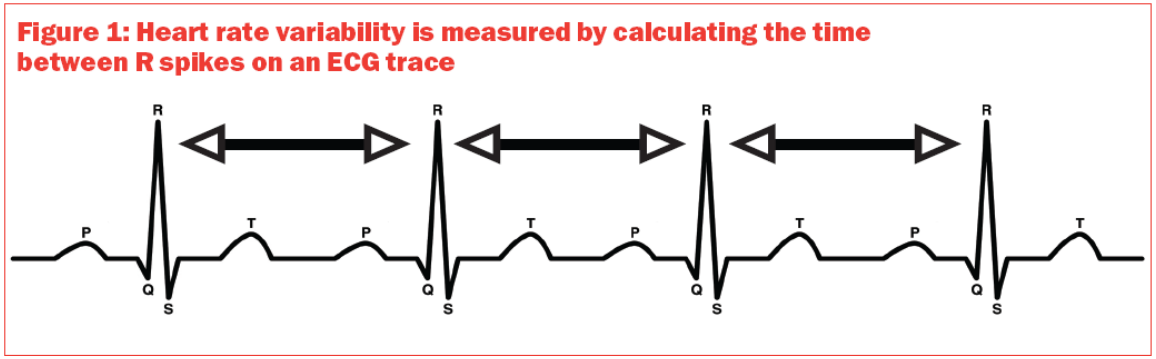
Monitoring Recovery

Technology and Manual Practices



Developed by:

Fabio Comana, MA., MS. NASM CPT, CES & PES; NSCA CSCS; ACSM EP-C; ACE CPT & HC; CISSN

Engage.. Ignite.. Empower..©

Introduction ….

Defining Recovery

Return to normal state of health, mind or body – process that involves rest, refueling (replenish), rehydration, regeneration (repair), re-synthesis, restoration, reduction (inflammation), replacement and ultimately a return to *homeostasis* (discussed next).

- Recovery is least understood piece of exercise-adaptation cycle.

Types:

- *Immediate recovery* between successive efforts (e.g., between reps within a set).
- *Short-term recovery* between interval sprints or weight training sets (e.g., rest interval between sets/intervals).
- Training recovery between successive workouts or competitions – affected by events outside of exercise session – MOST important!

Biological Design ….

Body's Biological Response

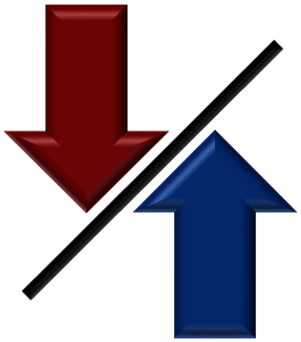
Physiological (Acute, Intense) Stress → 'Fight-or-Flight' Response → Physiological Work

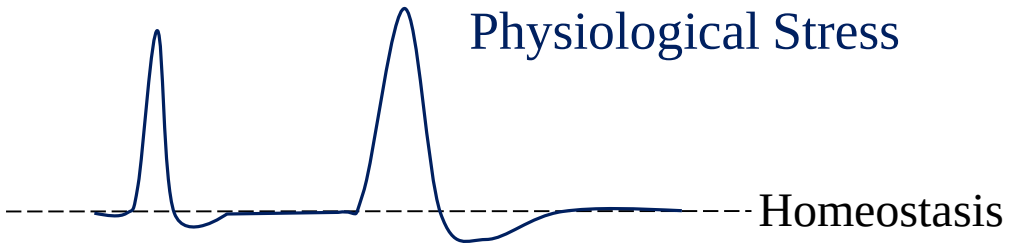
Allocation of Resources: PNS

Allocation of Resources: SNS

Acute Events Inhibited

Decreased salivary and digestive enzyme secretion, and digestion.
Decreased stomach/small intestinal contractility.
Decreased pain perception (analgesia).
Decreased growth, repair and maintenance.
Decreased reproduction capacity.





Let's examine more closely …

Acute Events Activated

Increased cardiopulmonary responses.
Increased vasodilation.
Increased mobilization of fuels.
Increased blood clotting ability.
Increased large intestinal contractility.
Increased bladder contractility.
Increased immune function.
Increased sweat rates.

Monitoring Recovery ….

Inability to properly recovery = elevated (sustained) levels of cortisol.

Monitoring Cortisol Levels – Adrenal Stress Index (ASI)

- Salivary test (4 samples at specific, but different times) – has several limitations:
  - Age, gender, pregnancy, smoking, menstrual cycles, medication, disease.
  - More accurate than blood test which is timestamped and stressful in itself.
- Future ideas:
  - Disposable, reusable wearable patch – Bluetooth/Ant to mobile device dashboard.

