WORKLOAD MANAGEMENT BASICS

A Practical Guide to Workload Management & Injury Prevention in Elite Sport

By Francois Gazzano, B.Sc.

AthleteMonitoring

CONTENTS

INTRODUCTION

Sport injuries are becoming a problem of epidemic proportions. In the U.S. alone, 1.5 million high school and college athletes are injured every year [9,6]. The cause of overtraining and injuries is multifactorial, but recent research has identified poor workload management as a major contributor to injuries and illnesses in sport [2,3,4,9]. In this document, we will present evidence-based workload management guidelines and strategies to reduce the risk of illness and injury in athletes, while also optimizing performance.

THE KEY CONCEPTS

Load

Load is the combination of sport and non-sport stressors[13]. Load is more than workload or training load alone and also includes competition, work, recreational activities, family, homework, etc. Load can be divided in two sub-categories: external load and internal load.

External load

External load is the external stimulus applied to the athlete[13]. It is the objectively measurable sport and non-sport physical work (number of sprints, weight lifted, total distance, etc.) performed during competition, training and daily life. External load is usually measured using global position system (GPS) devices, chronometers, accelerometers, dynamometers, etc.

Internal Load

Internal load is the individual physiological and psychological response to external loads, combined with daily life stressors and other environmental and biological factors[13]. It includes objective measures such as heart rate and blood lactate concentration, as well as subjective measurements, such as perceived effort (i.e. ratings of perceived exertion).

Internal Load vs External Load

While external load provides information about the work completed and the performance capacities of the athlete[13], internal load is the trigger of training-induced adaptations[16]. The constant monitoring of internal load can help identify recovery needs, predict performance decrements, anticipate health issues and adjust training, and competition programs. It's a cornerstone of an effective workload management program.

Term	Definition
Load / Workload	Combination of sport and non-sport stressors
External load	External stimulus applied to the athlete
Internal load	Physiological and psychological response to external loads, combined with non-sport stressors

The measurement of Internal Load

A simple, effective and validated method of measuring internal load is to use the session-rating of perceived exertion (RPE) scale developed by U.S. sport scientist Dr. Carl Foster [2,3]. This technique requires the athlete to rate each session's overall difficulty (sRPE) on a 10-point scale. The multiplication of the session difficulty by the session duration (in minutes) provides the "Load" for that session in arbitrary units (Load=RPE x Duration in minutes). This method doesn't require equipment and has been validated for monitoring internal loads in most sports, training and competition activities.

The modified RPE Scale used to rate the difficulty of sessions[3]

Rating	Descriptor
0	Rest
1	Very, very easy
2	Easy
3	Moderate

4	Somewhat Hard
5	Hard
6	*
7	Very Hard
8	*
9	*
10	Maximal

The original calculations used by the sRPE method[3]

1. Session load = session RPE x duration (minutes)
2. Daily load =Sum of all Session Training load for the entire day
3. Weekly Training load =Sum of all Daily Training load for the entire week
4. Monotony= standard deviation of Weekly Training load
5. Strain= Daily or Weekly Training load x Monotony

sRPE vs Heart Rate Monitoring

Heart rate (HR) monitoring is frequently used to estimate internal load. This method is based on the linear relationship between HR and the rate of oxygen consumption during steady-state exercise[30], and requires the use of a heart rate monitor.

While being scientific sound, HR monitoring has two important limitations:

1) HR monitoring underestimates internal load during short-duration high-intensity/anaerobic activities[27] (sprints, strength training, etc.), thereby limiting its effectiveness to aerobic activities.
2) Rest, submaximal and maximal exercise HR fluctuate daily[29] (by up to 6.5 % for submaximal HR[30]). Without a regular calibration of individual HR training zones, HR-derived internal load calculations will likely be inaccurate.

While heart rate monitoring can provide an additional physiological insight for sessions or events of aerobic nature, it cannot be effectively used to quantify internal load during all the activities performed by athletes during training and competition. The sRPE method is simpler and provides an accurate quantification of internal load [25] that can be applied to a much broader range of sports, as well as training and competition activities [27].

BETTER WORKLOAD MANAGEMENT –A KEY TO BETTER PERFORMANCES, LESS INJURIES

Inadequate workload is a leading cause of injuries

Excessive fatigue plays a key role in injuries as it impairs decision-making ability, coordination and neuromuscular control [13] . The risk of injury increases when the external load exceeds the capacity of the athlete[13]. For example, in professional ice-hockey, player's average playing time per game is a significant predictor of concussion[23] and in soccer, central fatigue contributes directly to anterior cruciate ligament (ACL) injuries[24].

