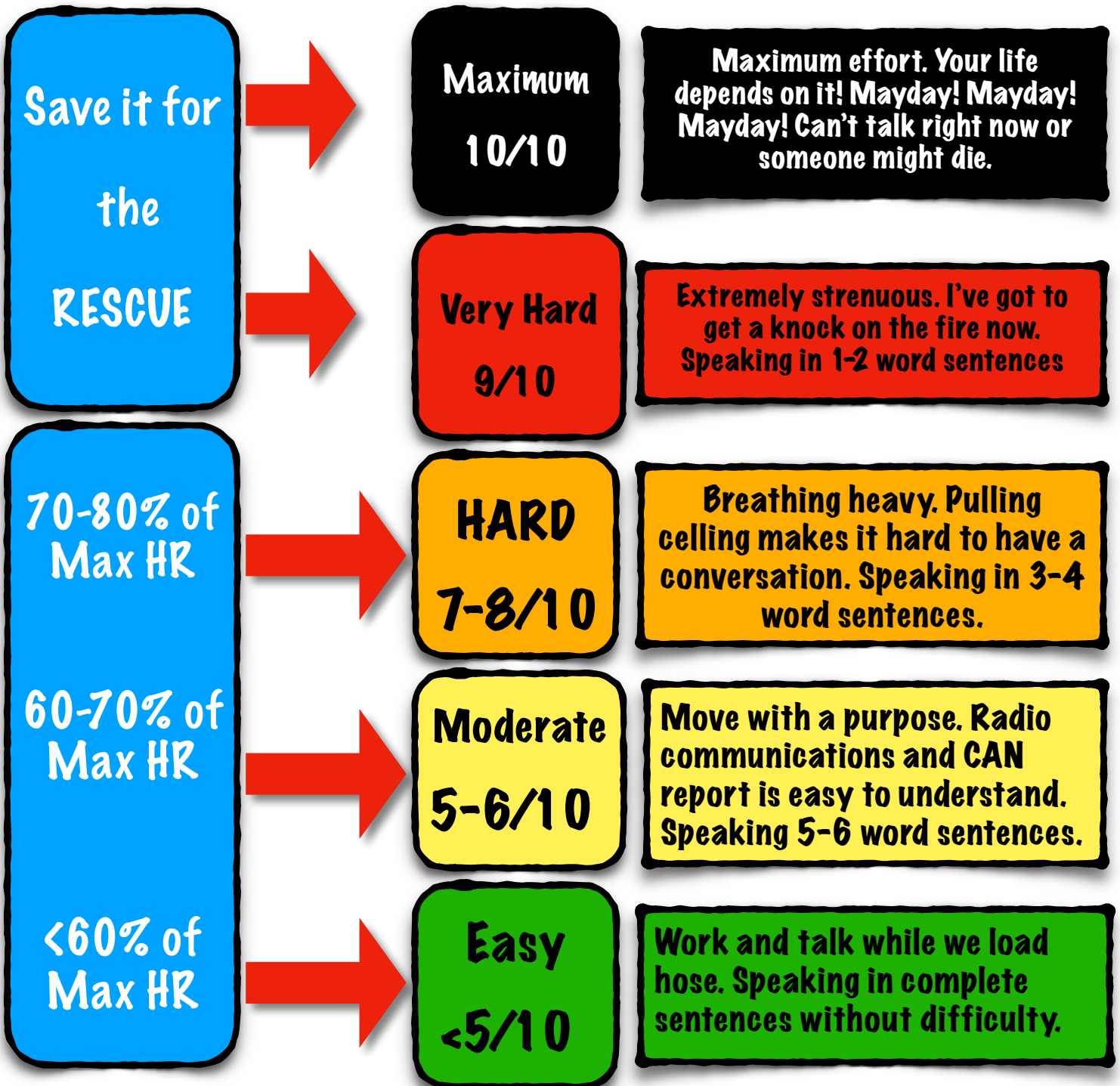
- Cardio: bike, swim, walk/run, hike, jump rope, etc.
- Strength: Dumbbells, resistive tubing, body weight, cable machines, stability balls, kettlebells

Relative Perceived Exertion

Did you get good sleep?
Do you feel sick?