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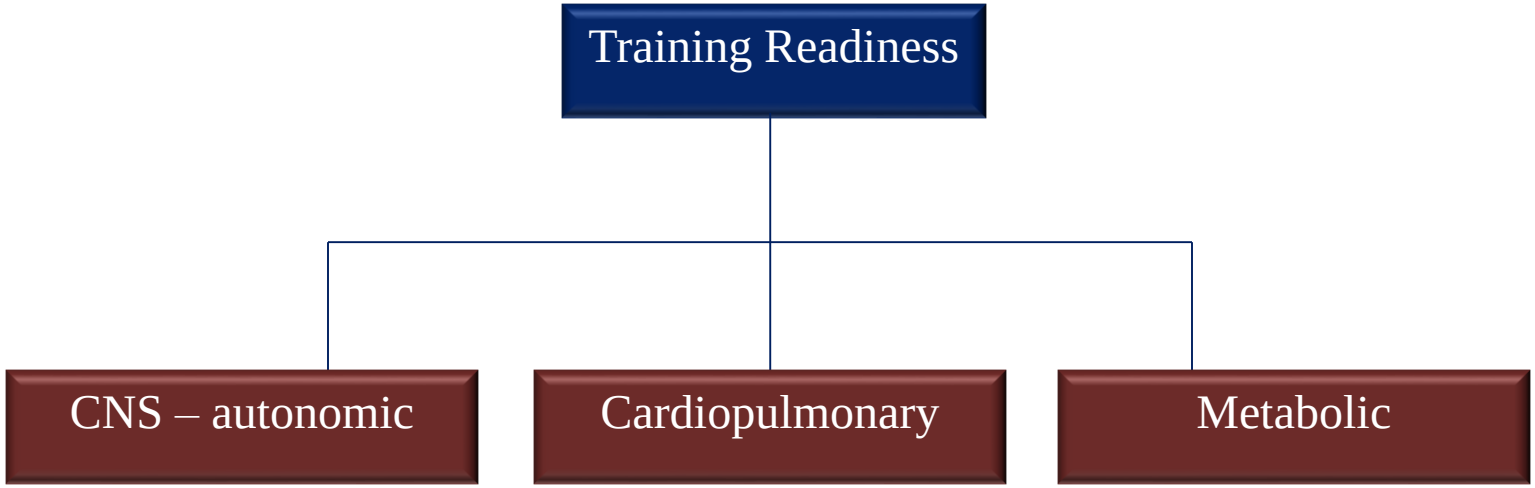
Stress and Training Readiness – Wearable Technology:



CNS Recovery and Readiness	Cardiopulmonary Recovery and Readiness	Metabolic Recovery and Readiness
Assess SNS-PNS dominance • Inventories (questionnaires) • Neural stimulation devices	RHR / Heart Rate Variability • Ambiotec, Hexoskin, Polar Breathing • Control Pause (breathing)	• O_2 kinetics (Ve/VO_2) • RER scores • Cortisol

Monitoring Recovery …

Resting Heart Rate (RHR) is influenced by numerous variables:

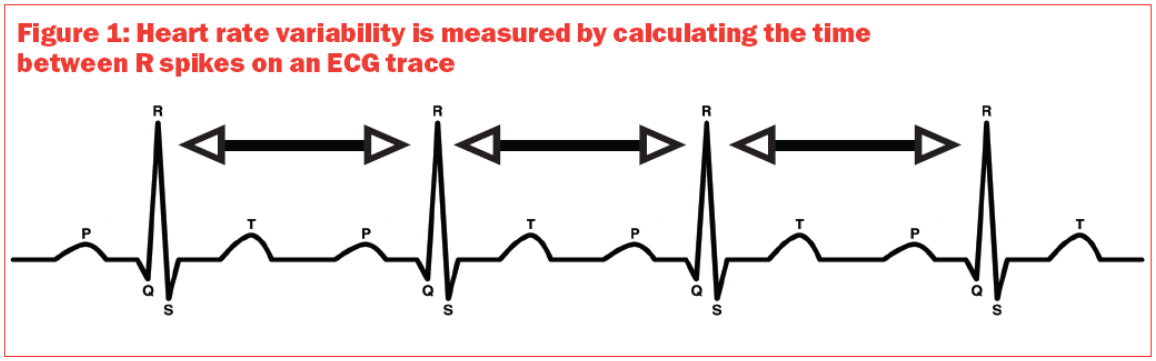
- Pre-exercise anticipation (SNS stimulation).
- Stress, diet, hydration status, medications, stimulants, HR suppressants, etc.
  - Men = 60-72 bpm
  - Women = 72-80 bpm (smaller hearts).
- Improvement – gradual lowering of RHR (Q = HR v SV)
- Overtraining – gradual elevation in RHR (consistent over a 7-10 day period).

