Monitoring de la charge d’entrainement

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Observations – sagesse commune

Quantifier le stress

Réponses individuelles a un stimulus… observations de tous les coaches

Ex. Athlète commence a s’entrainer

20 km / semaine	*…*	*Il s’améliore*
40 km / semaine	*…*	*Il s’améliore*
60 km / semaine	*…*	*Il se blesse*

Relation dose-réponse
Stimulus || Adaptation

Observations – sagesse commune

Relation dose-réponse
Stimulus - Adaptation

Différents stimulus ont différentes conséquences

Principe universel =

Charge d'entrainement = Intensité x Durée

Observations – sagesse commune

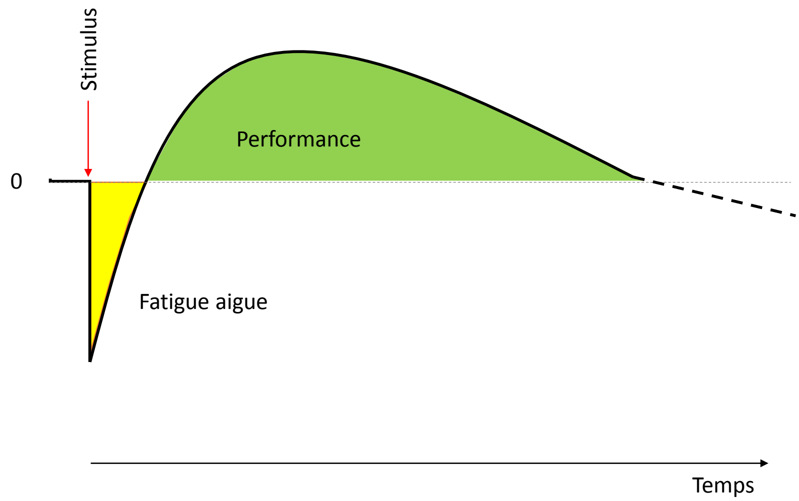
Un peu plus complexe que ca !

Courir **10 min @ 20 km/h** ou **20 min @ 10 km/h** ?

- Certaines réponses a l'augmentation de taux de travail sont +/- linéaires (FC/VO_2)
- D'autres ne le sont pas ([La] est +/- exponentielle)

Enjeux

Rapport charge / récupération – rapport forme / fatigue



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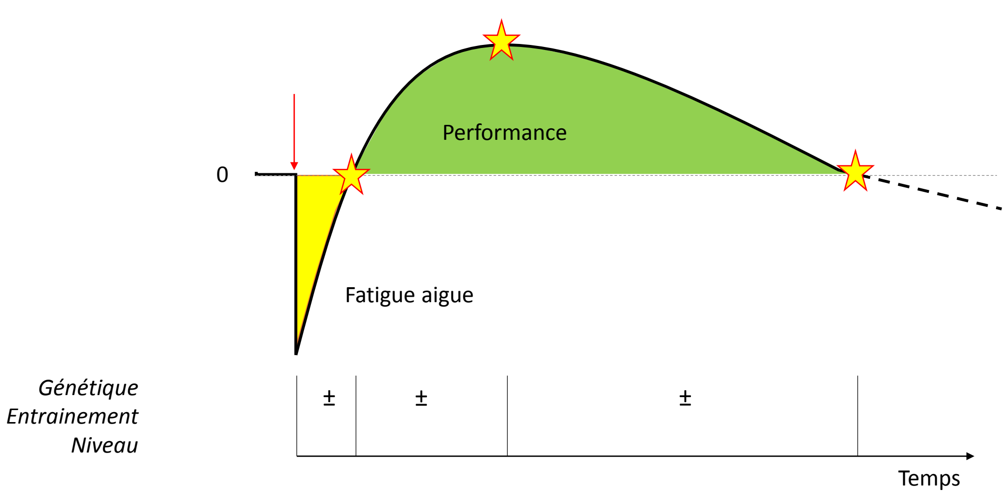