Do you have new joint pain?
Do you feel stressed?

If you answer "YES" to 2 questions, stay in the moderate zone.
If you answer "YES" to 3-4 questions, stay in the easy zone.



Wellness Fitness Initiative's Peer Fitness Trainer Manual
laff.org/wellness-fitness laff.org/wellness-fitness/#manual

Exhibit C

Signs of Overtraining

Overtraining = training too hard or too often for the amount of rest and nutrition your body has had.

- **Slower HR recovery than normal** – HR doesn't lie; feels like "just a bad day"
- **HR peak reached earlier than normal** – HR doesn't lie; feels like "just a bad day"
- Increased apathy
- Decreased appetite
- Insomnia
- Residual mm and jt. soreness
- Increased resting pulse over time
- Lack of progress
- Increased irritability

Reduce your training intensities if you see these signs. If these signs persist, take a day off of training. If they still persist, take several days off of training.

Exhibit D Anaerobic Threshold Training

Recommend Anaerobic Threshold conditioning only for off-duty training due to their intensity. Fireground tasks and CPR are anaerobic metabolically, so this is a necessary type of exercise in the fire service.

Anaerobic threshold typically sets in at about 80-85% MHR capacity. Instead of 1.5 hrs @ 85%, do shorter anaerobic training session between 15 min.-30 min. with 2-5 interspersed “push” intervals lasting 1-5 min. only after HR returns to 70% MHR.

A. Anaerobic Threshold (AT)

- a. When aerobic energy production not enough to keep going and requires additional simultaneous energy from anaerobic system
- b. When body metabolism / energy source changes over from aerobic to anaerobic: when CO₂ production > O₂ consumption
- c. When lactic acid production exceeds its removal
- d. AT is typically achieved at ~80-85% of MHR

Sample Anaerobic Threshold Training Session (Run, Bike, Row, Stair Mill)

Level	Work	Rest	Reps	Interval Intensity
Beginner	1 min.	until HR down to RPE 5/10 Moderate or 70% MHR (Goal = within 2 min)	1-2	80-85% HRm / RPE 7-8
Intermediate	2-3 min.	until HR down to RPE 5/10 Moderate or 70% MHR (Goal = within 2 min)	2-4	80-85% HRm / RPE 7-8
Advanced	4-5 min.	until HR down to RPE 5/10 Moderate or 70% MHR (Goal = within 2 min)	3-5	80-85% HRm / RPE 7-8

Exhibit E

Regressions & Progressions

Table 3.1 Degree of Difficulty Continuum

EASIER ←—————→ HARDER		
Regression	Primary progression principle	Progression
Lighter	1. Load	Heavier
Wider base	2. Base of support width	Narrower base
More points of contact	3. Base of support points of contact	Fewer points of contact
More stable	4. External stability	More unstable
Closer to base of support (BOS); closer to axis of rotation (AOR)	5. Center of mass positioning (relative to base of support or axis of rotation)	Further from base of support (BOS); further from axis of rotation (AOR)
Lesser range of motion (ROM)	6. Range of motion	Greater range of motion (ROM)
Slower	7. Speed	Faster
Static	8. Movement complexity	Dynamic
Sagittal	9. Planes of motion	Frontal and transverse

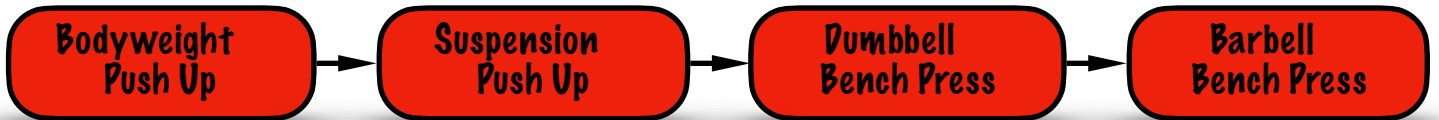
Copyright Citation: Human Kinetics website. Excerpt from “Secrets of Successful Program Design: a how-to guide for busy fitness professionals” by Alwyn Cosgrove.