Monitoring Recovery …

New Ideas in Fitness: Heart Rate Variability (HRV)

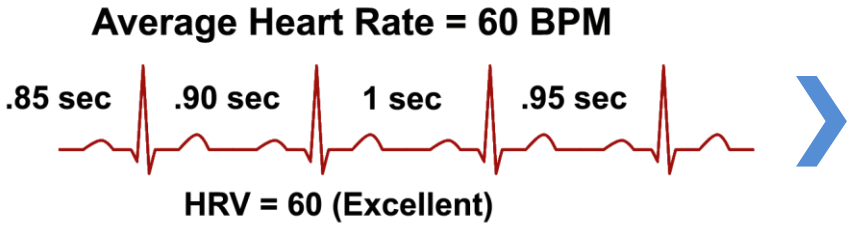
Physiological phenomenon – time variation (interval) between heartbeats:

- Predictor of Myocardial Infarct (MI) risk and other heart-health measures (e.g., diabetes).
- Now used to measure stress recovery – measure of autonomic nerve dominance = health.



How does HRV differ from HR?

- Best collected via chest EKG/ECG – excludes non-sinus heartbeats and EMG (muscle) activity.

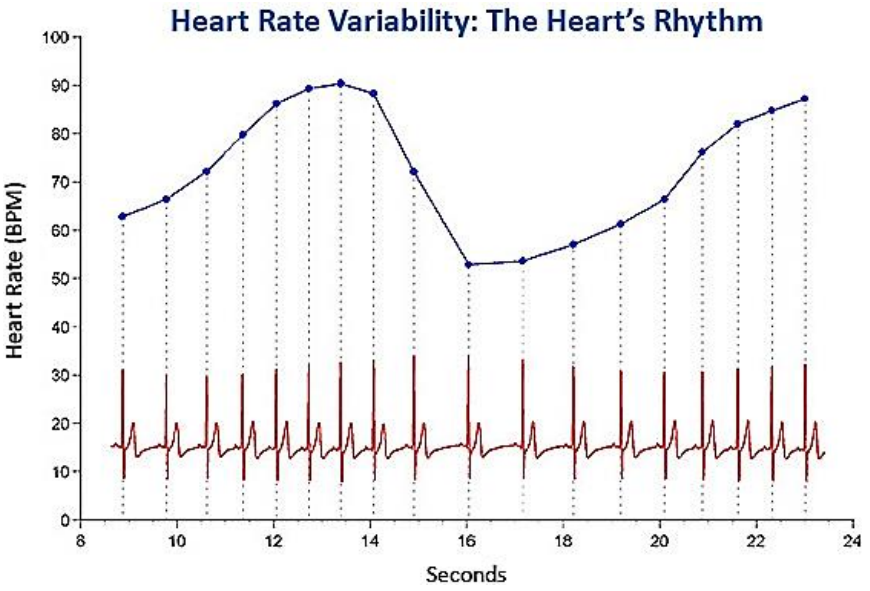


Monitoring Recovery …

New Ideas in Fitness: Heart Rate Variability (HRV)

How HRV works:

- PNS dominance (relaxation):
  - Greater variability in R-R intervals due to respiratory sinus arrhythmia and vagal nerve effect.
- SNS dominance (arousal):
  - Smaller variability in R-R intervals



Respiration gives rise to waves in heart rate – mediated primarily via PNS:

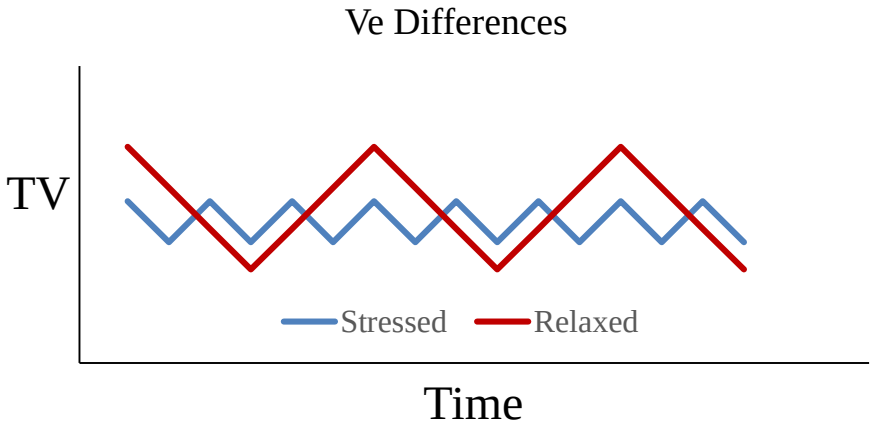
- High-frequency (HF) activity occurs with PNS.
- Low frequency (LF) activity occurs with SNS.