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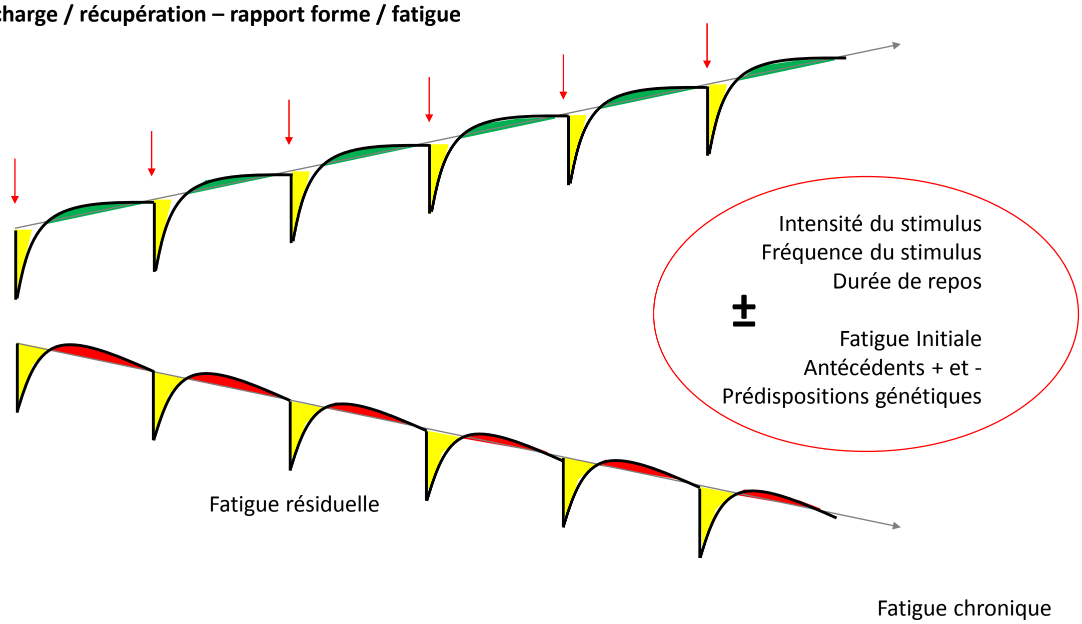


Enjeux

*Training-load monitoring has become ubiquitous in the world of professional sport. It helps inform the **attainment of peak performance, protects against injury**, and provides an evidence-based and systematic approach to **management decisions**. With the range of innovations in both hardware and software and the emergence of ever-more-complicated analytics, the future possibilities in this field will become increasingly exciting.*

Editorial 2017 IJSPP

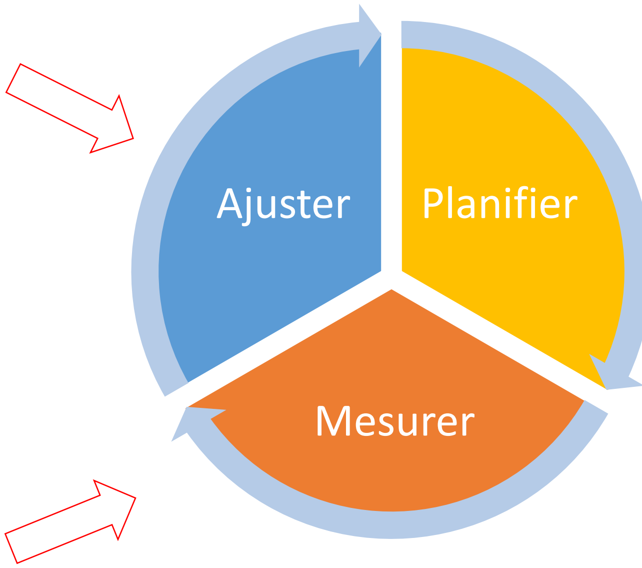
*Monitoring athletes' training load is essential for determining whether they are **adapting to their training program**, understanding individual responses to training, assessing fatigue and the associated need for recovery, and minimizing the risk of nonfunctional overreaching, injury, and illness.*

Consensus paper, IJSPP Editors 2017

*Monitoring TL has primarily been proposed in order to ensure that **optimal workloads** are induced to **maximize physical performance** and **reduce the occurrence of injury or illness**.*

Owen et al, 2017 Sci Med Foot

Enjeux

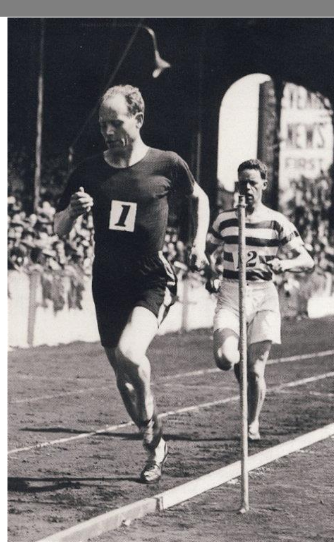


Historique

~1910/20s

Kolehmainen
Nurmi

Chronometre



Historique

~1910/20s

Kolehmainen
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Chronometre

~1930s

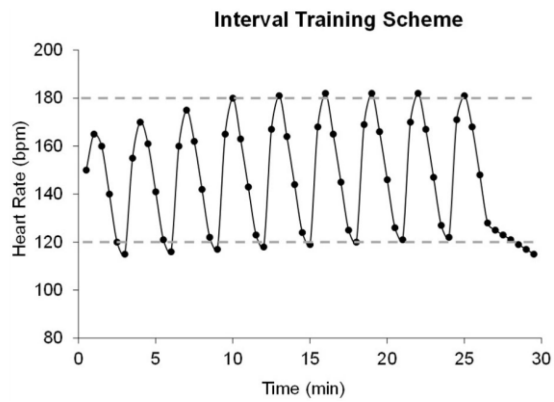
Holmer

Interval training
Fartlek

~1940s

Gerschler
Reindell

Interval training
(pacing, FC)