See progression graphic on the next page.

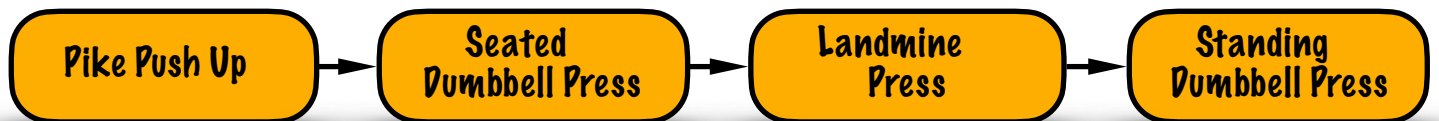
Courtesy of Jeffrey Krekling, Central Pierce

Basic Exercise Progressions

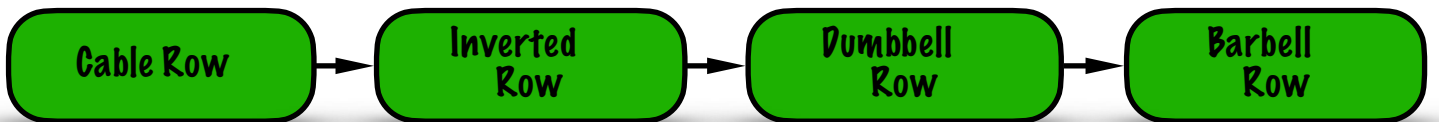
Horizontal Pushing Exercises



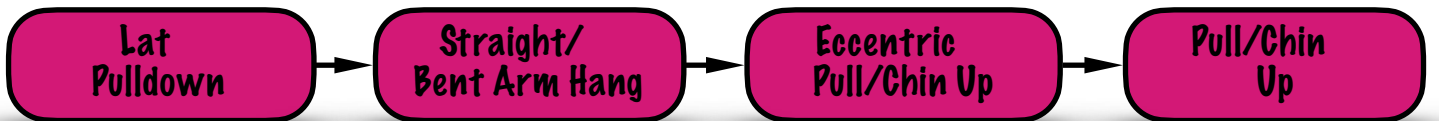
Vertical Pushing Exercises



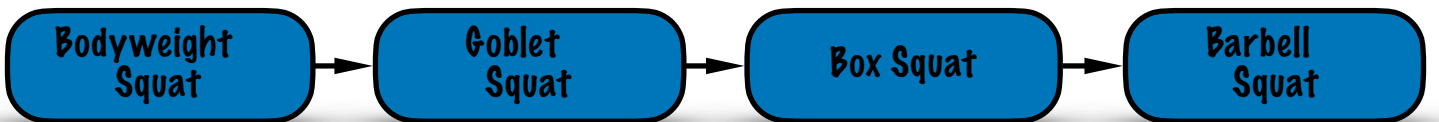
Horizontal Pulling Exercises



Vertical Pulling Exercises



Squatting Exercises



Hip Hinge Exercises

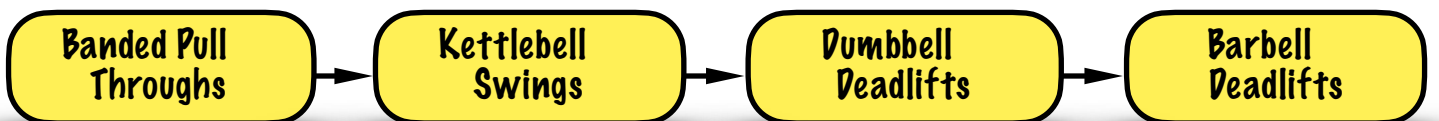


Exhibit F

Work:Rest Ratios, Duration, & Frequency for Beginner – Intermediate – Advanced

Strength

ACSM stand for progression models of Strength training in healthy individuals.