Monitoring Recovery …

Over-breathing

When stressed / ill / injured – does our breathing change?

- Shallow, faster breathing coupled with hyperventilation (forced expulsion of air from lungs).
- Consequences of hyperventilation?
  - Less O_2 delivery to cells.
  - Increased CO_2 removal from body.
    - Needed for lactate buffer.



Reduced O_2 Uptake	Excess CO_2 Removal
Acute: Fatigue, light-headedness, nausea, headaches	*Acute:* Dizziness, light-headedness, numbness, muscle discomfort/spasm, heart palpitations.
Chronic: Inflammation, tachycardia, pulmonary hypotension, cellular ischemia and damage.	*Chronic:* Altered blood pH (low bicarbonate = high-risk acute heart failure), respiratory alkalosis, lowered blood calcium (binding to proteins = seizures).

A Closer Look

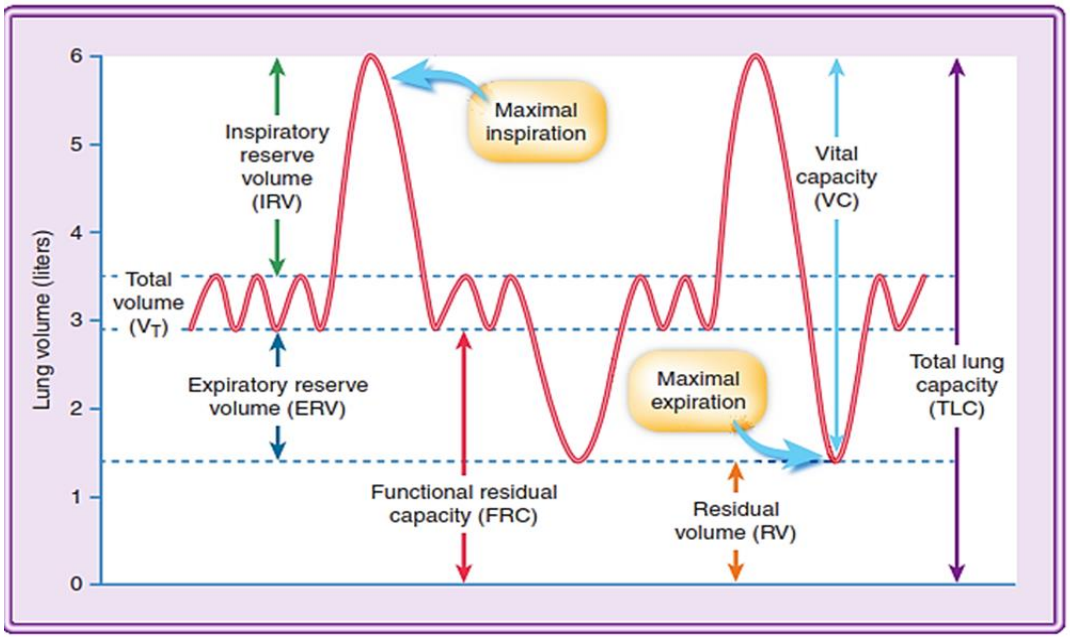
Monitoring Recovery …

To train breathing techniques, we must first examine physiological concepts of ventilation – a closer look.

- Lung volumes of interest:

TV = smaller volume of fresh air.
Higher O_2, lower CO_2

ERV + RV = FRC
Essentially larger volume of stale air.
Lower O_2, higher CO_2



TV + FRC = air mixing in lung tissue (alveoli)

Lung Volume	Definition	Males
Tidal Volume	Volume of air moved with normal breathing	Small volume (500 mL)
Residual Volume	Volume remaining after maximal expiration	Larger volume (1,400 mL)
Expiratory Reserve Volume	Volume remaining after normal expiration	Moderate volume (1,000 mL)

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Minute ventilation (Ve) = volume of air moved through lungs per minute.

Ve = Breath Rate (BR) x Tidal Volume (TV)

- Tidal volume (TV) = volume of air moved with a normal breath.

