The Science of Sleep

FATIGUE SCIENCE

HUMAN PERFORMANCE MODEL

Influencers of wins and losses

Understanding the most-untapped contributor to better team performance

Sleep plays a key role getting athletes ready to compete and has a direct, measurable and highly predictable effect on player performance. With a basic understanding of sleep science and the right tools, sleep can be managed the way other building blocks of human performance like conditioning and nutrition are.

On game day, winning or losing may come down to a ref's call or just plain luck, but athletes need to be ready to face those influencers in top form. Achieving their physical best involves constant management of a host of readiness factors. Sleep is too important to be left off that list.

Mental and physical fatigue aren't the same thing

At Fatigue Science, when we talk about fatigue, we're talking about reduced alertness, reaction time, and effectiveness—all of which manifest in the form of sub-optimal athletic performance. This mental fatigue happens when sleep and activities fall outside of our very specific biological needs to consistently sleep at night and be active in the day—it's not the same as fatigue resulting from physical exertion.

Those who routinely obtain less than 7-9 hours of interrupted sleep per 24-hour period will have a high homeostatic drive for sleep as the body struggles to restore balance. In addition, scheduling inconsistencies often lead to a high circadian drive for sleep at exactly the wrong times of day as well as to sleep-initiation problems at night. So, when athletes lose sleep due to any number of factors, when they're unable to stick to a consistent bedtime due to travel or social engagements, and when they have to train or play at the "wrong" times in a new time zone, they'll be faced with both a high homeostatic and a high circadian drive for sleep. The result will be impaired judgment, reaction time, and situational awareness—the hallmarks of poor mental effectiveness.

Unfortunately, we can't train our homeostatic and circadian requirements to tolerate stress like we can train our cardiovascular organs, respiratory system, and muscles. Sleep deprivation or circadian desynchronization will cut into the cognition and effectiveness of every human being, whether they're physically fit or not, without discrimination—and when we're deprived of sleep, our performance suffers.

Cognitive fatigue and physical fatigue are very different from one another, though the two can co-exist. While there's very little evidence that bursts of physical exertion impact judgment or reaction time, there's plenty of research to support the influence on the psychological over the physical. We'll explain this further when we examine factors of performance impacted by sleep in more detail.


"With sleep, we reset our memory, reduce metabolic demand on the brain, and stay alert. Nothing is more fundamental than that."
– Dr. David Dinges, sleep researcher and Professor at the University of Pennsylvania School of Medicine

At any given time, one's alertness is influenced by three things

Sleep debt (quantity of sleep)

To function in top form, athletes must clock 8-9 hours of sleep every 24 hours. Consistently coming up short (an hour here, and an hour there), creates sleep debt, and the more of a deficit we carry the harder it is to recover an even balance.

In elite team environments, creating adequate opportunity for players to get optimal sleep is difficult due to compressed travel, training and game schedules, as well as media and promotional activities. The science is clear though—the less sleep we get, the less alert we'll be.

Sleep/Wake timing (consistency of sleeping and waking relative to diurnal pressures)

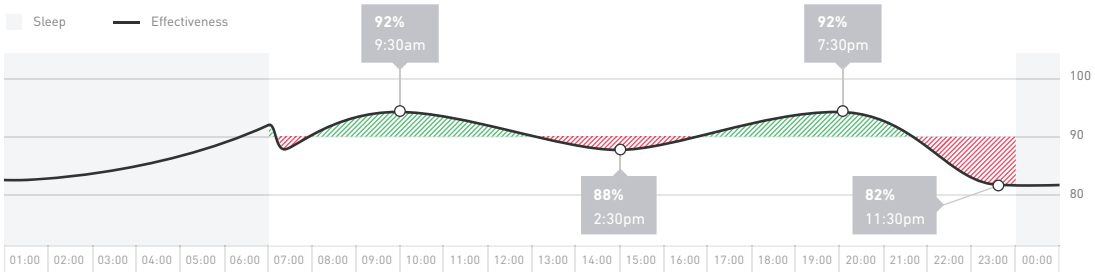
It's not just how much sleep we get, but the consistency of when it's obtained. When we cooperate with our diurnal nature to sleep at night and be active during the day, the restorative value of sleep is maximized, and the quality of waking performance is optimized.

From a homeostatic standpoint, the longer someone is awake, the greater the pressure to sleep. But when an athlete's opportunity to stick to a sleep/wake routine is disrupted by travel, late games or other commitments, it's not only waking performance that will be affected—nighttime sleep will be impacted as well.

