Say when: When more exercise isn’t better

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Why Exercise? What purpose does it serve?
1. **Health**: The avoidance of disease and disability, and potentially the extension of life.
2. **Fitness**: The improvement of physical capacities at the present moment and in the future.
3. **Performance**: A goal-based approach to improve physical capacities (for a sport or physical feat). Speed, agility, quickness, endurance, power, strength, and reaction speed and sport skills are often included amongst the physical capacities.

Exercise Would be the Best Drug on the Market

What determines Drug Dose & Effectiveness?
- Drug Dosage Regimens
  - Take 2 pills (amount)
  - once a day- Frequency
  - 250 mg of drug/pill- Intensity
- Drugs have Optimal Doses for a “Maximum Benefit”
  - Varies with the Individual’s Sensitivity
  - Varies with the Individual’s Need
  - Dose-Response Curve varies with drug parameters
  - An M.D. needs to consider many factors for prescription
When is Enough- Enough

- Exercise Obeys Dose-Response Curves like Drugs
  - Too little exercise= no effect
  - Too much exercise= harm
  - Varies with the individual’s conditioning
  - Varies with the individual’s needs, age, gender etc.

- Exercise Volume and Intensity
  - Volume= Frequency (sessions/day or week) * Duration (time)
    - With resistance exercise it can be related to sets and reps- respectively
  - Intensity= How hard are you going
    - Many ways to gauge intensity with cardiorespiratory exercise
    - What % of 1-repetition maximum (%1RM) in weight lifting

Dose-Response Curves- Optimal Points

A Little is Good- More Must be Better!

- Fixx and others felt runners were immune to heart disease and yet he died at age 52 of heart disease basically during a run.
- He ignored several small heart attacks in the previous weeks and urges to get a stress test from Kenneth Cooper!
- Thomas Bassler MD., published a 1977 article entitled- Running Protects Against Coronary Artery Disease. Completing a Marathon Confers Immunity Against Heart Attack
Ultrarunner- Legend of “Born to Run”

• Born to Run- Featured Ultrarunner- Micah True known as the Caballo Blanco (White Horse) died at 58 y.o.
• He is the reason for the book and Tarahumara Indians connections with McDougall
• True was suffering from idiopathic cardiomyopathy, which had caused the left ventricle of his heart to become enlarged

Recommended Dose of Exercise for Health

• “Health” is usually defined as “not dying” or mortality
• The U.S. Department of Health and Human Services, the parent agency of NIH, recommends that adults ages 18 to 64 engage in regular aerobic physical activity
  – 2.5 hours (150 min/wk) at moderate intensity- 3-6 METS (5 x 30 min)
  – 1.25 hrs (75 min/wk) at vigorous intensity—weekly- >6 METS (3 x 25 min)

Talk Test Gauge for Exercise Intensity
➢ Moderate activities are those during which a person could talk but not sing.
➢ Vigorous activities -a person could say only a few words without stopping for breath.

Exercise Dose and Mortality or Life Extension

• Exercise does not add a lot of years
• Intense exercise very effective to lower all cause mortality!
• After 50 minutes “Vigorous Exercise”- no additional benefit

Optimizing Training: A Model
Different Paths Taken based on Recovery?

How Does Someone Get Overtraining Syndrome?

- Overtraining = Training Volume * Training Intensity / Recovery
  - If the volume is normal but recovery is too low, overreaching (Stage 1) achieved. Performance decreases minor to non-existent. Longer recovery will restore normal functioning.
  - The volume alone can be too high in aerobic or resistance exercise
    - often causes sympathetic overtraining (Stage 2) nervous, hormonal, and mechanical imbalances causing various signs and symptoms
  - The volume and intensity can be too high
    - Often causes parasympathetic overtraining (Stage 3) associated with exhaustion of nervous and hormonal factors (dansensitization to stimulus)

Overtraining Syndrome— the effects of overtraining

- Overtraining Syndrome noticed by decreased performance and physiological function— despite effort or desire
  - Loss of muscular strength and coordination
  - Reduced exercise capacity and constant fatigue
  - Change in appetite
  - Sometimes body weight loss
  - Sleep disturbances— restlessness
  - Irritability, excitability (high resting HR), anxiousness
  - Loss of motivation and vigor, burnout
  - Lack of mental concentration and depression

Overtraining and depression have remarkably similar etiologies.