Historique

6 mai 1954

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~1930s

Holmer

Interval training
Fartlek

~1940s

Gerschler
Reindell

Interval training
(pacing, FC)

~1950s

Stampfl (Bannister)

Modulation de la charge =
10x400 D=3’ (descendre a 60 s)

Historique

Banister EW, Calvert TW, Savage MV, Bach A. A system model of training for athletic performance. Australian Journal of Sports Medicine. 1975;7:170–176

~1910/20s	~1930s	~1940s	~1950s	~1970s
Kolehmainen Nurmi	Holmer	Gerschler Reindell	Stampfl (Bannister) Bowerman (Oregon)	Banister
Chronometre	Interval training Fartlek	Interval training (pacing, FC)	Modulation de la charge = 10x400 D=3' (descendre a 60s) Ajoute jogging (low intensity) + programmation	Concept de charge Training Impulse (TRIMP)

Historique

1980's

Technologie

- Fréquence cardiaque
- Lactates
- VO2 portable

Individualisation

- Karvonen (FC réserve)
- Testing en laboratoire (seuils, intensités relatives)
- Balbutiements de calculs de la charge d'entrainement

Recherche

- Biomécanique : performance, blessures
- Physiologie : métabolisme, nutrition

Outils

CHARGE « INTERNE »

… <u>relative</u> biological (both physiological and psychological) stressors imposed on the athlete during training or competition. Measures such as heart rate, blood lactate, oxygen consumption, and ratings of perceived exertion (RPE) are commonly used to assess internal load.

Consensus paper, IJSPP Editors 2017

CHARGE « EXTERNE »

… <u>objective</u> measures of the work performed by the athlete during training or competition and are assessed independently of internal workloads. Common measures of external load include power output, speed, acceleration, time–motion analysis, global positioning system (GPS) parameters, and accelerometer-derived parameters.

Consensus paper, IJSPP Editors 2017

External training load can be defined as the work completed by the athlete, measured independently of their internal characteristics.

Cardinale, IJSPP 2017

Outils

Table 1 Summary and Evaluation of Some Common Methods Used to Monitor Athlete Training Load and/or Responses

Method	Cost	Hardware needed	Software needed	Ease of use	Valid	Reliable	Used to interpret	Used to prescribe	Variables
Internal Measures									
RPE	L	N	Y/N	H	M–H	M–H	Y	Y	Single variable in AU (time dependent)
Session rating of perceived exertion	L	N	Y/N	H	M–H	M–H	Y	Y	Single variable in AU (time dependent)
TRIMP[4]	L–M	Y	Y	M	M–H	M–H	Y	N	Single variable in AU (time dependent)
Wellness questionnaires*	L	N	Y/N	M–H	M	M–H	Y	Y/N	Ratings, checklists, AU scale measures
Psychological inventories (eg, POMS, Rest-Q-Sport)*	L–M	N	Y/N	M–H	M–H	M–H	Y	Y	Ratings, checklists, AU scale measures
Heart-rate indices	L–M	Y	Y	H	H	M–H	Y	Y	Heart rate, time in zones, HR variability/recovery measures, etc
Oxygen uptake	H	Y	Y	L	H	H	Y	Y	VO_2, metabolic equivalents
Blood lactate	M	Y	Y/N	M	H	H	Y	Y	Concentration
Biochemical/hematological assessments	M–H	Y	Y/N	L	H	M–H	Y	Y	Concentrations, volumes

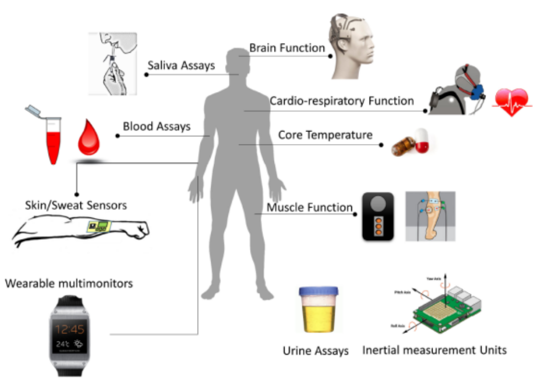
Outils

Table 1 Summary and Evaluation of Some Common Methods Used to Monitor Athlete Training Load and/or Responses