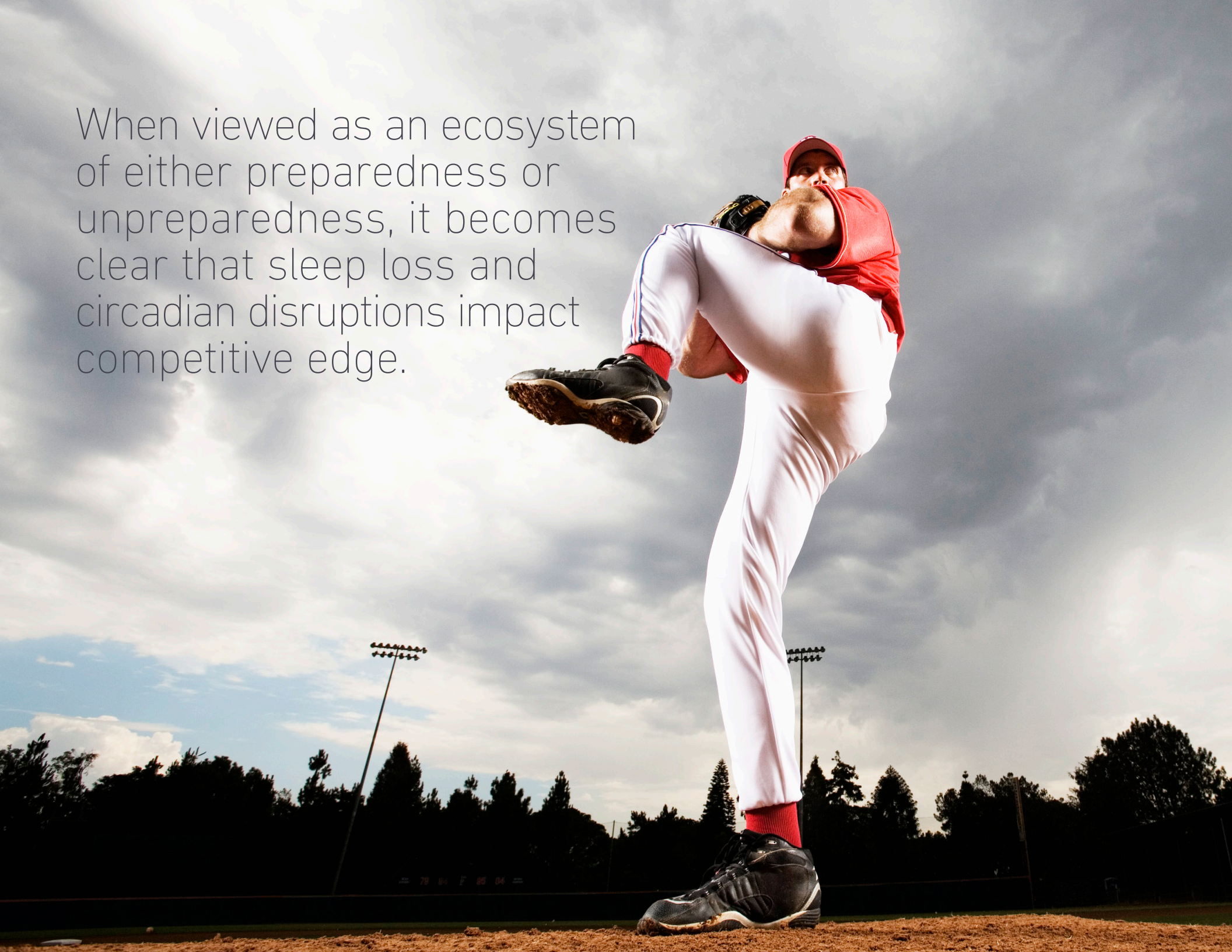
Time of day (the influence of our circadian rhythm)

Let's assume an athlete sleeps well for eight hours from 11pm to 7am. Throughout the coming day, his reaction time will vary up to 10% as his body experiences troughs and peaks in alertness. These natural troughs and peaks are our well-rested daytime baseline—an ebb and flow of cognitive effectiveness based mostly on circadian factors.