Comprehensive List of Overtraining Effects
Direct Factors Associated with Overtraining

- Training
  - Intensity
  - Volume
- Recovery
  - Time between workouts
  - Quality of Sleep
  - Daily Activity
- Nutrition
  - Inflammatory Agents
  - Antioxidants
- Daily Stresses
  - Vocational-Family
  - Relaxation activities

Overtraining—Similarities to Chronic Fatigue & Fibromyalgia Syndromes

- Chronic fatigue at rest and during exercise
- Psychological distress
- Immune system dysfunction
- Hormonal dysfunction
- HPA axis dysfunction
- Neurotransmitter dysfunction
- Difficult to diagnose—cause remains unknown

Background Physiology—Neuroendocrine System Function

Different Paths for Stress Effects

SAMP-HPA

- cortisol
Primary Signal Transduction Pathways in Skeletal Muscle

- Primary signals for muscle adaptation
  - Mechanical stretch
  - Calcium
    - Via calmodulin-dependent kinase
  - Free radicals
  - Phosphate/muscle energy levels
    - AMP/ATP ratio activates AMPK
- Primary signals lead to adaptations
  - Increased protein synthesis
- Effect depends on exercise stimulus
  - Intensity and duration
  - Resistance vs. endurance training

Secondary Messengers in Skeletal Muscle

- AMPK
  - Glucose uptake, fatty acid oxidation, and mitochondrial biogenesis
- PGC-1α
  - Increases in capillaries, mitochondria, antioxidant enzymes
  - Activated by p38 and CaMK
- Calcineurin
  - Fiber growth, fast-to-slow fiber type change
- IGF-1 / Akt / mTOR
  - Muscle growth from resistance training
- NFkB

Exercise-Induced Signaling Events

- Primary Signals
  - Ca++, AMP/ATP, free radicals
- Secondary signals
  - Calcineurin, CaMK, AMPK, p38, NFkB, PGC-1α
- Responses
  - Fast-to-slow fiber type shift
  - Mitochondrial biogenesis
  - Antioxidant enzyme synthesis

Resistance Training-Induced Signaling Events

- Primary Signal
  - Muscle stretch
- Secondary signals
  - IGF-1, Akt, mTOR
  - Promote protein synthesis
    - A single bout can increase protein synthesis 50–100%
- Responses
  - Muscle hypertrophy
    - Increased cross-sectional area of fibers
    - Increased number of myonuclei in each fiber
    - Arise from satellite cell
    - Required for continued muscle adaptations
Normal Training vs. Overtraining NE Responses

What determines the Anabolic or Catabolic Reaction?

- *Resistance training with excessive training load and insufficient recovery alters skeletal muscle mass-related protein expression*
  - Souza, Aguilar, Vechetti-Junior, Piedade, Rocha Campos, Dal-Pai-Silva
  - A 12 wk overtraining regimen in rats
  - Using rats enabled muscle analysis and signaling differences

Beta2-Adrenergic receptor downregulation and performance decrements with Overtraining

- **Subjects/ Protocol**
  - Weight trained men- OT-overtrained: 10 reps @1RM * 2 wks consecutive, Con- control: trained 2d/wk * 2 wks
- **Measures**
  - (Pre- Post) Muscle biopsies- vastus lateralis-β2-adrenergic R density measured, static/dynamic muscle performances, nocturnal urinary epinephrine
- **Results**
  - Urinary epi- ↑ 49% but not significant
  - β2-adrenergic R- ↓ 37%, no change control
  - Epinephrine to receptor density suggested a sensitivity ↓ 2.4 fold
- **Conclusion**- B2 receptor desensitization may explain

Normal Training vs. Overtraining Protein Signaling Responses
Potential Adverse Cardiovascular Effects From Excessive Endurance Exercise

- James H. O'Keefe, MD, Harshal R. Patil, MD, Carl J. Lavie, MD, Anthony Marston, MD, Robert A. Vogel, MD, Peter A. McCullough, MD, MPH.
- Long-term excessive endurance exercise may induce pathologic structural remodeling of the heart and large arteries.