Method	Cost	Hardware needed	Software needed	Ease of use	Valid	Reliable	Used to interpret	Used to prescribe	Variables
External Measures									
Time	L	Y	Y/N	H	H	H	Y	Y	Units of time (s, min, h, d, wk, y)
Training frequency	L	N	N	H	H	H	Y	Y	Session count
Distance/mileage	L	Y/N	Y/N	H	H	H	Y	Y	Units of distance (m, km)
Movement repetition counts	L	Y/N	Y/N	M–H	H	M–H	Y	Y	Activity counts (eg, steps, jumps, throws)
Training mode	L	Y/N	N	H	H	H	Y	Y	Weight training, run, cycle, swim, row, etc
Power output	M–H	Y	Y	L–M	H	H	Y	Y	Relative (W/kg) and absolute power (W)
Speed	L–M	Y	Y/N	M–H	H	H	Y	Y	Speed measures (m/s, m/min, km/h)
Acceleration	L–M	Y	Y	L	H	H	Y	Y	Acceleration measures (m/s^2)
Functional neuromuscular tests	L–M	Y	Y/N	M	M–H	H	Y	Y	Countermovement-jump and drop-jump measures
Acute:chronic-workload ratio	L–M	Y/N	Y	M	M–H	M–H	Y	Y	Size of acute training load relative to chronic load
GPS measures	M	Y	Y	M	M–H	M	Y	Y	Velocity, distance, acceleration, time in zones, location
Metabolic power	M	Y	Y	L–M	L–M	M	Y	N	Energy equivalent
Time–motion analysis video (automated)	H	Y	Y	L	M–H	M	Y	Y	Velocity, location, acceleration
Time–motion analysis video (nonautomated)	M–H	Y	Y	L	M–H	M	Y	Y	Velocity, location, acceleration
Accelerometry	M	Y	Y	L–M	M–H	M	Y	N	*x-y-z g* force
Player load	M	Y	Y	M	M	M	Y	Y	Single variable in AU (time dependent)

Abbreviations: L, low; M, medium; H, high; Y, yes; N, no; AU, arbitrary units.
*Measures of training response.

Outils



Cardiorespiratory Parameters	Humoral Parameters	Neuromuscular and muscle metabolism Parameters
Heart Rate: **H,$$**	Venous Blood: **L,$$$**	Electromyography: **M,$$$**
Heart Rate Variability: **L,$$**	Capillary Blood: **M,$$**	Electroencephalography: **L,$$$**
Breathing related Parameters: **L,$$**	Sweat: **L,$$$**	Galvanic Skin Response: **M,$$**
Oxygen Uptake and derived parameters: **L,$$$**	Saliva: **M,$$$**	Near Infrared Spectroscopy (NIRS): **L,$$$**
	Urinary Markers: **M,$$$**	Brain NIRS: **L,$$$**

Practicality: **H**igh, **M**edium, **L**ow; **Cost:** $,$$,$$$

Outils

Calculs de charge (TRImp = Training Impulse**)**

- TRImp = abréviation de « Training Impulse »
- Méthodes apparues dans les années 70
- Basée sur les réponses de FC, graduellement coefficientées
- Différenciées pour Femmes et Hommes

Outils

Calculs de charge (TRImp)

Banister (1980)
Détermination d'un profil individuel liant l'intensité et la FC (lactate pas facile sur le terrain)

TRImp = durée (min) x FC durant l'exercice x coefficient d'intensité

TRImp = durée (min) x (facteur A x %ΔFC x exp(facteur B x %ΔFC))

%ΔFC = (FC moyenne – FC repos) / (FC max – FC repos)

facteur A = 0.86 et facteur B = 1.67 (femmes)
facteur A = 0.64 et facteur B = 1.92 (hommes)

Modification de Morton (1990)

TRImp = durée (min) x ΔFC x 2.718 exp(facteur B x ΔFC)

Banister / Morton = intensités hautes affectent plus la charge que les intensités basses

Outils

Calculs de charge (TRImp)

Edwards (1993)
Formule plus simple a calculer avec des « bandes » de FC

TRImp = durée (min) x coeff Z1 + durée (min) x coeff Z2 + … + durée (min) x coeff Z5

Z1 : 50-60% FCmax = 1
Z2 : 60-70% FCmax = 2
Z3 : 70-80% FCmax = 3
Z4 : 80-90% FCmax = 4
Z5 : 90-100% FCmax = 5

Ex : 20’ a 75% + 20’ a 92% = (20x3) + (20x5) = 160

Outils

Calculs de charge (TRImp)

Stagno, Thatcher & Van Someren (2007)
Rajoute une dimension non-linéaire au modèle d’Edwards

TRImp = durée (min) x coeff Z1 + durée (min) x coeff Z2 + … + durée (min) x coeff Z5
Z1 : 50-60% FCmax = 1.25
Z2 : 60-70% FCmax = 1.71
Z3 : 70-80% FCmax = 2.54
Z4 : 80-90% FCmax = 3.61
Z5 : 90-100% FCmax = 5.16