Ve Example	Rest	Maximal Effort
	• TV = 500 mL (0.5 L). • Breath Rate (BR) = 12 breaths/min. Ve = 0.5 x 10 = 5.0 L / min.	• TV = 2,500 mL (2.5 L) • Breath Rate (BR) = 50 breaths/min. • Ve = 2.5 x 50 = 125 L / min.
Normal Breath Rate: Every 5-6 sec = 10-12 breaths per minute (v. 3-5 breaths per sec in children).		

Is this it? Just focus upon increasing Ve?....

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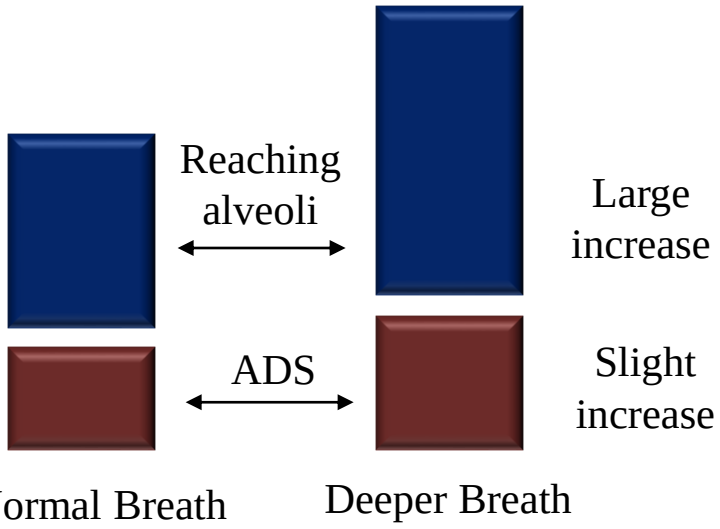
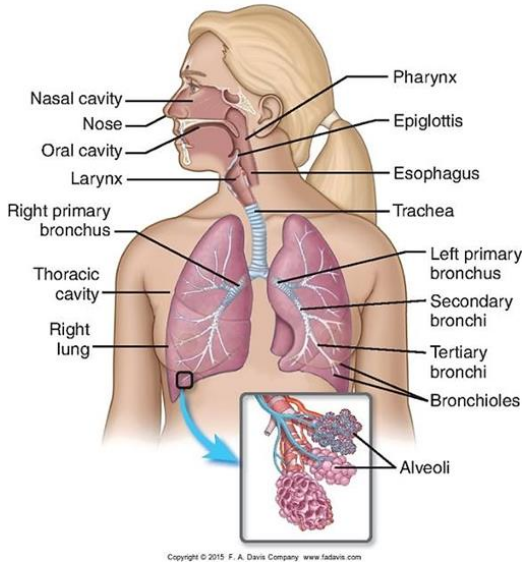
Alveoli Ventilation (AV) = actual volume of air reaching alveoli (i.e., air entering blood).

- Determined by subtracting volume of air that remains within the breathing passages over one minute (ADS) v. the total volume entering lungs over one minute (i.e., Ve).

$$AV = Ve - (\text{total ADS in one minute})$$

- Anatomic dead space (ADS):
  - Generally ~ 30% of resting TV (i.e., 150-200 mL).
  - Increases minimally with deeper breathing given slight air passage stretching (absolute).



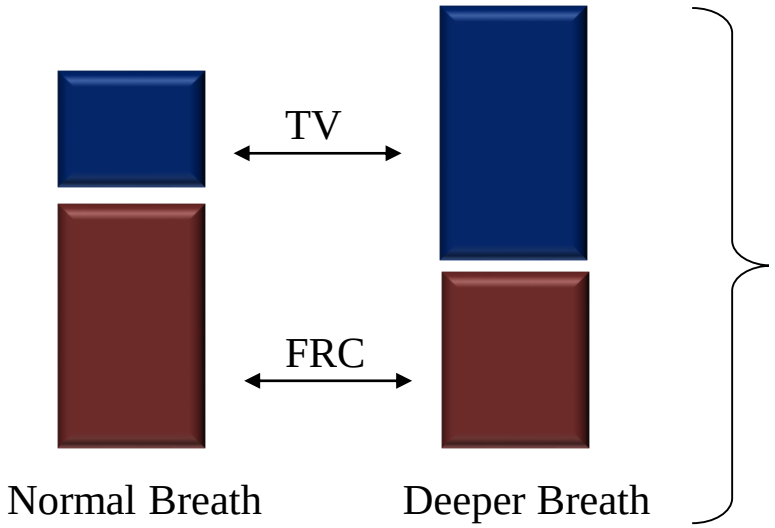


Monitoring Recovery …

To illustrate:

	BR	x	TV	= Ve	Anatomical Dead Space (ADS)	Ventilation (Alveoli)
Deep, slow	10	x	1 L	= 10.0 L	0.2 L x 10 = 2.0 L	8.0 L
Normal	20	x	0.5 L	= 10.0 L	0.2 L x 20 = 4.0 L	6.0 L
Shallow, rapid	40	x	0.25 L	= 10.0 L	0.2 L x 40 = 8.0 L	2.0 L

- What does increased alveolar ventilation mean?