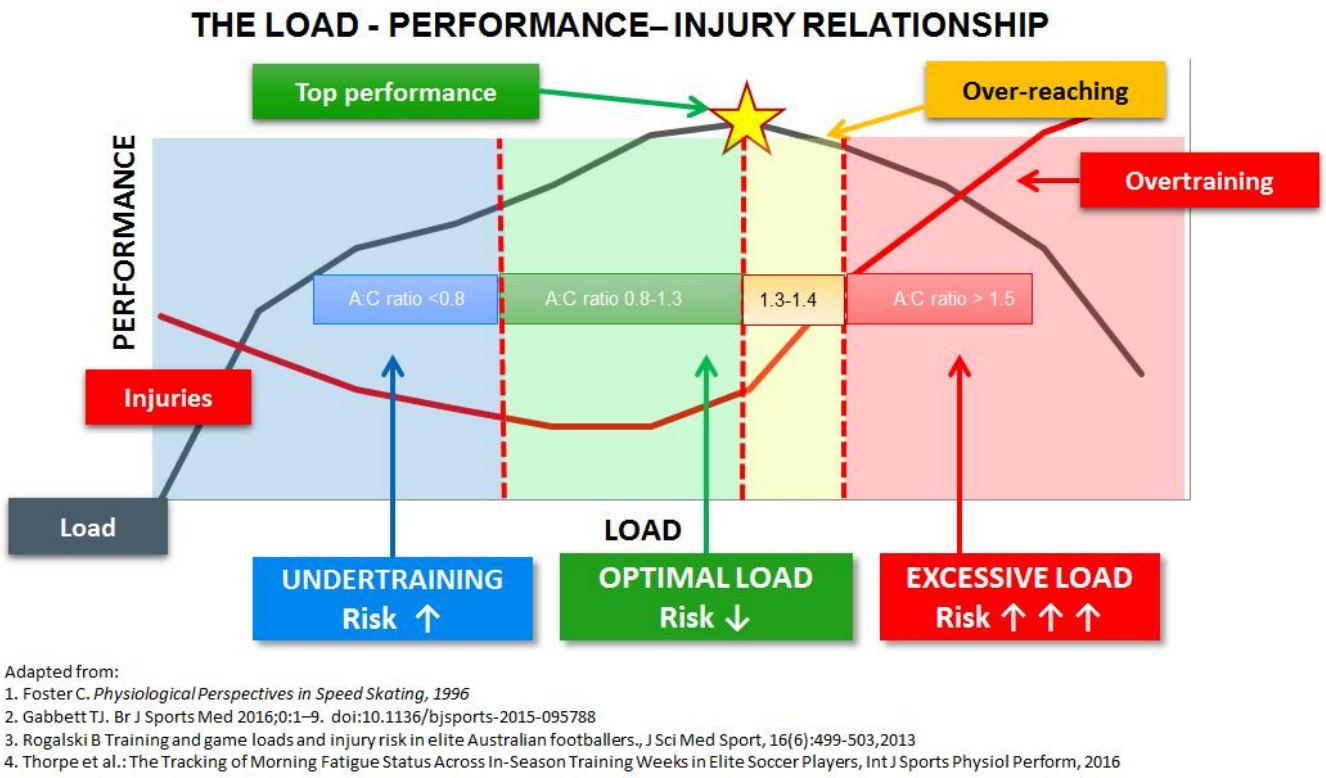
The risk of injury increases when : 1) high loads are applied to athletes who are psychologically and/or physically unfit to tolerate the prescribed workload (undertrained)[4], or; 2) when athletes are fit and well trained, but in need of rest[13]. In both cases, workload exceeds the athlete capacity, leading to excessive fatigue and increased risk of injury.

The role of workload management is to reduce the risk of injury and optimize performance by detecting excessive fatigue, identify its causes, and constantly adapting rest, recovery, training and competition loads, based on the athletes' individual fatigue (physical and psychological), wellness, fitness, health and recovery levels[13].

How to find the "optimal" workload

The "optimal" workload is a moving target. It differs for every athlete and changes constantly based on multiple factors, including phase of season, training status, fitness and fatigue levels, sleep quality, non-sport stressors, etc. Finding the optimal workload and

constantly adapting training programmes to the changing capacity of each athlete is both an art and a science. It is a continuous process that usually requires the daily monitoring of internal load, at least a measure of external load (often duration or distance), the tracking of wellness metrics and the use of these measures to adjust the athlete's training program, recovery and rest.



