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# Load management:

## what the research says about sports injury prevention, management, and performance.

Carol Mack, PT, DPT, SCS, CSCS, PN-1

# Carol Mack, PT, DPT, SCS, CSCS, PN-1

- Carol Ferkovic Mack, PT, DPT, SCS, CSCS is the owner of CLE Sports PT & Performance in Cleveland, Ohio. Carol graduated from Duquesne University's Doctor of Physical Therapy program in 2006 after playing four years of varsity soccer. She is a Board Certified Specialist in Sports Physical Therapy specializing in end-stage rehabilitation of soccer athletes, female athletes, and runners. Carol is also a Certified Strength & Conditioning Specialist and a Precision Nutrition Level 1 Certified Coach. She serves as a Physical Therapist for Beaumont School Athletics, Distance Coach for Fleet Feet Sports Cleveland, and consultant to the Yoga Roots Educational Team.
- Carol recently finished her second term as Chair of the American Academy of Sports Physical Therapy's Female Athlete Special Interest Group. She now serves as Vice-Chair of Educational Programming. She is also a member of the US Olympic Committee's Volunteer Medical Staff. Carol was previously a Physical Therapist at Cleveland Clinic's Sports Health Center, where she was chair of Cleveland Clinic's "Match Fit" soccer performance enhancement and injury risk reduction program and co-director of Cleveland Clinic's Sports Physical Therapy Residency.

- Presenter Disclosure: Financial: Presenter has received an honorarium for presenting this course. Non-financial: Presenter has no relevant non-financial relationships to disclose.

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# Learning Outcomes

After this course, participants will be able to:

- Define “load management.”
- List 2 principles of load management as related to rehabilitation and management of sports injuries.
- List 2 principles of load management as related to sports performance.

# DEFINITIONS

# TRAINING CONCEPTS

# Program Design: Periodization

Planned manipulation of training variables…

- load
- sets
- repetitions

…to maximize adaptation and prevent overtraining

*American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Med. Sci. Sports Exerc. Mar 2009*

# “Workload”

- Sometimes called “training load”

- **Load applied to tissue > capacity = overload**
  - Training gains, or injury risk

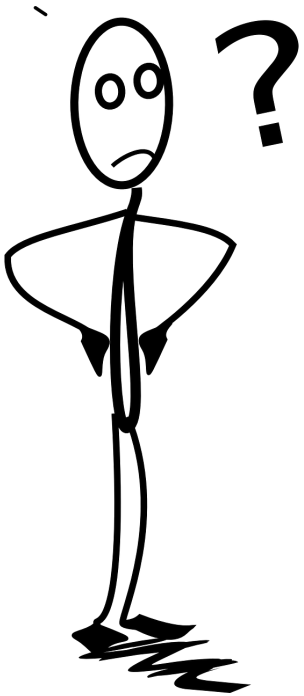
Neilsen, et al, 2018

# Injury risk

- Complex phenomenon
- Risk factors
  - Poor physical capacity
  - History musculoskeletal dysfunction
  - Rate of increase training load

# “Workload”

- No universal definition of workload



Impellizzeri, 2020

# “Workload”

- *“The cumulative amount of stress placed on an individual from multiple training sessions and games over a period of time, expressed in terms of either the external workloads performed (eg, resistance lifted, km run) or the internal response (eg, heart rate, rating of perceived exertion) to that workload”*

Gabbett, 2014, Windt 2017

# “Workload”

- Wide variation

*“Combining and/or comparing results from different studies using workload-related exposure variables should be done with extreme caution, if at all, as the underlying measures of workload are likely to be very different.”*

How Has Workload Been Defined and How Many Workload-Related Exposures to Injury Are Included in Published Sports Injury Articles? A Scoping Review

Udby C, Impellizzeri FM, Lind M,, Nielsen RØ
*Journal of Orthopaedic & Sports Physical Therapy*
Published Online:September 30, 2020 Volume50

# “Workload”

- Impellizzerri, et al 2020:
  - Important to…
    - Understand what “workload” means
    - Use identical measures of workload

Gabbett, 2014, Windt 2017

# Definitions

- **Training stress:** general term
  - Influenced by two types of load:
    - external: application of mechanical load
    - internal: physiological/psychological responses

Moving Beyond Weekly "Distance": Optimizing Quantification of Training Load in Runners
Paquette MR, Napier C, Willy RW, Stellingwerff T.
*Journal of Orthopaedic & Sports Physical Therapy*
Published Online: 30 Sep 2020 Volume 50 Issue 10 Pages 536-586

# Definitions

- **Daily stress:** from non-training factors
- **External load**:
- (physiologic) **Internal load:**
- **Tissue** internal load:
- **Training load:**