Ex : 20’ a 75% + 20’ a 92% = (20x2.54) + (20x5.16) = 154

Banister / Morton / Edwards / Stagno = utilisent des mesures de FC [pratiques mais dépendantes du statut hydrique, fatigue, stress…]

Outils

Calculs de charge (TRImp)

Mujika & al. (1996)
Pour nageurs ou disciplines multimodales (triathlètes : détermination d'unités d'entrainement basée sur [La]

TRImp = Volume (km) x coeff Z1 + … Volume (km) x coeff Z5

Z1 (<2 mmol/L) = 1
Z2 (<4 mmol/L) = 2
Z3 (<6 mmol/L) = 3
Z4 (>10 mmol/L) = 5
Z5 (sprint) = 8

Outils

Calculs de charge (TRImp)

Foster & al. (2001)

TRImp = durée (min) x sRPE

RATING OF PERCEIVED EXERTION (RPE)

Borg's Scale (Gunner borg 1982):

6-
7- very, very light
8-
9- very light
10-
11- fairly light
12-
13- somewhat hard
14-
15- hard
16-
17- very hard
18-
19- very, very hard
20-

Modified Borg Scale:

0- at rest
1- very easy
2- somewhat easy
3- moderate
4- somewhat hard
5- hard
6-
7- very hard
8-
9-
10- very, very hard

Outils

Calculs de charge (TRImp)

Banister	FC	**TRImp = durée (min) x (facteur A x %ΔFC x exp(facteur B x %ΔFC))** facteur A = 0.86 et facteur B = 1.67 (femmes) facteur A = 0.64 et facteur B = 1.92 (hommes)	**TRImp = durée (min) x %ΔFC x 2.718 exp(facteur B x %ΔFC)**		Morton
Edwards	FC	**durée (min) x coeff Z1 + durée (min) x coeff Z2 + … + durée (min) x coeff Z5** Coeffs : Z1 (50-60%) = 1 ; Z2 (60-70%) = 2 ; Z3 (70-80%) = 3 ; Z4 (80-90%) = 4 Z5 (90-100%) = 5	**durée (min) x coeff Z1 + durée (min) x coeff Z2 + … + durée (min) x coeff Z5** Coeffs : Z1 (50-60%) = 1.25 ; Z2 (60-70%) = 1.71 ; Z3 (70-80%) = 2.54 ; Z4 (80-90%) = 3.61 Z5 (90-100%) = 5.16		Stagno
Foster	RPE	**TRImp = durée (min) x sRPE**	**Volume (km) x coeff Z1 + … Volume (km) x coeff Z5**	[La]	Mujika

Outils

Charge journalière TRImp

Charge hebdomadaire Somme des TRImp journaliers

Moyenne hebdomadaire Moyenne des TRImp journaliers

Les variations brutales de la charge peuvent induire des blessures non-traumatiques…
… mais un stimulus trop conservateur n'induit pas d'adaptations importantes.

Problèmes de volume *vs* variabilité sont habituellement le cas, par ex. :

- <u>En course a pied</u>… mais généralement peu de valeurs très hautes. Donc aussi : kilométrage, VFC, humeur…
- <u>En sports de grand terrain</u> : surtout en période compétitive = réduire la variabilité de la charge… maintenir piscine, force

Enjeu = mesure de variabilité de la charge

Outils

Charge journalière TRImp

Charge hebdomadaire Somme des TRImp journaliers

Moyenne hebdomadaire Moyenne des TRImp journaliers

Monotonie Indice de variabilité de la charge = relation densité *vs* repos
ratio de la charge moyenne hebdomadaire par l'écart-type

$$Monotonie = \frac{X_{7j}}{SD_{7j}}$$

Contrainte Monotonie x charge hebdomadaire

Fitness Charge hebdomadaire - Contrainte

Stimulus hebdomadaire Moyenne de la charge sur 7j x Monotonie

Outils

Charge aigue fatigue, a court terme
moyenne sur 7 j (en général)

Charge chronique fitness, a plus long terme
moyenne sur 28 j (en général)

Ratio

ACWR (« acute-chronic workload ratio ») **= Charge aigue / Charge chronique**

Tableur

Charge Jour 1	
Charge Jour 2	
Charge Jour 3	
Charge Jour 4	
Charge Jour 5	
Charge Jour 6	
Charge Jour 7	=moyenne(A1:A7)