Deeper breaths:

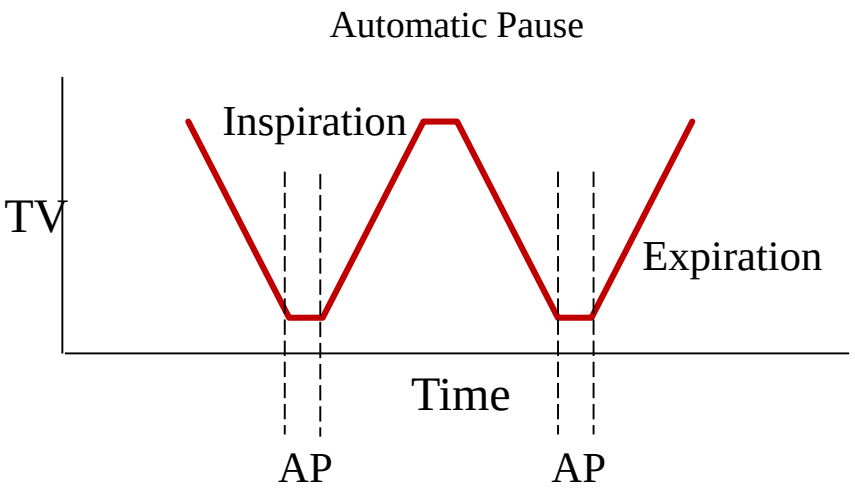
- Larger TV (fresh air) mixing with smaller FRC volume (stale air) = increases alveoli O_2 concentration = greater O_2 delivery to cells with same Ve.
- Also explains why we breath more deeply at altitude (reduced O2 pressure).

Monitoring Recovery …

Do you over-breathe?

How do we measure?

- Automatic Pause (AP) = natural delay in breathing after an unconscious exhalation (i.e., before next inhalation).
  - Ideal = 2+ seconds.
- Control Pause (CP) = body-oxygen test – breath-holding after normal exhalation until 1st distress.
  - Measuring CP: Breath-hold after normal exhalation until 1st point of distress.
  - Instructions:
    - Assume upright posture, exhale normally – pinch nose with fingers.
    - Start stopwatch – hold breath until first need to breathe normally again (entire breath-hold = completely effortless).



Monitoring Recovery …

Genesis Wellness Group

Buteyko Table of Health Zones (average adult resting parameters)

- Measured early morning, sitting upright.

Health State	Score	BR (rate/min)	Alveolar CO_2	Automatic Pause (AP) *	Control Pause (CP) **
Super-health	4/5	≤ 4	≥ 7.4%	≥ 12 sec	≥ 150 sec
	3	5	7.3%	9 sec	120 sec
Very healthy	2	6	7.1%	7 sec	100 sec
	1	7	6.8%	5 sec	80 sec
Normal	0	8	6.5%	4 sec	60 sec
	-1	10	6.0%	3 sec	50 sec
Average person	-2	12	5.5%	2 sec	40 sec
Slight risk	-3	15	5.0%	-	30 sec
Moderate risk	-4	20	4.5%	-	20 sec
Severely ill	-5/-6	≥ 26	≤ 4.0%	-	≤ 10 sec

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What Does this Mean?

Low CPs = Hyperventilation = greater SNS stimulation:

- Most apparently healthy people today have 20-30 sec CPs.

Consequences of over-breathing (i.e., hyperventilating):

- Flush out more CO_2 from blood (to lungs) – at rate faster than cellular production of CO_2 – we MUST maintain certain levels of CO_2 to regulate breathing.
- Alters blood pH:
  - Normal blood pH = 7.35 – 7.45 – controlled by H^+ and HCO_3^-
  - $HCO_3^- + H^+ = CO_2 + H_2O$ …… *Note:* H+ lowers blood pH.
  - With more CO_2 flushed = more H^+ lost = elevated blood pH (known as respiratory alkalosis – RA).
    - RA can trigger vasoconstriction (light-headedness – caution with excessive hyperventilation or underwater breath-holding preparation = ‘blackouts’).
    - Lowers lactate buffer = compromised performance.