Moving Beyond Weekly "Distance": Optimizing Quantification of Training Load in Runners
Paquette MR, Napier C, Willy RW, Stellingwerff T.
*Journal of Orthopaedic & Sports Physical Therapy*
Published Online: 30 Sep 2020 Volume 50 Issue 10 Pages 536-586

**Q8**

# Definitions

- Training load:
  - product of external and physiological internal loads
    - Duration x sRPE
    - Peak tibial acceleration x SRPE
    - Number of steps x sRPE

Moving Beyond Weekly "Distance": Optimizing Quantification of Training Load in Runners
Paquette MR, Napier C, Willy RW, Stellingwerff T.
*Journal of Orthopaedic & Sports Physical Therapy*
Published Online: 30 Sep 2020 Volume 50 Issue 10 Pages 536-586

continued

# THE EVIDENCE…

# Training load

- Acute load:  most recent weekly training
- Chronic load: four-week average of work

- Acute: chronic ratio = athlete's current status

  (Gabbett 2016, Hulin et al 2017)

  - "Sweet spot" 0.8-1.3 in healthy athletes
  - <1.5:  2-4x increased risk injury (following week)
    - <2.11:  3.4x increased risk

**Q1, Q2**

# Training load

- How to monitor (Bourdon et al, Consensus Statement 2017)
  - RPE, heart rate, O2 consumption = internal load (biological and physiological stressors)
  - Power output, speed, acceleration, GPS, accelerometer = external load (objective measures of work)
- Monitor specific to the sport/workload!
- Subjective measures: superior sensitivity, consistency (Saw 2016)

# Training load

- Example:  marathon runner “peak weeks”
  - Week 8: 21 miles
  - Week 9: 23 miles
  - Week 10: 25 miles
  - Week 11: 30 miles

- Acute load (wk 11) = 30 miles
- Chronic load (avg mileage 4 wks prior) =  24.75 miles
  - Acute load ÷ chronic load = acute:chronic load ratio
    - 30/24.75 = 1.21

# Training load

- "Taper weeks"
  - Week 11: 28 miles
  - Week 12: 24 miles
  - Week 13: 23 miles
  - Week 14: 18 miles
    - *Week 15: race week*
- Acute load (wk 14) = 18 miles
- Chronic load (avg mileage prior 4 wks) = 23.25
  - Acute load ÷ chronic load = acute:chronic load ratio
  - 18/23.25 = 0.77

# Training load

- Example 2:  Offseason Strength Program
  - External load: total pounds lifted per week
    - Repetitions  x  pounds or kg

- **Squat and Bench Press** Monday, Wednesday,Friday
  - Squat: 3 x 8, 100 lbs  = 2,400 lbs volume x 3 workouts = 7,200 lbs weekly volume
  - Bench Press: 4 x 8 reps, 50 lbs = 1,600 lbs volume x 3 workouts = 4,800 lbs weekly volume

# Training load

- Example 2:  Offseason Strength Program
  - Acute load: 12,000 lbs.
  - Chronic load:  11,000 lbs
    - average weight lifted per week

- Acute divided by chronic: 12,000/11,000 = 1.09.

# Training load: the reality

- **Unwise to rely only on calculated load**
- MUST take into account other factors:
  - Age: older, younger athletes at higher risk of injury
  - Physical qualities
    - baseline fitness, speed, strength
  - Training history, timing
  - Injury/health history
  - Mobility, biomechanics
  - Stress, anxiety
  - Sleep
  - Diet

*Gabbett, 2019*

*“We get caught up with data…I think one of my strengths is relationships with players that almost determine what a player needs.”*

- Dawn Scott, former High Performance Coach, World Cup Champion US Women’s Soccer

Coaches, scientists, media quick to point a finger at loading when an injury occurs.

*"Training load can just provide information to allow a coach to do his/her job better…scientists should stop giving these magical numbers powers they just don't have…injury occurrence is a complex phenomenon."*

- Franco Impellizzeri, et al;
Professor, Sport and Exercise Science and Medicine,
University of Technology, Sydney

# Internal and external training load: 15 years on

Impellizzeri FM, , Marcora SM, , Coutts AJ. **Int J Sports Physiol Perform**. 2019; 14: 270– 273.