Adapted from:
1. Foster C. *Physiological Perspectives in Speed Skating, 1996*
2. Gabbett TJ. Br J Sports Med 2016;0:1–9. doi:10.1136/bjsports-2015-095788
3. Rogalski B Training and game loads and injury risk in elite Australian footballers., J Sci Med Sport, 16(6):499-503,2013
4. Thorpe et al.: The Tracking of Morning Fatigue Status Across In-Season Training Weeks in Elite Soccer Players, Int J Sports Physiol Perform, 2016

Figure 1. The Load-Performance-Injury Relationship

THE TOOLS OF EFFECTIVE WORKLOAD MANAGEMENT

An effective workload management program can be implemented with two simple tools:

1. A relation of trust and open communication between players, coaches and training staff. Because self-reported information is used extensively to quantify internal load and pre training readiness, for your monitoring program to work, players need to report their data and feedback as honestly as possible. Having the entire coaching and management team behind the monitoring project increase the chances of a successful outcome[21].

2. A robust workload management software. To maximize athletes "buy-in", the software should be able to: 1) quickly collect quality and meaningful data from the athlete with minimal effort[21]; 2) monitor wellness, internal and external load metrics; 3) help coaches interpret the key metrics in a time effective manner. AthleteMonitoring.com is an excellent example of such system.

Sport technology – nice to have but absolutely not mandatory

Effective workload management's main focus is on monitoring internal load, detecting excessive fatigue and identifying external stressors.

While many professional teams have access to expensive tracking technology (GPS, video tracking, etc), this is not a necessity for a successful athlete monitoring system. Tracking devices are useful for monitoring external load, but can't provide information on internal load. As a result, expensive equipment is not required to keep athletes performing well and injury free.

THE KEY WORKLOAD MANAGEMENT METRICS

Despite decades of scientific research and empirical experience, no single marker of elevated risk of injury or overtraining has been identified [13].

Today, a multifaceted approach to workload and recovery management is considered best practice [12, 13]. This approach includes the collection and analysis of both subjective and objective measures, and the careful monitoring and optimization of the key metrics below.

Note: while thresholds and indicators presented in this article are published in the scientific literature, they should be used as guideline and not as 'magic' numbers. Large inter-individual variations exists.

Chronic Load (CL)

This is the average weekly load (Load=duration x RPE), typically over the previous 4 weeks. Usually, the higher the *Chronic Load*, the fitter the athlete. In some situations, chronic load can also be calculated using exponentially weighted moving averages, and for periods longer than 4 weeks.

Acute Load (AL)

The *Acute Load* represents the cumulative load of the current week. Usually, the higher the acute load (compared to chronic load), the more tired the athlete. In some situations, AL can also be calculated using shorter periods (eg: 3 days).

Freshness Index (FI)

Similar to the *Training stress balance* proposed by Andrew Coogan[17], the Freshness index represents the difference between chronic and acute load (CL-AL) or between 'fitness' and 'fatigue'. A positive Freshness Index indicates an unloading phase where low fatigue and good performance levels are to be expected.

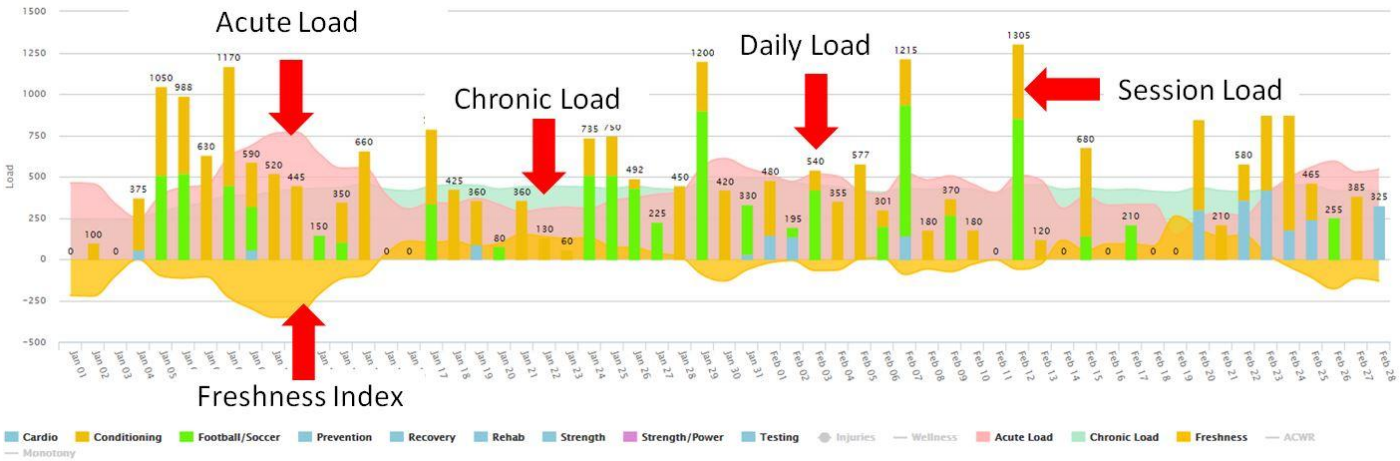


Figure 2. Graphical visualization of 3 months of acute, chronic, daily, session loads and freshness index by the AthleteMonitoring.com system

Monotony

The *Monotony* Index proposed by Carl Foster[3] measures the fluctuation of daily loads within the week. Intensive training combined with a high Monotony Index (>2) is an important risk factor for illness and overtraining[3].