<https://pubmed.ncbi.nlm.nih.gov/19204579/>

Recommendations for frequency, set and repetition ranges in resistance training vary among different individuals. Multiple sets may convey greater benefits.

Beginner (untrained or several years of no resistance training)

- Frequency: 2-3 days per week
- Repetitions: 8-12 per set

Intermediate (6 months - several years of consistent resistance training)

- Frequency: 3-4 days per week
- Repetitions: 1-12 reps per set

Advanced (several years on consistent resistance training)

- Frequency: 4-5 days per week
- Repetitions: Emphasis on heavier loading with 1-6 reps per set

Increasing the weight should be limited to a 2-10% increase once the current workload can be performed by more than 1-2 repetitions over the recommended guideline.

Sample Interval Tempo Training Session

Level	Work	Rest	Reps	Sets	Rest between Sets	Intensity
Beginner	:10 sec	1:00 min	10	1-2	2:00 min	RPE 5-6 / 60-70% MHR
Intermediate	:15 sec	1:00 min	15	2-3	2:00 min	RPE 6-7 / 70-80% MHR
Advanced	:20 sec	1:00 min	20	2-4	2:00 min	RPE 7-8 / 80% MHR

Aerobic

ACSM recommends adults should engage in moderate intensity cardiorespiratory training for a minimum of 30 min, for a minimum of 5 days per week or vigorous intensity exercise for 20 min per day for a minimum of 3 days per week.

[NSCA recommendations for cardiorespiratory aerobic training progressions.](#)

Beginner (low cardiorespiratory fitness levels or untrained; building foundation)

Foundation: Start at 10 min. and build weekly toward 45-60 min. goal 65-70% MHR / RPE

- Frequency: 2 days per week
- Intensity: 60-70% of MHR, RPE 5-6
- Time: 10-45 min

Intermediate: (moderate cardiorespiratory fitness or training for > 8-12 months)

Building Capacity: Start at 10 min. and build weekly toward 30 min. goal 75-80% MHR / RPE

- Frequency: 3 days per week
- Intensity: 70-80% of MHR, RPE 5-7 (introduce moderate intensity intervals)
- Time: 30-60 min
- Interval durations ranging from 3-5 min with work : recovery ratios 1:1 - 1:2
 - (ex. 3 min work : 3 min recovery)

Advanced: (high levels of cardiorespiratory fitness or training for > 1 yr)

- Frequency: 2-4 days per week
- Intensity: 70 - 80% of MHR, RPE 7-8 (introduce high intensity intervals)
- Time: Variable
- Interval durations ranging from 10 sec - 2 min with work : recovery ratios 1:1 - 1:5 depending on duration and fitness level
 - (ex. 20 sec work : 1 min recovery)

Exhibit G

WFI Submax Treadmill & Stairmill Protocols & VO₂ Estimates

From the Wellness Fitness Initiative Manual

Maximum oxygen uptake was estimated from the WFI-Treadmill (TM) protocol using the equation modified in 2008:

VO₂ max = $56.981 + (1.242 \times TT) - (0.805 \times BMI)$, where test time (TT) is the time required to achieve target heart rate, determined as 85% of maximal heart rate ($208 - (0.7 \times \text{age}) \times 0.85$) and BMI is body mass index (kg/m²).