- Recommend internal load as primary measure
  - Not always practical, BUT caution against only using external

- Be clear on internal load

# Training load: the reality

- Excessive simplification
  - Difficult for clinicians to interpret
- Correlation does **not** equal causation

*Impellizzeri 2020*

# Training load: the reality

- Many studies are likely impacted by questionable research practices
  - Intentional or unintentional

- Common practices
  - HARKing
  - Publication bias
  - P-Hacking
  - Mixed messages

*Impellizzeri 2020*

# Training load: the reality

- Interpretation considerations:
  - Study design
  - Sources of bias
  - Contradictory evidence
  - Clinical relevance
  - Study limitations
  - Statistical approach
  - Effect size, uncertainty
  - Conflicts of interest

*Impellizzeri 2020*

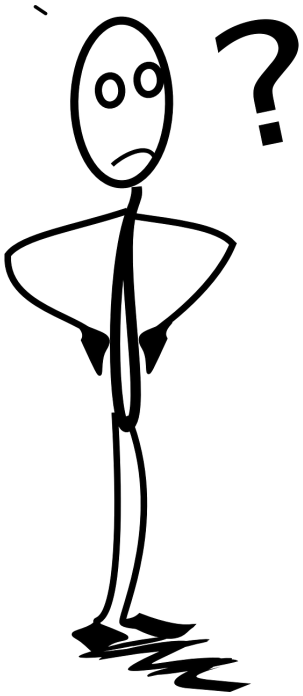
# Training load: the reality

- Before using a training load metric:
  1. **Ensure interpretation coherent with nature of the study**
     - Descriptive, predictive, causal
  2. **Carefully assess trustworthiness**
     - Understand research limitations, risk bias
  3. **Go beyond metric**
     - Verify strength of physiological or biomechanical meaning

*Impellizzeri 2020*

# Training load: the reality

- So what CAN we recommend??
  - Don't go beyond "too much too soon"



*Impellizzeri 2020*

# Tech

Workload a-WEAR-ness: Monitoring Workload in Team Sports With Wearable Technology. A Scoping Review

Benson LC, Räisänen A, Volkova. VG, Pasanen K, Emery CA

*Journal of Orthopaedic & Sports Physical Therapy*

Published Online: 30 Sep 2020 Volume 50 Issue 10 Pages 536-586

- GPS most common for external load
  - Does not work well indoors!
- Heart rate monitors allow for monitoring of internal load

# Tech

- Benefits!
  - Improves, off-loads data collection
  - Measures sport-specific load

"To Tech or Not to Tech?" A Critical Decision-Making Framework for Implementing Technology in Sport

Windt J, MacDonald K, Taylor D, Zumbo BD, Sporer BC; Martin DT,

*J Athl Train (2020) 55 (9): 902–910*

# Tech


- Pitfalls:
  - Promises not kept
  - Does not provide right data
  - If it can't be implemented- waste of time, money, space!

"To Tech or Not to Tech?" A Critical Decision-Making Framework for Implementing Technology in Sport

Windt J, MacDonald K, Taylor D, Zumbo BD, Sporer BC; Martin DT,

*J Athl Train (2020) 55 (9): 902–910*

# So what do we do?!?!

- Ask the right questions:
  - Would the promised information be helpful
  - Can you trust the information you will be getting?
  - Can you integrate, manage, and analyze the data effectively?
  - Can you implement the technology in your practice?

- Look for sources of evidence

# Bottom line

- Start with the end in mind.
- Understand the existing environment
- Evaluate continually.
- Plan ahead.
- Educate practitioners involved

# PRACTICAL APPLICATION

# From the floor to the ceiling

- Gabbett, JOSPT, 2019:
  - Floor = current capacity
  - Ceiling = optimal capacity

  - Challenge - time needed to get there
    - Too little: increased injury risk

# From the floor to the ceiling

- Gabbett, JOSPT, 2019:
  - How to bridge the gap
    - Maintain adequate fitness when not competing to improve load tolerance in-season
      - Off-season
      - Injuries

# From the floor to the ceiling

- How to bridge the gap
  - Be realistic about what's needed to reach optimal performance
    - Needs assessment
  - Respect differences in training tolerance between athletes
    - Plan for it!

# End-stage rehab


- Know your athlete and sport
  - “Needs analysis” is CRUCIAL!
- End-stage rehab:  be objective
  - Quantify/document workload, re-assess
    - link to re-injury: “key focus area”
      - 2016 Consensus Statement on Return to Sport from the First World Congress in Sports Physical Therapy

Q5

# Running

- Tracking mileage is valuable, but only a piece of the puzzle

- External load: volume (distance or minutes), pace
- Internal load: session rating of perceived exertion (sRPE), heart rate, blood lactate

Paquette et al, *JOSPT* 2020

# Running

- Internal **physiological** load vs internal **tissue** load
  - Examples
    - 10k fatigued vs fresh legs
    - Workout prescribed at fast pace
- Difficult to estimate external load from distance and pace alone.