Outils

Fréquence cardiaque

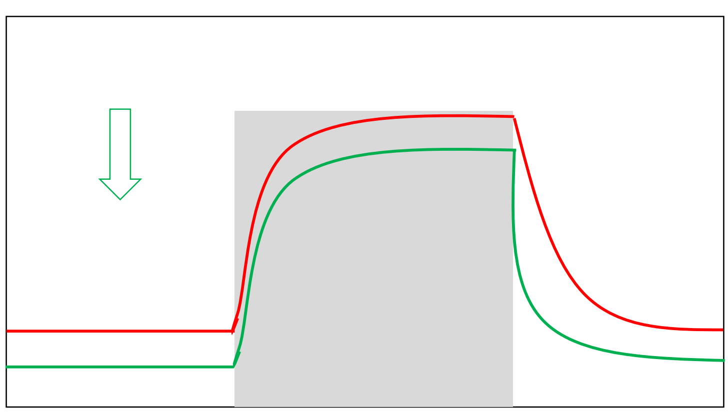
- FC liée au fonctionnement de plusieurs systèmes physiologiques
- FC est une mesure indirecte du statut du système nerveux autonome
  (Aubert et al., 2003; Michael et al., 2017)
- FC reflète a la fois adaptations aérobies (+) et fatigue (-)
  (Buchheit, 2014; Hottenrott and Hoos, 2017; Thorpe et al., 2017).
- Attention : FC mesure psychobiologie, influencée par des facteurs multiples :
  - Facteurs non-modifiables (âge, sexe, ethnicité)
  - Facteurs modifiables (mode de vie, niveau d'entrainement, sommeil, drogues, alcool, medicaments)
  - Facteurs lies a l'activité (intensité, duree, économie de mouvement, position du corps)
    (Sandercock et al., 2005;Buchheit, 2014; Fatisson et al., 2016; Sessa et al., 2018)
    - Environnement (chaud/froid, bruit, lumière)
    - Physiologie (morphologie cardiaque, volume plasmatique, activité du SNA)
    - Psychologie (émotions, humeur, stress)
    - Pathologie (maladies cardiovasculaires)

Outils

Fréquence cardiaque

FC de repos
FC lors d'un exercice standard
Cinétique de récupération

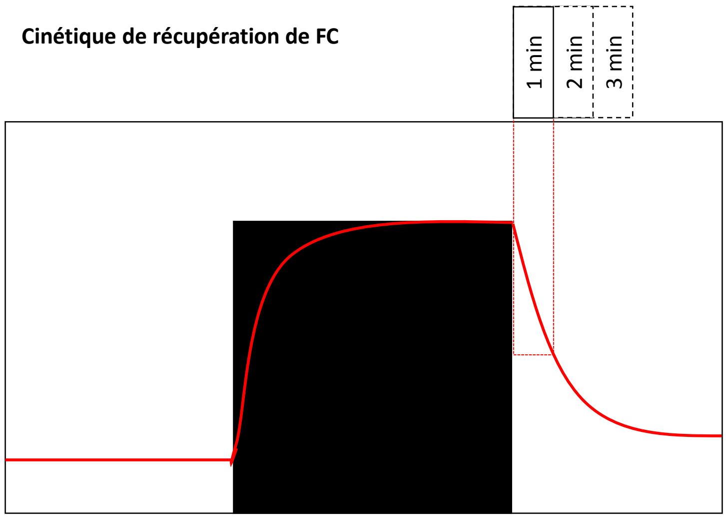
} indices de forme / de fatigue



Outils

Fréquence cardiaque

Cinétique de récupération de FC



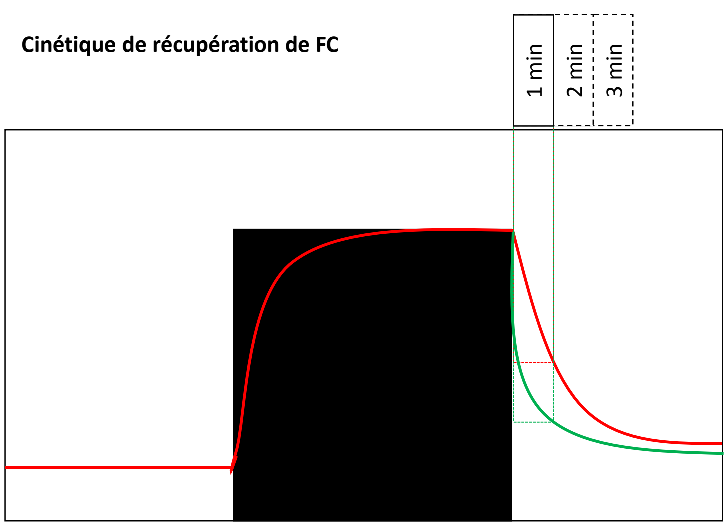
Outils

Fréquence cardiaque

Cinétique de récupération de FC

Expression :

bpm/min
%



Augmentation de la recuperation de FC (bpm/min)

=

Meilleure recuperation

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Fréquence cardiaque

HIMS test

« Heart-rate Interval Monitoring System » = Test sous-maximal (~ test navette)
= Test de récupération de FC entre étapes