The WFI-TM is a modified ramp protocol made-up of a 3min warm up of 3 m.p.h. at 0% gradient followed by an increase in speed to 4.5 m.p.h. The rest of the test involves 1min intervals of alternate increases in speed (0.5 m.p.h.) and gradient (2%). Usually this protocol is purposely terminated at the TT when subjects have reached 85% of their age-predicted maximal heart rate for at least 15 seconds.

However, for this study, subjects continued the test until volitional fatigue in order to measure VO₂ directly via exhaled gas analysis.

Maximum oxygen uptake was determined from the highest 15 second average and accepted as maximal in the presence of a plateau in VO₂ despite increasing work rate and a maximum heart rate within 16 beats/min of the age-predicted maximum ($208 - (0.7 \times \text{age})$).

The WFI recommends cardio sub-maximal fitness assessment is a “pass” if meeting or exceeding VO₂ output standard of 39.55 ml/kg⁻¹/min⁻¹. See green outlines added below indicating the “pass” thresholds.

Helpful Hint: purchase treadmills and stairmills with embedded sub-maximal cardio fitness protocols.

What are Normal VO₂max Values?

The tables below display standard VO₂max classification ranges for both women and men.

VO₂max (mL*kg⁻¹*min⁻¹) Classifications for Women

Age (years)	Poor	Fair	Good	Excellent	Superior
20 - 29	≤ 35	36 - 39	40 - 43	44 - 49	50+
30 - 39	≤ 33	34 - 36	37 - 40	41 - 45	46+
40 - 49	≤ 31	32 - 34	35 - 38	39 - 44	45+
50 - 59	≤ 24	25 - 28	29 - 30	31 - 34	35+
60 - 69	≤ 25	26 - 28	29 - 31	32 - 35	36+
70 - 79	≤ 23	24 - 26	27 - 29	30 - 35	36+

VO₂max (mL*kg⁻¹*min⁻¹) Classifications for Men

Age (years)	Poor	Fair	Good	Excellent	Superior
20 - 29	≤ 41	42 - 45	46 - 50	51 - 55	56+
30 - 39	≤ 40	41 - 43	44 - 47	48 - 53	54+
40 - 49	≤ 37	38 - 41	42 - 45	46 - 52	53+
50 - 59	≤ 34	35 - 37	38 - 42	43 - 49	50+
60 - 69	≤ 30	31 - 34	35 - 38	39 - 45	46+
70 - 79	≤ 27	28 - 30	31 - 35	36 - 41	42+

Source: V. H. Hayward, Advanced Fitness Assessment and Exercise Prescription, Fifth Edition, 2006, Champaign, IL: Human Kinetics.

Original Source: The Cooper Institute for Aerobics Research, The Physical Fitness Specialist Manual. Dallas, TX. 2005

Sources

NFPA 1582

IAFF/IAFC Wellness Fitness Initiative

[NSCA recommendations for cardiorespiratory aerobic training progressions.](#)

[ACSM stand for progression models of Strength training in healthy individuals.](#)

[Medicine & Science in Sports & Exercise: July 2011 - Volume 43 - Issue 7 - pp 1334-1359 Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise](#)