Paquette et al, *JOSPT* 2020

# Running- external loads

| Parameter | 10-km Recovery Run (Fresh) | 10-km Recovery Run (fatigued) | Ten 1-km Track Repeats in Rigid Spikes |
|---|---|---|---|
| Duration (volume), min:s | 37:30 | 43:20 | 27:30 |
| Pace, min:s/km | 3:45 | 4:20 | 2:45 |
| Estimated steps, n | 6750 | 7669 | 5445 |
| Estimated accumulated vGRF, BW | 20925 | 22240 | 17969 |

Paquette et al, *JOSPT* 2020
Chan-Roper et al 2012
Hanley B, , Bissas A 2018
Arampatzis et al 1999
Dorn et al. 2012

# Running- internal loads

| Parameter | 10-km Recovery Run (Fresh) | 10-km Recovery Run (Very Tired) | Ten 1-km Track Repeats in Rigid Spikes |
|---|---|---|---|
| Internal loads | | | |
| RPE (1–10) | 2 | 5 | 9 |
| Estimated heart rate, % maximum | 70 | 80 | 95 |
| Estimated blood lactate, mmol/L | 2.5 | 4.5 | ≥10 |

Paquette et al, *JOSPT* 2020
Chan-Roper et al 2012
Hanley B, , Bissas A 2018
Arampatzis et al 1999
Dorn et al. 2012

# Running- training loads

| Parameter | 10-km Recovery Run (Fresh) | 10-km Recovery Run (Very Tired) | Ten 1-km Track Repeats in Rigid Spikes |
|---|---|---|---|
| Training loads | | | |
| Duration × RPE | 75 | 217 | 248 |
| Accumulated GRF × RPE (/1000) | 42 | 111 | 162 |
| Accumulated achilles tendon force × RPE (/1000) | 135 | 355 | 564 |

Paquette et al, *JOSPT* 2020
Chan-Roper et al 2012
Hanley B, , Bissas A 2018
Arampatzis et al 1999
Dorn et al. 2012

# Running

- Quantifying training load
  - Look at both external **and** internal load
    - sessionRPE (sRPE) <u>and</u> volume

- sRPE correlates with blood lactate concentration

Dantas et al 2015
Scherr et al 2013

**Q8**

# Running

- Programming workouts:
  - Challenging to prescribe loads
    - Variability between sessions of internal load response
- Give external load (distance, time) with internal load guidelines
  - "easy pace"  "hard effort"
- Constantly evaluate status

Paquette et al, *JOSPT* 2020

# Running

- Acute-chronic workload
  - Can be used
    - Quantify current fatigue vs accumulated fitness


Paquette et al, *JOSPT* 2020

# Running

- Emerging research:
  - Biomechanical metrics
  - Wearables

Paquette et al, *JOSPT* 2020

| Lap | Elev. Loss ft | Avg Pace min/mi | Avg Moving Pace min/mi | Best Pace min/mi | Avg Heart Rate bpm |
|---|---|---|---|---|---|
| 6 | 62 | 10:56 | 10:56 | 10:12 | 125 |
| 7 | 27 | 10:42 | 10:42 | 9:49 | 131 |
| 8 | 30 | 10:47 | 10:47 | 9:55 | 133 |
| 9 | -- | 10:17 | 10:17 | 9:20 | 143 |
| 10 | -- | 9:13 | 9:12 | 8:07 | 155 |
| 11 | -- | 4:49 | 4:49 | 8:07 | 161 |

# Running

- Load and injury:
  - Evaluate difference between
    - Cumulative load at specific anatomical structures
    - Load capacity of the structure, ability to modify

Paquette et al, *JOSPT* 2020
Bertelsen. 2017

# Running- bottom line

- Look at internal and external load


Paquette et al, *JOSPT* 2020
Bertelsen. 2017

# Team sports

- External load
  - GPS does not quantify acceleration/deceleration
    - Accelerometers, biomechanical measures
- Internal load
  - Heart rate, blood lactate values
  - RPE
- Physiological vs biomechanical load

Dalen-Lorentsen et al, *BJSM* 2020
Malone et al, *Science and Medicine in Football* 2020

# Soccer

- Evidence
  - GPS used widely Recommendations:
    - Be consistent with use
    - Know what you're measuring
    - Be appropriate with feedback

- Acute-chronic workload: no reduction in health problems, elite youth soccer

Dalen-Lorentsen et al, *BJSM* 2020
Malone et al, *Science and Medicine in Football* 2020

# Soccer

- US Soccer:
  - *“Not the high load… how you get there*"
- Expose athlete to:
  - Heart rate loads
  - Volume high speed running
  - >90% max sprint velocity
  - Intense acceleration/deceleration
  - Technical skill
  - Position/formation

# Soccer

- Types of load:
  - Cardio
  - Neuromuscular/mechanical
  - **Cognitive**

- Manipulate physical load:
  - Field size, neutral players, number of players, work-rest ratio, duration, volume, **coach encouragement**

# Baseball

- Volume, intensity of throws neglected in current workload standards.
- Use multiple techniques

Onate et al, *J Athl Train* 2020.

# References

- See PDF