O’Keefe et al. Study- continued

- When excessive exercise is carried out long term

Author’s note: Long term exercise still very beneficial and more investigation should be done to confirm above findings

Cross Country Skiers and Atrial Fibrillation

- Andersen et al. investigated 52 755 athletes
  - They used creative measures of exercise to develop a ‘dose–response’ curve
  - further circumstantial evidence for the premise that AF risk is increased in the very fittest athletes and in those who perform exercise over many years.
- Primary endpoint of any arrhythmia, which was a composite of brady- & tachy-arrhythmias,
  - those completing the race within 60% of the winner's time were 1.3 times more likely to be diagnosed with an arrhythmia than those who took more than twice the time to complete the race.
- Similarly, those who had completed the race ≥5 times had a 1.3-fold increase in arrhythmic risk as compared with those who completed the race only once.

Possible Explanations for Atrial Fibrillation

- Some factors outside one’s control
- Some exercise= blessing → Too much exercise= curse
Coronary Artery Plaque in Elite Women Marathon Runners Compared with Sedentary Controls

- On a per lesion basis, plaque volume and percent stenosis were not significantly different between each group indicating that when plaque is present, both groups exhibited similar plaque characteristics.
- Results suggest that coronary plaque, while less prevalent in women runners, developed the same volume and percent stenosis when it occurred.
- This result differs from studies in elite male runners, who had identical plaque prevalence and significantly more plaque volume than sedentary controls.

Authors: Kelly Wickstrom; Ross F Garberich; Sue Duval; Denise Winderburg; Stephen C Oesterle; William Roberts; John R Lesser; Kevin M Harris; Robert S Schwartz

Dose of Jogging and Long-Term Mortality: Copenhagen City Heart Study

- Peter Schnohr, MD, DMSc; James H. O’Keefe, MD; Jacob L. Marott, MSc; Peter Lange, MD, DMSc; Gorm B. Jensen, MD, DMSc


- Background People who are physically active have at least a 30% lower risk of death during follow-up compared with those who are inactive. However, the ideal dose of exercise for improving longevity is uncertain.

Strenuous Exercise without Recovery also Bad for the Brain

- Freund et al (2012) measured grey matter volume before, during and 8 mo after ultramarathon- 2788 mi in 64d consecutively
  - Approximately a 6% reduction in GM during the race w/ weight loss
  - The GM volume recovered by 8 mo
- Other studies have found prolonged endurance exercise is linked to an elevated risk of cerebral lesions and edema.
- Theories believe- increased inflammation and elevate stress hormones, along with hypoxia, and oxidative stress may compromise brain structure and function
- Evidence suggests an optimal dose for brain function- much lower than for performance based activities (walking – 20km (12.5 mi) or 3000 kcal/wk

Detecting Overtraining in Endurance Athletes with HR
Overtraining Detection Methods - Detailed

- Wake Up Heart Rate
  - If in sympathetic overtraining may see slight increase- must perform many times-variable
  - If in parasympathetic overtraining the ↓HR may be misinterpreted as conditioning

- Heart Rate Variability (HRV)
  - Athlete app: www.athlete.com
  - HRV should be maintained- the app will detect variations w/in 2 min sample

- Maximum aerobic function - MAF test
  - Calculate your 180-age HR
  - Run 3 miles consecutively at the 180-age HR (if 30 yrs = 150)- should see increasing times with each mile
  - If not getting faster with time then likely overtraining

- Recovery HR- Go 60-80%HRmax (220-age)
  - Take HR immediately after
  - Take HR 2 min after
  - 3 Zones- less than 22- ↑risk of heart disease, 44- about normal, 66- very good

Which is early? Which is late? RPE 3 vs 9?

Effect of Conditioning on Heart Rate

<table>
<thead>
<tr>
<th>Rating of Perceived Exertion (RPE)</th>
<th>RPE</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>complete rest</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>very, very easy</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>easy</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>moderate</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
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<td>5</td>
<td>5</td>
<td>hard</td>
</tr>
<tr>
<td>6</td>
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<td>7</td>
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<td>extremely hard</td>
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<td>8</td>
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<td>almost maximal</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>maximum effort</td>
</tr>
</tbody>
</table>

## Methods for Strength and Hypertrophy

### Going to Failure for Hypertrophy

- **Time Under Tension Theory**
- **Motor Unit Stimulation Theory**
- **Eccentric load and Myofibrillar Damage Theory**