Strain

Early work by Foster demonstrated that 89% of illnesses and injuries could be explained by spikes in individual *Strain* in the 10 days preceding the incident[3]. Thus, monitoring the *Strain* variable can be a valuable tool to control individual adaptation to training load, and prevent workload-related illness and overtraining[3].

Acute:Chronic Workload Ratio (ACWR)

The Acute:Chronic Workload Ratio (ACWR)[4,9,18] measures the relationship between acute load (current week load) and chronic load (last 4-weeks average load). Monitoring ACWR helps to keep player's workload in the 'high-load, low-risk zone' (0.8-1.3). When ACWR is too low (less than 0.8) or too high (1.5 or more), risk increases and workload may be adjusted.

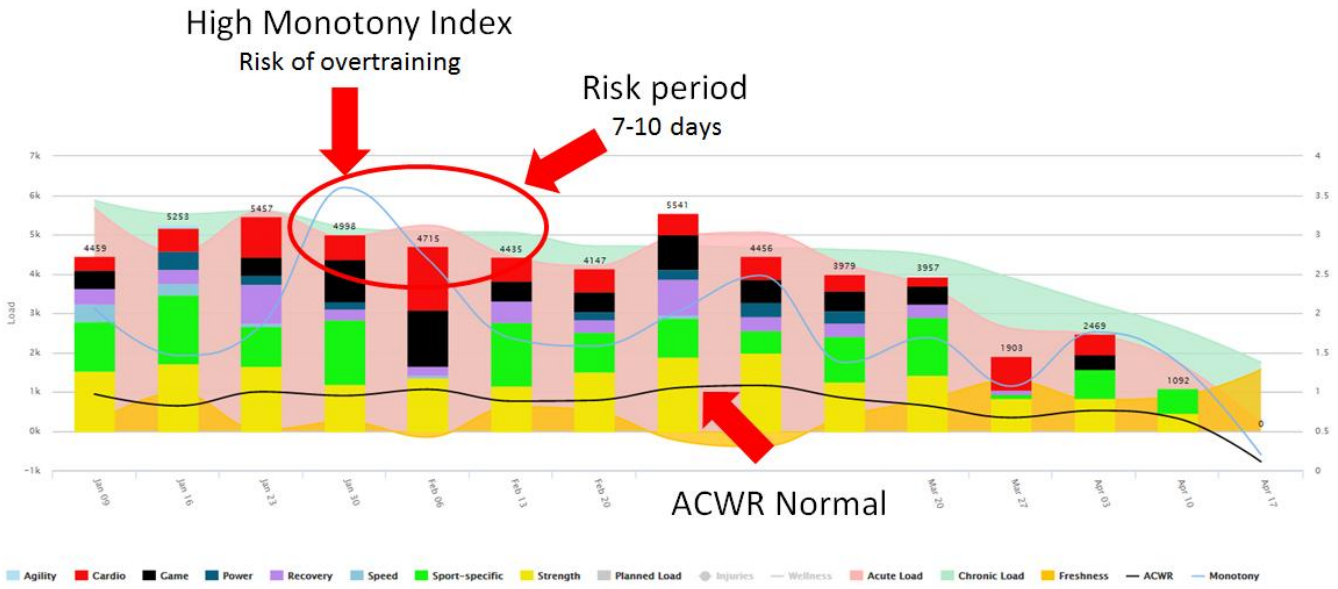


Figure 3. A peak in monotony can increase the risk of overtraining during 7-10 days, even if ACWR is in the optimal range

Week-to-Week Load Increase

This represents the percentage of load increase from one week to the next. It's a major injury risk factor as studies have shown that a large percentage of injuries are associated with rapid change or spikes in weekly loads [9,4,3] . When load increases by ≥15 % from the preceding week, the risk of injury increases by up to almost 50 %[4]. Monitoring week-to-week changes in load helps detect spikes in load and plays a crucial role in injury prevention.