13 minutes au total *= 4 étapes de 2 min (S1, S2, S3, S4), avec 1 min de récupération entre chaque étape*
S1, S2, S3, S4 *= A-R entre lignes distantes de 20 m*
allure déterminée par bande audio *: S1 (8.4 km/h), S2 (9.6 km/h), S3 (10.8 km/h), S4 (12 km/h)*

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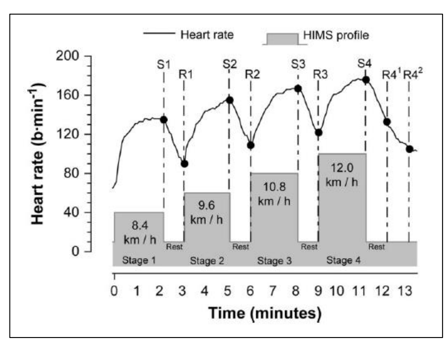
Utilisation #1 : indicateur de forme
S1 – R1 = x bpm
S2 – R2 = x bpm
S3 – R3 = x bpm
S4 – R4 = x bpm



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Fréquence cardiaque

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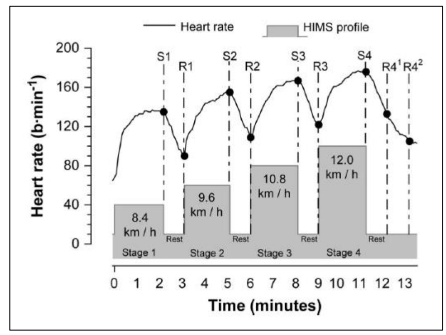
allure déterminée par bande audio *: S1 (8.4 km/h), S2 (9.6 km/h), S3 (10.8 km/h), S4 (12 km/h)*

Utilisation #2 = indicateur de fatigue accumulée (fatigue résiduelle)
=> surtout à l'intensité la plus haute (car la moins variable)
S4 – R4 = x bpm



Outils

Indice de cout physiologique (ICP)

Moyenne de FC à une intensité standard

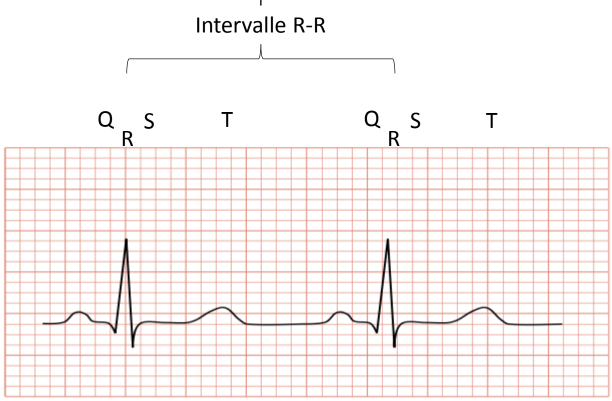
= nécessite un contrôle d'allure très précis (tapis ? Protocole précis ?)

ICP (bpm/m) = FC moyenne (bpm) / vitesse (m/min)

Avantages / inconvénients de l'ICP ?

Outils

Variabilité de la FC



$X^1 = (Int^{RR1} - Int^{RR2})^2$
$X^2 = (Int^{RR2} - Int^{RR2})^2$
...
$X^x = (Int^{RRx} - Int^{RRx})^2$

$$RMSSD = \sqrt{\text{moyenne}\ (X^1 + X^2 + \cdots + X^x)}$$

Outils

Variabilité de la FC

- Mesurée au repos (le plus souvent en position allongée), et au réveil.
- Minimum de 5 min
- Pour identifier un niveau de fatigue “général” = RMSSD ("*root mean square of successive differences*")

  si RMSSD décroit = fatigue (tonus vaso-vagal)
- Encore + fin : LnRMSSD

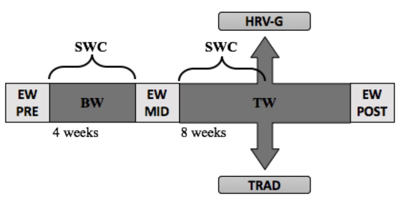
  si CV du LnRMSSD décroit = NFOR

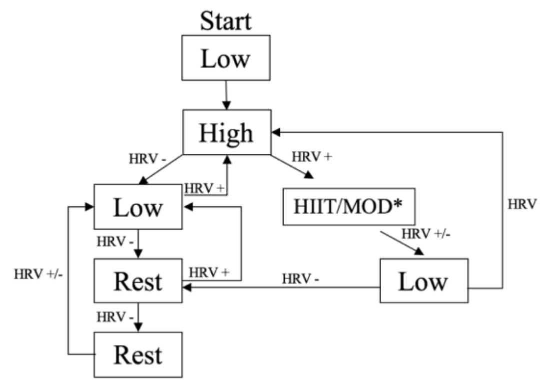
Outils

Javaloyes A, Sarabia JM, Lamberts RP, Moya-Ramon M. *Training Prescription Guided by Heart Rate Variability in Cycling.* International Journal of Sports Physiology and Performance, 2018. **0**: p. 1-28