### Some authorities believe NOT going to maximum allows:
- Reduced time between sets and more sets - thus ↑ T.U.T.
- Greater safety especially for lifts like the deadlift
- Reduced recovery time and thus greater frequency
- Avoidance of tendon damage and rhabdomyolysis

Stopping a repetition or two short of maximum is recommended

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## To Fail or Not to Fail? - This is the conundrum


### Weight Lifting Over-Reaching-

- Failure training can be anabolic if done sparingly, but it’s catabolic if done too often. Obey the balance
- Failure training shouldn’t be used on every set. This will set up early central fatigue (brain effort) and catabolic reactions
- If you use failure training, do so only on the last set of an exercise, and perhaps only on a hypertrophy day.
- Individuals using "beyond failure" intensity techniques should factor in additional rest when doing so. Allow your body to recover!
  - Assisted repetitions with a spotter
  - Drop sets

*BodyBuilding.com- Ask the Muscle Prof. Jacob Wilson, Ph.D., CSCS*

Last updated: Feb 26, 2015
Intracellular Signaling and Inhibition of Protein Synthesis

Exertional Rhabdomyolysis

- Rhabdomyolysis- rod-shaped, muscle cell breakage-
- the breakdown of muscle fiber- release of contents into blood stream
- Can be fatal- hard to distinguish from DOMS
- Proteins (and Potassium) leak out of the cell and precipitate in the kidney
- This can cause acute renal failure or death
- Symptoms include: severe muscle ache throughout body, muscle weakness, and dark (cola colored) urine
- Presence of myoglobin, electrolytes
- Occurs more often in unfit people but can occur in highly fit
- Start unfit people slowly and let them build up

Does CrossFit cause Exertional Rhabdomyolysis?

- A total of 132 responses were collected with 97 (73.5%) having sustained an injury during CrossFit training.
- A total of 186 injuries were reported with 9 (7.0%) requiring surgical intervention.
- An injury rate of 3.1 per 1000 hours trained was calculated. No incidences of rhabdomyolysis were reported.
- Injury rates with CrossFit training are similar to that reported in the literature for sports such as Olympic weight-lifting, power-lifting and gymnastics and lower than competitive contact sports such as rugby union and rugby league.
- Shoulder and spine injuries predominate with no incidences of rhabdomyolysis obtained.

- J Strength Cond Res. 2013 Nov 22. [Epub ahead of print]
- The nature and prevalence of injury during CrossFit training.
- Huk FF. Holocaust: E. Hickey R

Training Effect = Improved Performance due to several interdependent factors

- What is needed to get a training effect?

  Overload a Specific Metabolic or Structural System

  Histories
Classic Periodization Phases

\[ F \times I \times T = \text{Training Load} \]

Don’t ↑ Load > 10%/wk

Functional Periodization

- Focus on Injury Prevention and Reduction
  - Build anatomical stability and strength 1st
  - Develop muscular endurance and aerobic base 2nd
  - Develop power and speed 3rd
  - Develop speed and ballistic agility last (if at all)

- Seasonal Periodization
  - Best when a particular predictable season occurs in a given year
  - Building a base-functional capacities- should be done “off-season
  - Programming intensity needs to be done closer to actual competition

Periodization for Endurance Athletes

Short and Long-Term Recovery
- Keep in mind that there are two categories of recovery. There is immediate (short-term) recovery from a particularly intense training session or event, and there is the long-term recovery that needs to be built into a year-round training schedule. Both are important for optimal sports performance.

The Principle of Adaptation to Exercise
- Specific Adaptation to Induced Demand (SAID) states that when we undergo the stress of physical exercise, our body adapts and becomes more efficient. Once you adapt to a given stress, you require additional stress to continue to make progress.

How do you progress a training program?