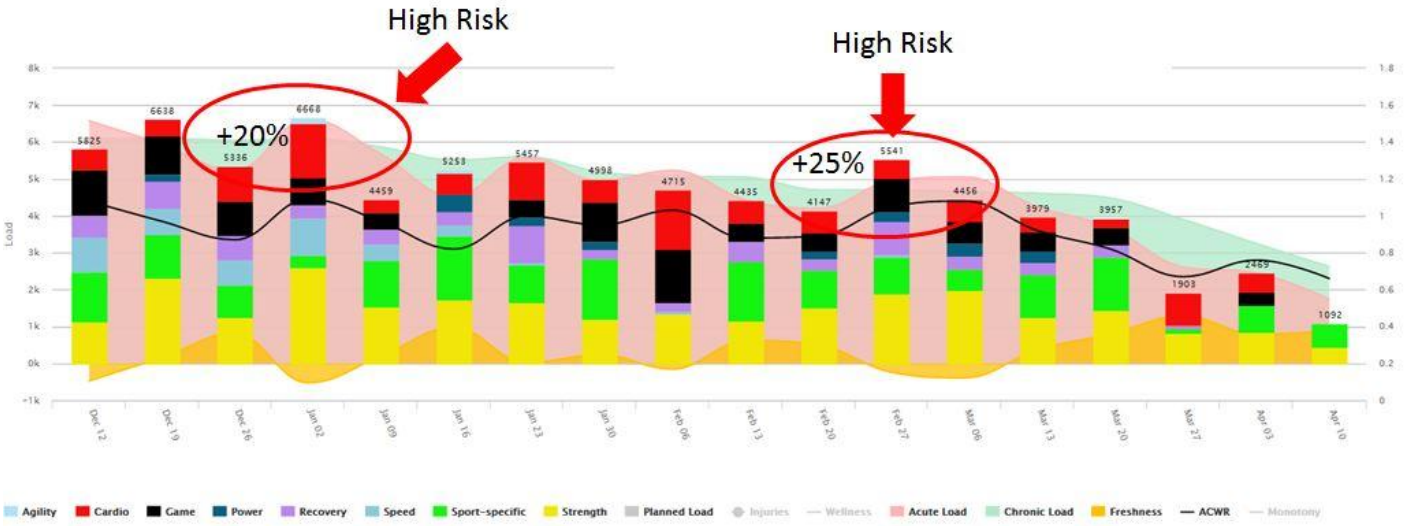


Figure 4. Weekly change in loads in a professional rugby team during a 4 month period. In this example, load has been reduced after each peak in load, allowing the athletes to recover and reducing risk.

Weekly training hours

Recent research [26] conducted by Neeru Jayanthi, an expert on youth sports injuries, indicates that when young athletes train/compete more hours per week than their age (eg: when a 12 years old train/compete 18h/week), the risk of overuse injury can increase by up to 70 %.

Using an athlete's age to guide the weekly training and competition volume is a simple and effective approach that can help maximize performance while promoting effective and injury-free athletic development.

Self-reported Wellness

Asking athletes to complete a self-reported wellness questionnaire is a reliable and accurate method to identify athletes' readiness to train, and to measure the impact of non-sport stressors on the recovery process [5,7,11].

Poor wellness scores indicate potential psychological or physical under-recovery and may lead to adjustments to the training or competition program. Self-reported wellness questionnaires are key injury prevention tools, and should be used to guide the adaptation of training and competition loads[13].

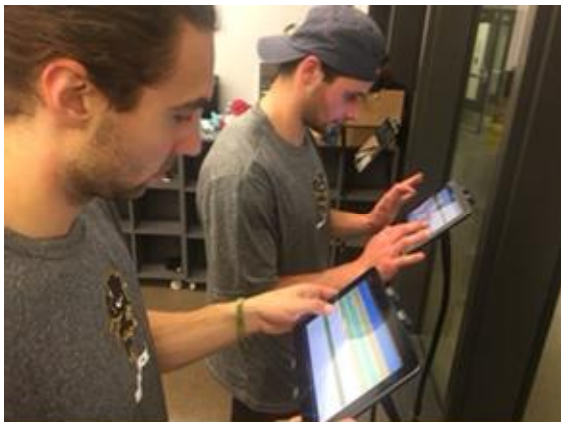


Figure 4. Collegiate ice-hockey players are reporting their post-session feedback on AthleteMonitoring.com

Personal feedback

Personal oral / written feedback from athlete can help identify potential motivation / stress / fatigue /training issues. This is crucial information often overlooked by busy coaches. When an athlete reports negative feedback, it must be taken very seriously as it could lead to motivational problems and larger underlying issues.