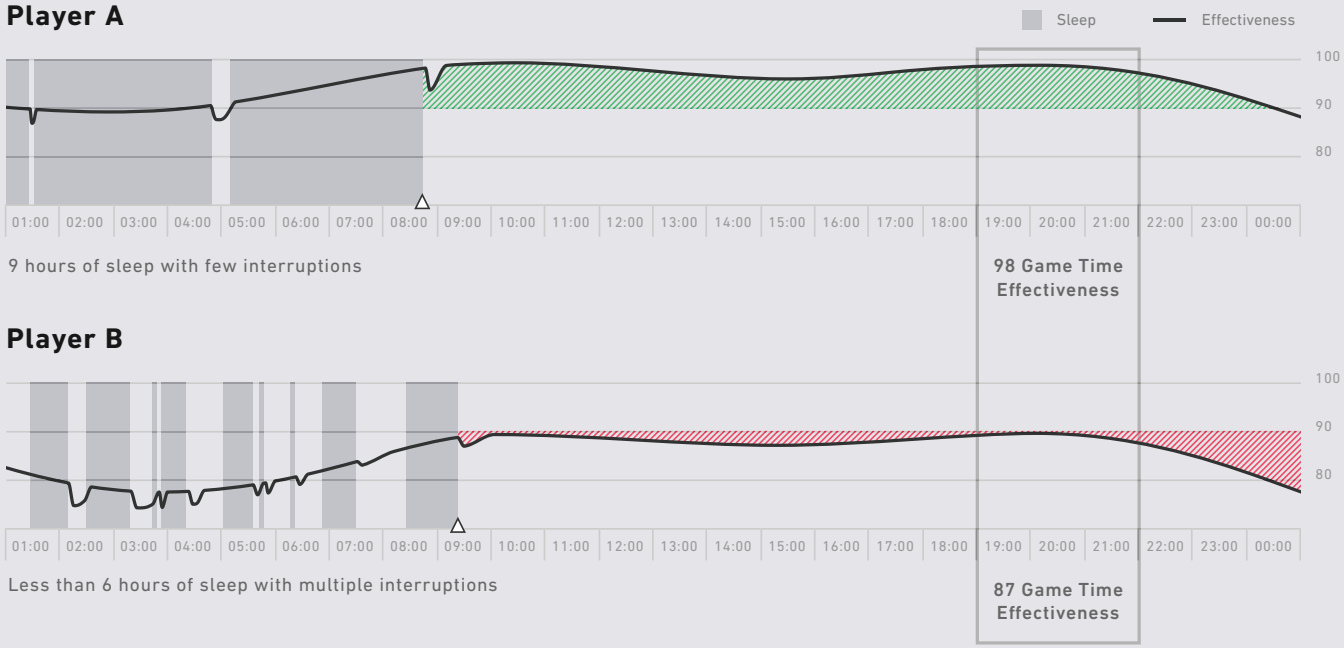
Circadian factors influence athletic performance to such a degree that, based on 40 years of win-loss data, west coast NFL teams have proven dominant when playing evening games on the east coast. Imagine harnessing this knowledge for your team: you can't change game times, but to some degree, can influence the timing of these daily circadian peaks.



When viewed as an ecosystem of either preparedness or unpreparedness, it becomes clear that sleep loss and circadian disruptions impact competitive edge.



A tale of two sleepers: the shots-on-goal comparison



Player A, a pro soccer goalkeeper, averages close to nine hours of quality sleep each night, with good consistency and quality. At the start of an evening game, his effectiveness score is 98. His decision-making, in-play responsiveness, strength and speed, and physiological sharpness are at their peak.

Player B, also a keeper, averages seven hours of sleep at best with commonly disrupted or interrupted periods. The night before the game, he slept for less than six hours. His pattern of inadequate and low-quality rest—and the cognitive fatigue that results—slows his reaction time at game time by 20%.

Who would you put in the net?

What else is sleep influencing in your athletes?

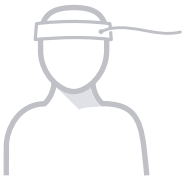
Sleep deprivation not only reduces reaction time and decision-making ability. It impairs immune functions, physical and psychological performance, motivation, memory consolidation, and increases risk of injury, anxiety, stress, and inflammatory markers. Finally, since sleep loss affects motivation and appetite regulation, it predisposes people to weight gain and increased body fat percentage.

> Even though physical fatigue has little to no impact on mental alertness, the reverse is true—mental fatigue has a great deal of impact on physical performance. This is how a competitive decline takes root under conditions of sleep loss.

An athlete who sleeps consistently well will demonstrate high effectiveness even when physical energy has been temporarily depleted. Athletes with insufficient sleep will still be able to run, lift weights, and perform with basic capacity and resilience. But their time to physical exhaustion will be shorter, their perception of exertion and endurance distorted, and their motivation, judgement, alertness, decision-making, and situational awareness impaired. This is what more than 25 years of military research tells us: although mental and physical fatigue are not directly linked in a mechanical or biological way, the two are inextricably intertwined.