SPECIAL COMMUNICATIONS: Position Stand

Abstract

The purpose of this Position Stand is to provide guidance to professionals who counsel and prescribe *individualized* exercise to apparently healthy adults of all ages. These recommendations also may apply to adults with certain chronic diseases or disabilities, when appropriately evaluated and advised by a health professional. This document supersedes the 1998 American College of Sports Medicine (ACSM) Position Stand, "The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults." The scientific evidence demonstrating the beneficial effects of exercise is indisputable, and the benefits of exercise far outweigh the risks in most adults. A program of regular exercise that includes cardiorespiratory, resistance, flexibility, and neuromotor exercise training *beyond* activities of daily living to improve and maintain physical fitness and health is *essential* for most adults. The ACSM recommends that most adults engage in moderate-intensity cardiorespiratory exercise training for $\geq 30 \text{ min}\cdot\text{d}^{-1}$ on $\geq 5 \text{ d}\cdot\text{wk}^{-1}$ for a total of $\geq 150 \text{ min}\cdot\text{wk}^{-1}$, vigorous-intensity cardiorespiratory exercise training for $\geq 20 \text{ min}\cdot\text{d}^{-1}$ on $\geq 3 \text{ d}\cdot\text{wk}^{-1}$ ($\geq 75 \text{ min}\cdot\text{wk}^{-1}$), or a combination of moderate- and vigorous-intensity exercise to achieve a total energy expenditure of $\geq 500\text{-}1000 \text{ MET}\cdot\text{min}\cdot\text{wk}^{-1}$. On 2-3 $\text{d}\cdot\text{wk}^{-1}$, adults should also perform resistance exercises for each of the major muscle groups, and neuromotor exercise involving balance, agility, and coordination. Crucial to maintaining joint range of movement, completing a series of flexibility exercises for each the major muscle-tendon groups (a total of 60 s per exercise) on $\geq 2 \text{ d}\cdot\text{wk}^{-1}$ is recommended. The exercise program should be modified according to an individual's habitual physical activity, physical function, health status, exercise responses, and stated goals. Adults who are unable or unwilling to meet the exercise targets outlined here still can benefit from engaging in amounts of exercise *less than* recommended. In addition to exercising regularly, there are health benefits in concurrently reducing total time engaged in sedentary pursuits and also by interspersing frequent, short bouts of standing and physical activity between periods of sedentary activity, even in physically active adults. Behaviorally based exercise interventions, the use of behavior change strategies, supervision by an experienced fitness instructor, and exercise that is pleasant and enjoyable can improve adoption and adherence to prescribed exercise programs. Educating adults about and screening for signs and symptoms of CHD and gradual progression of exercise intensity and volume may reduce the risks of exercise. Consultations with a medical professional and diagnostic exercise testing for CHD are useful

when clinically indicated but are not recommended for universal screening to enhance the safety of exercise.

ACSM's . Exercise and Acute Cardiovascular Events: Placing the Risks into Perspective. Medicine & Science in Sports & Exercise: [May 2007 - Volume 39 - Issue 5 - pp 886-897](#)

SPECIAL COMMUNICATIONS: Joint Position Statement

Ostensibly healthy adults without known cardiac disease should be encouraged to develop gradually progressive exercise regimens. Because the least fit individuals are at greatest risk for exercise-related events, gradually progressive programs should theoretically increase fitness and reduce acute CAD events without excessive risk. Patients with known cardiac disease also should be counseled to include at least 5 minutes each of warm-up and cool-down in their exercise training sessions to reduce the likelihood of inducing cardiac ischemia with sudden, intense physical effort ^(62,63) and to avoid the decrease in central blood volume that can occur with the abrupt cessation of physical activity. Patients with cardiovascular disease who are interested in participating in competitive sports should be evaluated and advised in accordance with the 36th Bethesda Conference guidelines ⁽⁵⁶⁾. Physically inactive individuals and patients with known cardiovascular disease should avoid strenuous, unaccustomed exercise in both excessively cold and hot environmental conditions. Vigorous exercise in the cold such as snow shoveling has repeatedly been associated with acute cardiovascular events ^(44,45,64), and hot, humid environments require an increased heart rate response to handle the increased thermal load ⁽⁶⁵⁾. Increased altitude reduces oxygen availability and augments the cardiorespiratory and hemodynamic responses to a given submaximal work rate, thereby increasing cardiac demands. Individuals exercising at altitudes of > 1500 m should limit the intensity of their exercise until acclimatized ^(54,66).

Stretching At Work

ACSM Position Stand Dr. Thacker et al (2004)

"...Adverse effects of stretching/flexibility. There is some evidence of unintended adverse effects of stretching and/or increased flexibility. Stretching has been associated with a temporary strength deficit (up to 1 h) (24,57) and increased arterial blood pressure (13). Recent studies of passive stretching shows significant adverse effects on jump performance (14) and plantar flexion (65). Increased flexibility decreases running economy (15,27) and peak performance (77)..."