Enjoyment with training

Enjoyment with training and competition activities should be carefully monitored and maximized for two main reasons: 1) Enjoyment is an important determinant of intrinsic motivation, which directly predicts effort and persistence[19] and; 2) a lack of enjoyment is associated with staleness and burnout[1]. To maximize athlete engagement, motivation and performance, coaches are encouraged to created environments that allow athletes to have an enjoyable sport experience.

Other useful measures

When adequate equipment is available, additional daily tests of neuromuscular fatigue and recovery, such as Counter Movement Jump (CMJ), and musculoskeletal tests can provide useful information about neuromuscular recovery and/or injury[20]. Results in these tests allow coaches to manage athletes on an individual basis, based upon their training and recovery status.

PUTTING IT ALL TOGETHER

The flowchart below illustrates the integration of all metrics and the decision-making process. This model may be used as a general template of a practical and evidence-based workload management program.

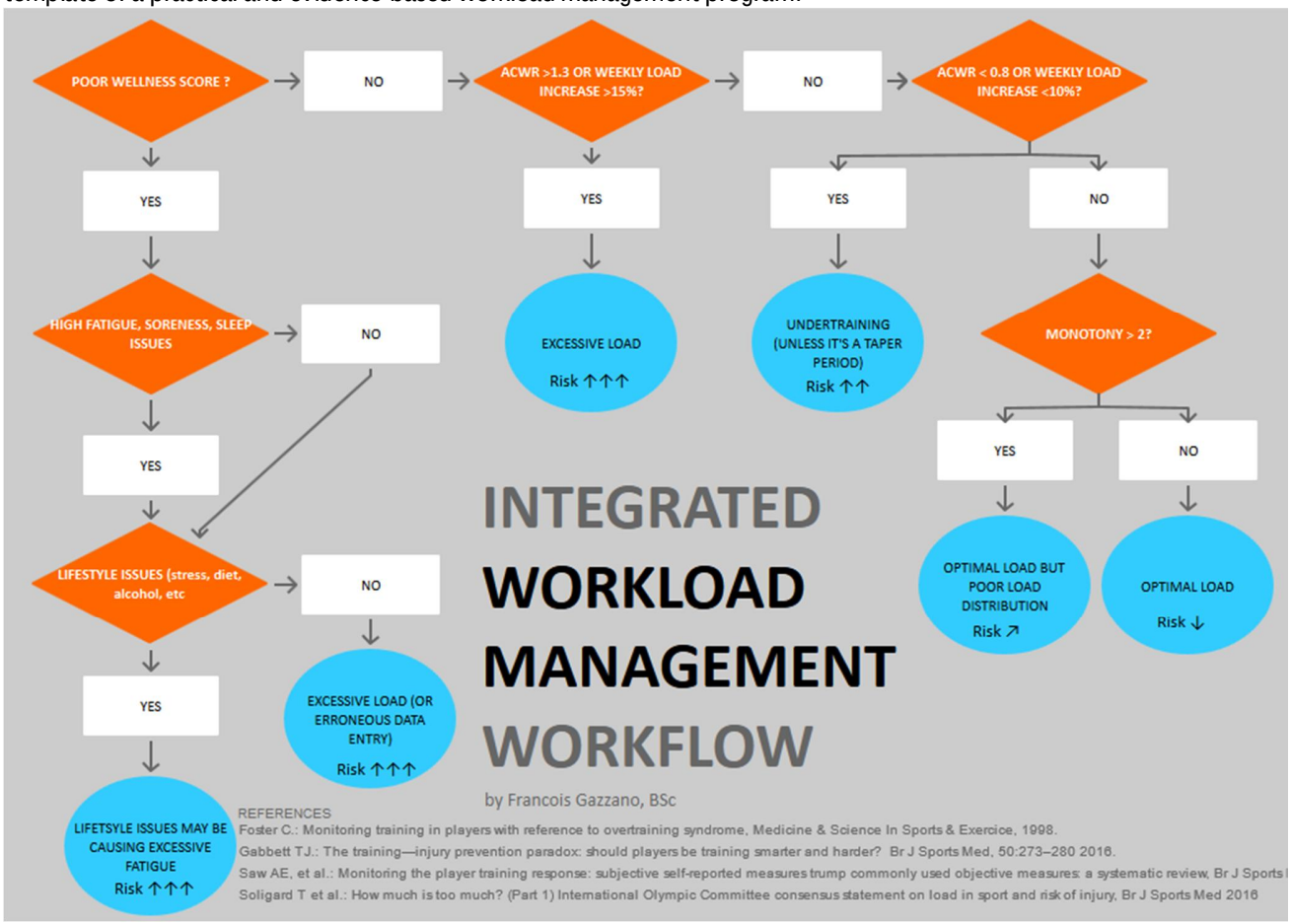


Figure 5. Model of workload management workflow using evidence-based metrics and methods

The dashboard below illustrates the integration of all metrics in the AthleteMonitoring.com dashboard and the individual alerts that helps coaches make workload management decisions based on evidence-based methods.