Do they Work?

Monitoring Recovery …

Reducing DOMS

Inevitable – some DOMS will always occur:

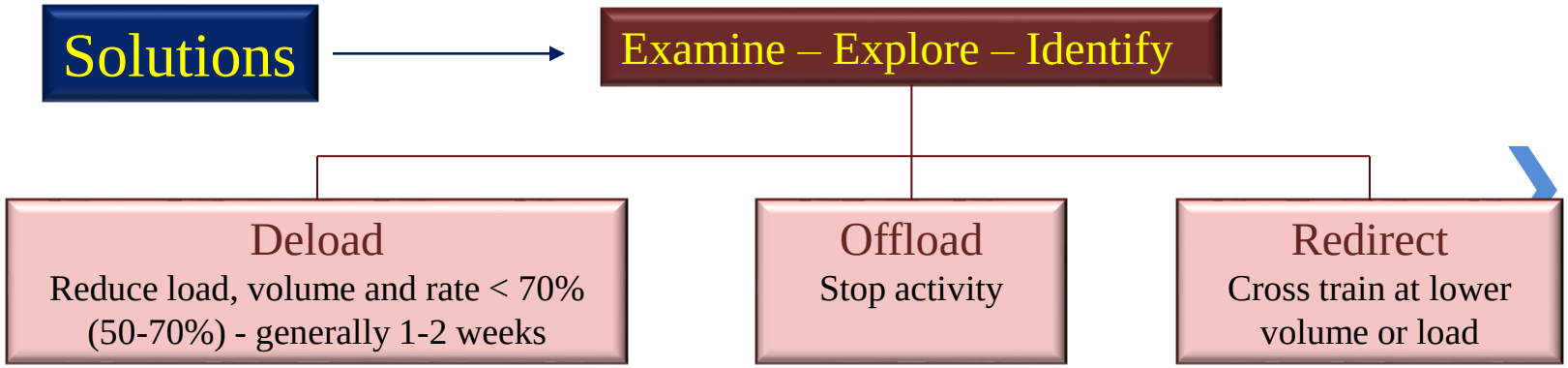
- Techniques:
  - Non-steroidal anti-inflammatory drugs (NSAIDS).
  - Massage – research inconclusive.
  - Cryotherapy (cold compress, icing), ultrasound, electrical stimulation (TENS).
- Practices:
  - Post-exercise cool-down + stretching – research inconclusive.
  - Reduced initial training loads and volumes.
  - Reduced eccentric training phase (TUT or tempo) during initial training.
    - Given the time lapse for muscle growth - why impose unnecessary muscle soreness upon novice individuals - impacts exercise experience.
    - Being with 1 set (+ shorter eccentric phases) – progress gradually.

Also consider deloading same muscles = reduced training loads/volumes for 1-2 days following DOMS-producing exercise.

Monitoring Recovery …

Overtraining Syndrome – be aware and modify programming as necessary.

- Generally attributed to inadequate recovery – also excessive training or burnout.
  - Symptoms include:
    - Decreased performance over 1-2 week period.
    - Increased resting heart rate and/or blood pressure.
    - Decreased body weight
    - Reduced appetite or loss of appetite; nausea
    - Disturbed sleep patterns and inability to attain restful sleep
    - Muscle soreness and general irritability.
    - Lack of motivation / adherence.



Recovery Techniques …

Modality	Methodology	Claimed Benefits	Evidence
Active Recovery	Brief anaerobic bursts to very-light activity	Accelerate lactate clearance (H^+ ion removal), Stimulating localized blood flow and signaling proteins.	Faster rate v. passive recovery. Moderate intensity (60-100% LT) better than light intensity (0-40% LT). ****
Massage	Physical manipulation of tissue.	Decreased muscle soreness, pain and stress; improved circulation and lymphatic flow; overall enhanced perception of recovery.	Potential muscle damage. Immediate post-ex = reduced blood flow, impaired lactate/H^+ removal. Improved muscle activation and prioprioception, and reduced DOMS. **
Compression	Clothing, inflatable, pulsatile pneumatics.	Minimize muscle fatigue/soreness; accelerate lactate removal; increase venous and lymphatic flow; improve performance.	Elastic compression reduces muscle soreness/fatigue, but slows byproduct removal. ** Pneumatic compression increases blood flow, decreases muscle stiffness. ***

RICE (rest, ice, compress, elevate) v. CAM (compression, activity, massage).