- Some people build endurance into speed others build speed into endurance
  - Experienced runners with less than 2 mo. layoff gearing up for long distance race can build endurance into speed
  - Most runners should intensify after “base” established
Periodization- Planning a Training Year

3 Levels of Cycles
- **Microcycle**: each week of sessions
- **Mesocycle**: weeks to months
- **Macrocycle**: Months of training (the phases to the right are 4 macrocycles)

Year-Round Conditioning for Athletes

- **Off-season conditioning**
  - Prevent excessive weight (fat) gain
  - Maintain muscular strength or endurance
  - Maintain bone and ligament integrity
  - Maintain skill level
- **Preseason conditioning**
  - 8–12 weeks prior to competition
  - Increase to maximum the energy systems used in particular sports
- **In-season conditioning**
  - Maintenance of fitness level

Potential Diet and Nutrition Tips- Overtraining

- Reduce (or eliminate) high-glycemic foods.
  - Moderating carb intake may help lower cortisol release
- Consume smaller, more frequent meals- control blood sugar and cortisol levels
  - Especially important when depression, fatigue, restless sleep kick in
- Adequate caloric intake is very important
  - Never go hungry and include plenty of protein- eggs/meat/healthy fats
- Overtraining may disrupt the normal balance of fats, which control inflammation
  - Reduce vegetable oil intake (soy, peanut, safflower, corn) ↑inflamtn
  - EPA (fish oil) can help reduce inflamtn, dairy fats or gluten may ↑inflamtn

Suggested Activities for the Various Phases of A Year-Round Training Program

<table>
<thead>
<tr>
<th>Off-Season</th>
<th>Preseason</th>
<th>In-Season</th>
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<tbody>
<tr>
<td>Weight training</td>
<td>Weight training</td>
<td>Maintenance program</td>
</tr>
<tr>
<td>Running</td>
<td>Running</td>
<td></td>
</tr>
<tr>
<td>Skill practice</td>
<td>Skill practice</td>
<td></td>
</tr>
<tr>
<td>Participation in other sports</td>
<td>Learning strategies (increased intensity)</td>
<td></td>
</tr>
</tbody>
</table>
Potential Diet and Nutrition Tips- Overtraining- cont.

- Caffeine consumption may be contraindicated if overtrained
  - Avoid stimulants- coffee, tea, soda, chocolate, OTC drugs
- Zinc may help control abnormally high cortisol- timing important
  - Cortisol should be measured throughout day to determine peak
  - Supplement Zinc 2-3 hrs before cortisol peak (typically morning peak)
- Malabsorption of nutrients common especially when intestinal function is poor and stress is high
  - >40 yrs is more common
  - Betaine HCl- improve digestion,
  - L-glutamine- may improve absorption

Influence of Genetics on Responsiveness and Exercise responses on Epigenetics

- Genetics plays an important role in how an individual responds to training
  - High responders vs. low responders
  - Åstrand and Rodahl: “If you want to become a world-class athlete, you must choose your parents wisely.”
- Anaerobic capacity is more genetically determined than aerobic capacity
  - Training can only improve anaerobic performance to a small degree
  - Dependent largely on fast (IIX) fibers
    - Determined early in development
- Data shows that exercise may alter the genes that are turned on

Conclusions and Summary

- Overtraining leads to Overreaching and eventually to Overtraining. Each stage has identifiable characteristics.
  - The recovery for each stage gets increasing longer
  - A strong trend in training is to go “more often” not “harder”.
- A stressed system is a weakened system
  - Recovery is a critical part of the training effect
  - Mental stress is additive to physical stress
  - The harder the workout the greater the recovery
  - Immune and endocrine functions can be weakened by stress
- New methods of detection and dietary practices can reduce the incidence of overtraining
- Evidence shows chronic excessive training may lead to heart problems and potentially death

Is There a “No Fly Zone” or “Black Hole”?

- Some authorities in running (Dr. Steve Seiler & Dr. Jonathan Esteve-Lano) believe there may be a “black hole”?
  - Improvements plateau, progress stagnates?
- Seiler & Kjerland, 2006- found in Nordic skiers, cyclists and runners 70-80% in or below Zone 1, and 5-10% in Zone 3, with little 15-20% time in Zone 2 where you expect the majority of time!
  - The training zone above the Maffetone (max aerobic only) suggestion- approx. <75% HRR.
  - The training zone below the HIIT (interval anaerobic zone)- below 85%->HRR.
- Many athletes just ”grind out” a majority of their workouts in this zone thinking it is “tough but sustainable”. Studies show most top runners avoid it.
- Too hard to maintain, too easy to see strength changes.
- No HARD proof for this, but VERY interesting concept!