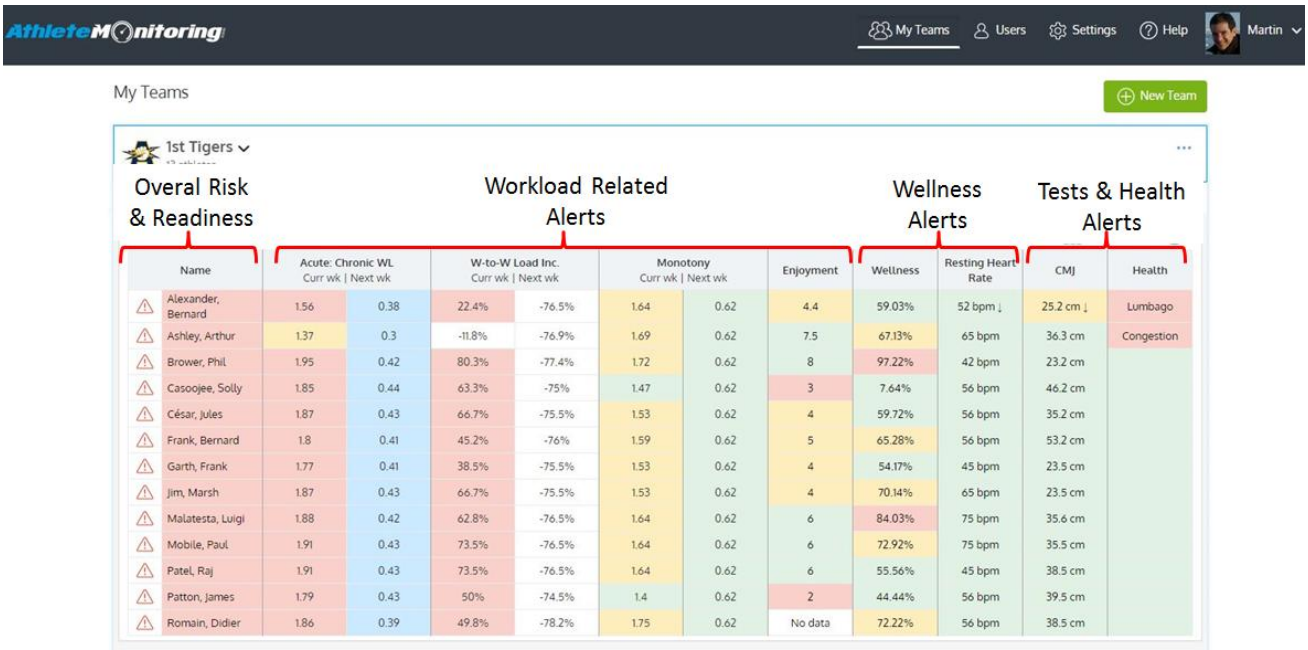


Figure 6. AthleteMonitoring.com team dashboard showing the interpretation of evidence-based workload management metrics.

CONCLUSION

Managing workload and optimizing athlete performance while promoting injury-free participation is relatively simple. To ensure athletes optimize performance and minimize injury risk:

1. Start with the right tools,
2. Monitor the key metrics,
3. Increase weekly loads very progressively,
4. Avoid spikes in load,
5. Alternate hard, moderate and easy training days,
6. Use athlete's wellness data to guide daily load adjustments,
7. Proactively manage training and competition loads during stressful periods and,
8. Make sure athletes have an enjoyable sport experience.

ACKNOWLEDGEMENTS

The author would like to thank Stefani Webb, Andy Taylor and Dominique Richard for their helpful and constructive comments that greatly contributed to improving the final version of this article.

ABOUT THE AUTHOR

Francois Gazzano is a performance coach and athlete monitoring specialist who graduated from the Université de Montreal with a degree in Exercise Science. As a full-time strength and conditioning coach and performance consultant in Europe and North America for more than 15 years, François has helped dozens of youth, elite and professional athletes across a wide range of sports reach their highest performance goals. Francois is the founder & CEO of FITSTATS Technologies, Inc. and creator of AthleteMonitoring.com (http://www. athletemonitoring.com), an evidence-based workload optimization and athlete management system used by high school, collegiate, national and professional teams worldwide.