...Some have argued that warm-up is more important than stretching in the prevention of injuries in sports (79). Warm-up increases blood flow to muscles, speed of nerve impulses, oxygen and energy substrate delivery to working muscle while removing waste products, and oxygen release from hemoglobin and myoglobin; warm-up decreases both the activation energy for cellular reactions and muscle viscosity (59,81). These changes prepare the body for vigorous exercise by accelerating metabolism in muscle fibers and decreasing intramuscular resistance, thus increasing both mechanical efficiency and range of motion (i.e., flexibility), as well as the speed and force of muscle contraction. Animal studies suggest that warm-up increases muscle elasticity, which decreases the likelihood of muscle tearing (80)..."

Choi & Woletz, 2010

Industry-specific workplace stretching programs: computer, manufacturing, heavy, construction work
Effects on reducing work-related MSDs and injuries - 7 studies Inconclusive

- stretching improves flexibility/ROM and self worth, but stretching alone might not prevent WMSDs and injuries
- strength training, conditioning, and warm up could play an important role in preventing WMSDs

Suni, 2013

The incidence of days off due to low back pain in 356 military personnel who received a 6-month intense exercise intervention and education program to improve control of their lumbar zone and to avoid full lumbar flexion in all daily tasks was significantly lower than in a control group who just participated in regular military service training.

[A Meta-Analysis of the Effects of Foam Rolling on Performance and Recovery](#)

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Abstract

Foam rolling is thought to improve muscular performance and flexibility as well as to alleviate muscle fatigue and soreness. For this reason, foam rolling has become a popular intervention in all kinds of sport settings used to increase the efficiency of training or competition preparation as well as to speed post-exercise recovery. The objective of this meta-analysis was to compare the effects of foam rolling applied *before* (pre-rolling as a warm-up activity) and *after* (post-rolling as a recovery strategy) exercise on sprint, jump, and strength performance as well as on flexibility and muscle pain outcomes and to identify whether self-massage with a foam roller or a roller massager is more effective. A comprehensive and structured literature search was performed using the PubMed, Google Scholar, PEDro, and Cochrane Library search engines. Twenty-one studies were located that met the inclusion criteria. Fourteen studies used pre-rolling, while seven studies used post-rolling. Pre-rolling resulted in a small improvement in sprint performance (+0.7%, $g = 0.28$) and flexibility (+4.0%, $g = 0.34$), whereas the effect on jump (-1.9%, $g = 0.09$) and strength performance (+1.8%, $g = 0.12$) was negligible. Post-rolling slightly attenuated exercise-induced decreases in sprint (+3.1%, $g = 0.34$) and strength performance (+3.9%, $g = 0.21$). It also reduced muscle pain perception (+6.0%, $g = 0.47$), whereas its effect on jump performance (-0.2%, $g = 0.06$) was trivial. Of the twenty-one studies, fourteen used foam rollers, while the other seven used roller massage bars/sticks. A tendency was found for foam rollers to offer larger effects on the recovery of strength performance (+5.6%, $g = 0.27$ vs. -0.1%, $g = -0.01$) than roller massagers. The differences in the effects between foam rolling devices in terms of pre-rolling did not seem to be of practical relevance (overall performance: +2.7%, $g = 0.11$ vs. +0.4%, $g = 0.21$; flexibility: +5.0%, $g = 0.32$ vs. +1.6%, $g = 0.39$). Overall, it was determined that the effects of foam rolling on performance and recovery are rather minor and partly negligible, but can be relevant in some cases (e.g., to increase sprint performance and flexibility or to reduce muscle pain sensation). Evidence seems to justify the widespread use of foam rolling as a warm-up activity rather than a recovery tool.