Recovery Techniques …

Modality	Methodology	Claimed Benefits	Evidence
Cryotherapy	Cool/cold applications to localized tissue.	Vasoconstriction; temporarily reduces inflammation/pain.	Slows normal regenerative inflammatory reaction; damage due to prolonged exposure to cold (nerve, skin). *
Water Immersion (Hydrotherapy)	Water pressure alters HR, peripheral blood flow/resistance.	Alters skin/muscle/core temp – influence inflammation, immune function, muscle soreness and fatigue.	Cold (CWI): **** Hot (HWI): * Contrast (CWT): *** • CWI = lower muscle soreness, smaller losses in muscle strength 24-48-hours post v. CWT.
NSAIDS	Accelerate muscle recovery, reduced muscle soreness and creatine kinase activity.		Ibuprofen and acetaminophen can suppress some post-exercise muscle protein synthesis. **
Hyperbaric O_2	Greater O_2 delivery to cell to accelerate recovery.		Shows promise in enhancing muscle repair and recovery. ***

Recovery Techniques …

Modality	Methodology	Claimed Benefits	Evidence
Vibration Therapy	Oscillations (25-50Hz) with 2-4mm amplitude in 3D.	F=MA – triggers nerve impulses (30-40 impulses/sec) = micro-contractions = improved blood flow	Appears to improve nerve system reactivity; remove metabolic waste; strengthen myofascial tissue. **
Myofascial Release	Realignment of myofascial tendrils	Improved stability-mobility; reduced pain/discomfort; improved overall functionality.	Requires adequate tissue hydration, movement (rhythmic is most appropriate) + 3D movement. ****
Stretching	Believed to reduce muscle soreness and risk of injury	• Slower recovery v. CWT/active recovery. • Some improved ROM and some reduced DOMS. • No detrimental effects on recovery and subsequent performance. ***	
Sleep	Attaining needed basal sleep each night for recovery.	Sleep debt increases stress/cortisol accumulation = impaired overall recovery – increases likelihood to overtraining or non-functional overreaching. ****	

Recovery Techniques …

Modality	Notion	Claimed Benefits	Evidence
Fluid	Euhydration (optimal body water) helps restore normal physiology to expedite post-exercise adaptive process.	• Rehydrate with 120-150% of lost fluid volume with H_2O – greater urine production (diluted blood). • Rehydrate with 100-125% of lost fluid volume with sports drink – faster intestinal absorption.	
Electrolytes	Fluid balance, normal neuromuscular physiology (nerve-muscle conduction/contractility)	Virtually impossible to estimate – recommendations: • ~ 110-165 mg sodium / 240 mL (8 oz.). • ~ 18-46 mg potassium / 240 mL (8 oz.).	
Carbohydrates	Glycogen replenishment	Timing, type and quantity: • Glycogen synthase activity most active in 1st hours. • Glucose sources (e.g., dextrose; maltodextrin, sucrose) are 2x faster than fructose sources. • 1.0-1.2 g/Kg (0.45-0.55g/lb.) within 1st post-exercise. Repeat as needed over 4-6 hours.	
Protein	Optimize muscle protein synthesis (MPS)	• Daily ingestion = 1.2-2.0 g/Kg (0.55 - 0.91g/lb.) • Immediate post-exercise: 0.24g/Kg (0.11g/lb.) • Protein-carbohydrate combination (1:2-1:4) promotes greater muscle glycogen and attenuates muscle damage v. stand-alone solutions.	

Recovery Techniques …

Modality	Notion	Evidence
BCAA	Reduced muscle soreness; faster muscle recovery	• *Resistance training:* 10-25g/hour during training = reduced muscle soreness + faster muscle recovery. • *Endurance training:* 5-15g/hour during training = reduced mental fatigue and RPE. • Leucine = MPS: Leucine threshold (LT) ≥ 2g needed to active MPS (20g whey isolate)
L-glutamine	Promote MPS and immune recovery.	• 5g supplementation to body's natural production accelerates recovery – Glutamine = moving nitrogen atoms to wherever needed. • BCAA supplementation = helps recover glutamine levels and immune function.
Other compounds:	• Vitamin C (promotes collagen synthesis) = 150mg, • HMB or β-Hydroxy-β-methylbutyrate (promotes MPS) = 3g, • Vitamin E (removes creation phosphokinase from blood) = 10-15mg, • Omega-3 fatty acids (anti-inflammatory) – equivalent to a good fish serving.	

Thank You..!!

For Your Commitment to Excellence

Questions .. ??

Name: Fabio Comana, MA., MS.

Credentials: NASM CPT, CES & PES; ACE CPT & HC; NSCA CSCS; ACSM EP-C; CISSN.

Email: comana.fabio@gmail.com

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