To begin to understand sleep's influence on team performance, it needs to be measured

In sleep and fatigue research, there are three common ways to measure sleep.



PSG (polysomnography)

The gold standard, PSG is the most comprehensive, most reliable form of sleep measurement. It involves subjects sleeping in a lab where various physiological functions are monitored.

100% accurate

Actigraphy

By capturing body movement via a wrist-worn device, actigraphy is a non-invasive method of measuring sleep/wake patterns.

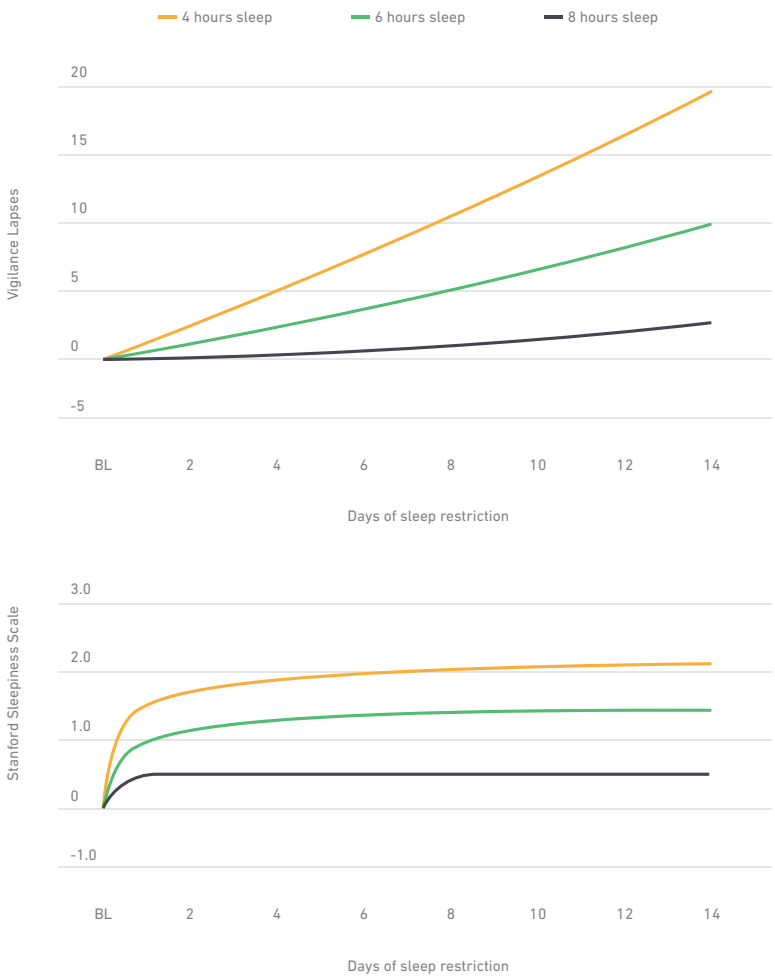
93% accurate when using the scientifically validated Fatigue Science Readiband

Self-Reporting

A low-tech substitute is diary-keeping. This strategy relies on an individual's ability to estimate or recall his own sleep pattern.

50-60% accurate—most respondents overestimate their sleep by as much as 70 minutes/night

While Polysomnography is the most accurate way to measure actual sleep obtained, it's not practical in an elite team environment. Actigraphy, on the other hand, is simple, cost-effective, and practical. And while there are many actigraphy devices available, the Fatigue Science Readiband is both scientifically validated and trusted by researchers with the US Army, US Special Operations Command, and Harvard University.



Van Dongen, Maislin, Mullington Dinges, 2003

People aren't great at estimating how much sleep they get and its impact on their performance

Conducted by the University of Pennsylvania School of Medicine, a sleep restriction study that put subjects through fourteen days of restricted sleep showed a predictable and sharp increase in the number of vigilance lapses or mental errors (top left). Then, those same subjects were asked to self-report their fatigue using a standardized subjective measure: the Stanford Sleepiness Scale. During the first few days of sleep restriction, subjects were fairly accurate at self-reporting their level of fatigue (how tired they felt), but as the study (and their sleep deprivation) intensified, they failed to recognize their significantly increasing levels of tiredness (bottom left).

Researchers call it ‘renorming’—when we assess our physical and mental state, we can’t help but compare how we feel today to how we felt yesterday or the day before. We quickly forget how we felt even three days ago.