Francois can be reached at francois@athletemonitoring.com
Twitter @gazzanofrancois

REFERENCES

1. Di Fiori et al.: Overuse Injuries and Burnout in Youth Sports: A Position Statement from the American Medical Society for Sports Medicine, Clin J Sport Med; 24:3–20, 2014.

2. Foster C et al.: Athletic performance in relation to training load, Wis Med J., 95(6):370-4, 1996

3. Foster C.: Monitoring training in players with reference to overtraining syndrome, Medicine & Science in Sports & Exercice, 1998.

4. Gabbett TJ.: The training—injury prevention paradox: should players be training smarter and harder?, Br J Sports Med, 50:273–280 2016.

5. Gallo et al.: Pre-training perceived wellness impacts training output in Australian football players, J Sports Sci., 4:1-7, 2015.

6. Kerr Z et al.: College Sports-Related Injuries -- United States 2009–14 Academic Years http://www.medscape.com/viewarticle/855867

7. Mann B et al: Effect of Physical and Academic Stress on Illness and Injury in Division 1 College Football Players, J Strength Cond Res 30(1):20-5, 2016

8. National High School Sports-Related Injury Surveillance Study [http://www.ucdenver.edu/academics/colleges/PublicHealth/research/ResearchProjects/piper/projects/RIO/Documents/2012-13.pdf]

9. Piggott B, Newton MJ, McGuigan MR. The relationship between training load and incidence of injury and illness over a pre-season at an Australian Football League club, J Aust Strength Cond, 17:4–17, 2009.

10. Robson-Ansley, Michael Gleeson & Les Ansley: Fatigue management in the preparation of Olympic players, Journal of Sports Sciences, 27:13, 1409-1420, 2009.

11. Saw AE, et al.: Monitoring the player training response: subjective self-reported measures trump commonly used objective measures: a systematic review, Br J Sports Med, 0:1–13, 2015.

12. Schwellnus M et al.: How much is too much? (Part 2) International Olympic Committee consensus statement on load in sport and risk of illness, Br J Sports Med 2016

13. Soligard T et al.: How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury, Br J Sports Med 2016

14. Snyder AC et al.: A physiological/psychological indicator of over-reaching during intensive training, Int J Sports Med. 14(1):29-32, 1993

    Stevens ST et al: In-game fatigue influences concussions in national hockey league players, Res Sports Med. 16(1):68-74, 2008

15. Weston, M et al.: The application of differential ratings of perceived exertion to Australian Football League matches, Journal of Science and Medicine in Sport, 18(0): 704–708, 2015

16. Coggan A: The Science of the Performance Manager https://www.trainingpeaks.com/blog/the-science-of-the-performance-manager/ , 2008

17. Hulin B et al.: The acute:chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players, Br J Sports Med, 50:231–236 2016

18. Fraser-Thomas J. et al.: Examining Adolescent Sport Dropout and Prolonged Engagement from a Developmental Perspective, Journal of Applied Sport Psychology, 20: 3 18-333,2008

19. McLean D. et al: Neuromuscular, Endocrine, and Perceptual Fatigue Responses During Different Length Between-Match Microcycles in Professional Rugby League Players, International Journal of Sports Physiology and Performance, 5, 367-383, 2010.

20. Saw A et al.: Monitoring Athletes Through Self-Report: Factors Influencing Implementation, Journal of Sports Science & Medicine, 14(1):137-46, 2015

21. Mann J et al.: Effect of Physical and Academic Stress on Illness and Injury in Division 1 College Football Players, J Strength Cond Res, 30(1):20-5, 2016

22. Stevens ST. et al: In-game fatigue influences concussions in national hockey league players, Res Sports Med. 16(1):68-74, 2008

23. McLean SG, Samorezov JE: Fatigue-induced ACL injury risk stems from a degradation in central control. Med Sci Sports Exerc, 41(8):1661-72, 2009

24. Impellizzeri FM et al.: Use of RPE-based training load in soccer, Med Sci Sports Exerc. 36(6):1042–1047, 2004

25. Foster C et al. A new approach to monitoring exercise training, J Strength Cond Res. 15(1):109–115, 2001

26. Neeru Jayanthi : Sports specialized risks for reinjury in young athletes: a 2+ year clinical prospective evaluation http://bjsm.bmj.com/content/51/4/334.2, 2017

27. http://childinjuryprevention.ca

28. Little T, Williams AG: Measures of exercise intensity during soccer training drills with professional soccer players. J Strength Cond Res, 21(2), 2007

29. Bosquet L et al.: Is heart rate a convenient tool to monitor over-reaching? A systematic review of the literature. Br J Sports Med, 42(9), 2008

30. Halson S.: Monitoring Training Load to Understand Fatigue in Athletes, Sports Med, 44 (Suppl 2), 2014