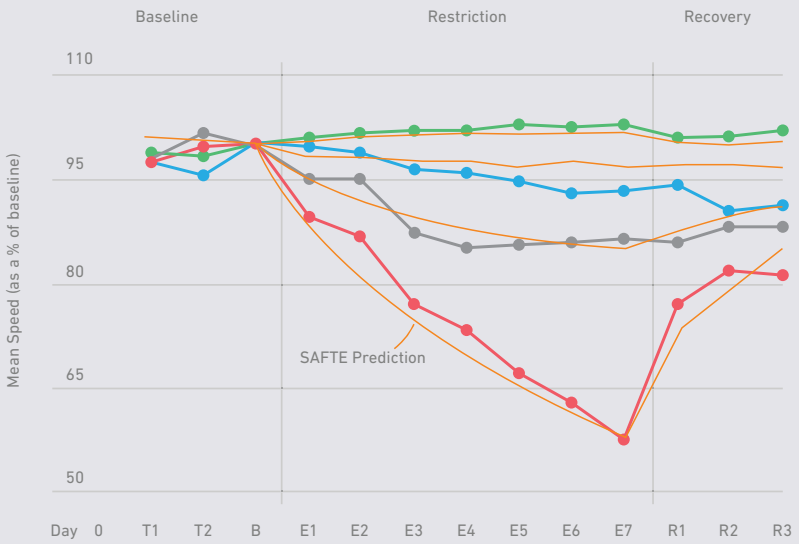
From a research setting to the real world, a means of predicting fatigue

To better understand fatigue in the realm of elite sports, what's needed is a tool that can predict change in mental effectiveness based on actual sleep obtained and the timing of that sleep in relation to the body's internal clock. And it must be both convenient and accurate.

Tasked with understanding the effect of disrupted sleep on critical operations, the US military's brightest minds devised a biomathematical model that simulates the effects of sleep loss on mental effectiveness. This model, called SAFTE (Sleep, Activity, Fatigue, Task, Effectiveness), is the result of more than 20M dollars investment and 25 years of applied research. Today, it's used to mitigate fatigue onboard Air Force One and remains the working fatigue model of the US Department of Defence.

SAFTE's accurate prediction of the effects of fatigue on reaction time and other aspects of mental effectiveness is proven through a number of studies, including those conducted by Universities, the US military, the US Department of Transportation and the Federal Aviation Administration.

SAFTE fatigue model: some validation studies



Hursh, Redmond, Johnson et al, 2004

To validate the SAFTE model, the Walter Reed Army Research Institute restricted participants' sleep for seven consecutive nights, and had them do reaction-time and other tests at regular intervals throughout the day to determine the effects of sleep loss on performance. At the end of the week, subjects were given the chance to sleep for a solid eight hours per night—with the intention of allowing researchers to assess the speed at which subjects could recover from the imposed sleep restriction. The laboratory setting ensured the capture of excellent sleep data, which was then fed into the SAFTE model to assess the latter's fatigue prediction accuracy. Researchers found that SAFTE was 94% accurate in predicting not only performance declines, but also the pattern of performance recovery.

More recently, the FAA conducted another study used Fatigue Science Readibands to measure actual sleep obtained in an operational context. After collecting and analyzing more than 10,000 sets of performance data from 200 on-duty flight attendants, it too demonstrated SAFTE's predictive accuracy. And in this case, given the broad spectrum of participants, affirmed that fatigue as a result of sleep loss and schedule disruptions, is highly predictable across the adult population.

Because sleep can be measured, it can be managed in a team environment

You know sleep is a crucial component to your high performance management program. You also know it's challenging to address without the tools or know how.

As with any program aimed at gaining a competitive advantage, the solutions start with an objective look at where the opportunity for improvement lies.

Measuring sleep is a first step in better understanding your athletes—how they manage their sleep, how their sleep is affected by late games, early practices, rigorous travel, post-season stress, their state of health and other factors.

By understanding how sleep influences your athlete's daily alertness and ability to perform effectively, you'll have a host of inputs to put them on higher ground.

For example:

- make decisions to better limit the overall impact of sleep and circadian disruptions on team performance, and;

- justify sleep and proper sleep management to individuals as part of a key training responsibility

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To learn about Fatigue Science's Team Platform, designed specifically for sports teams, get in touch with us.

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About Fatigue Science

Founded in 2006 and based in Vancouver BC, Fatigue Science is a trusted pioneer in sleep and its relationship to human performance. We work with pro sports teams like the Seattle Seahawks, Dallas Mavericks and the Vancouver Canucks to provide technology-enabled, data-driven insights that help them perform better at game time.

We've developed the Fatigue Science Readiband, a scientifically validated actigraph device, and hold exclusive commercial rights to the SAFTE fatigue model.

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