Variabilité de la FC

METHODS: Seventeen well-trained cyclists participated in this study. After an initial evaluation week (EW), cyclists performed 4 baseline weeks (BW) of standardized training to establish their resting HRV. Then, cyclists were divided into two groups, a HRV-guided group (HRV-G) and a traditional periodization group (TRAD) and they carried out 8 training weeks (TW). Cyclists performed two EW, after and before TW. During the EW, cyclists performed: (1) a graded exercise test to assess VO_2max, peak power output (PPO) and ventilatory thresholds with their corresponding power output (VT1, VT2, WVT1, and WVT2, respectively) and (2) a 40-min simulated time-trial.





Outils

Variabilité de la FC

SWC: Smallest worthwhile change

LnRMSSD: The natural logarithm of the root mean squared differences of successive RR intervals

$LnRMSSD_{7day\text{-}roll\text{-}avg}$: 7-day rolling average of the natural logarithm of the root mean squared differences of successive RR intervals

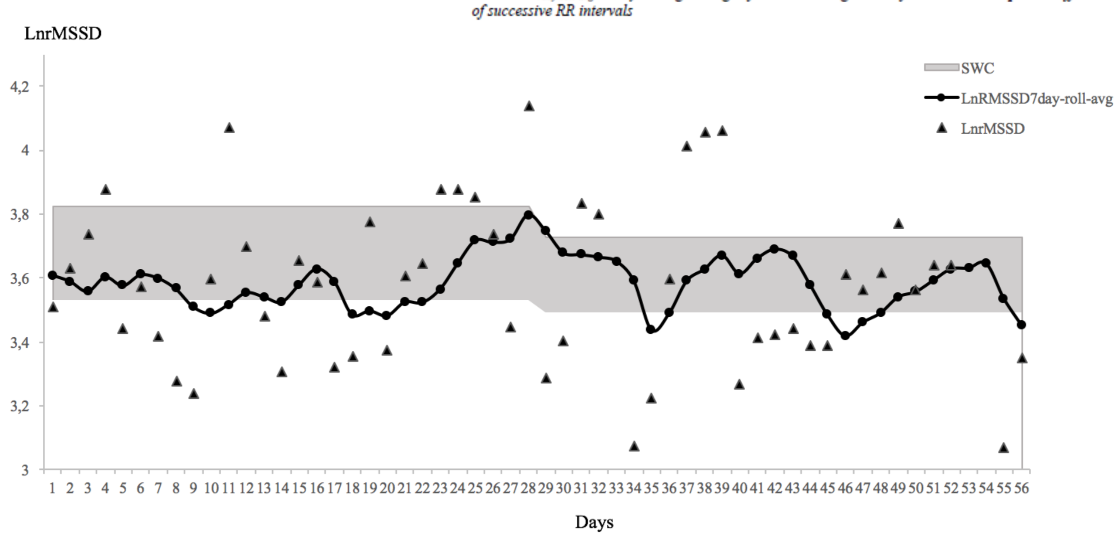
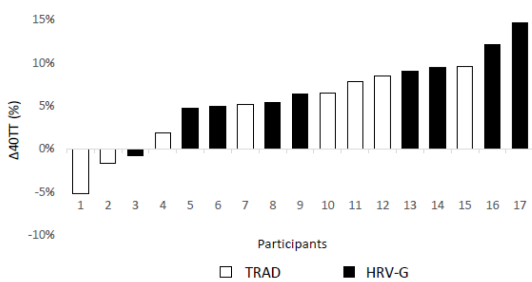


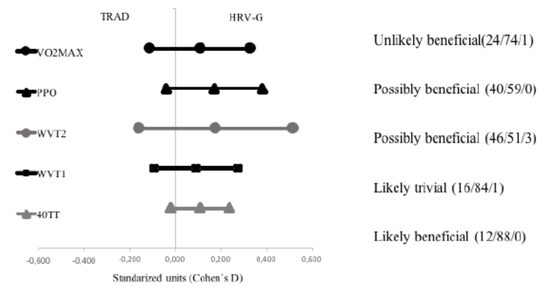
Figure 3. Example of individual response of HRV in a HRV-G cyclist.

Outils

Variabilité de la FC



40TT: Power output during the 40-min time-trial



PPO: Peak power output
WVT2: Power output at VT2 intensity
WVT1: Power output at VT1 intensity
40TT: Power output during the 40-min time-trial

Figure 4. Individual differences in changes in performance for both groups.

Figure 5. Between-group changes in performance.

Outils

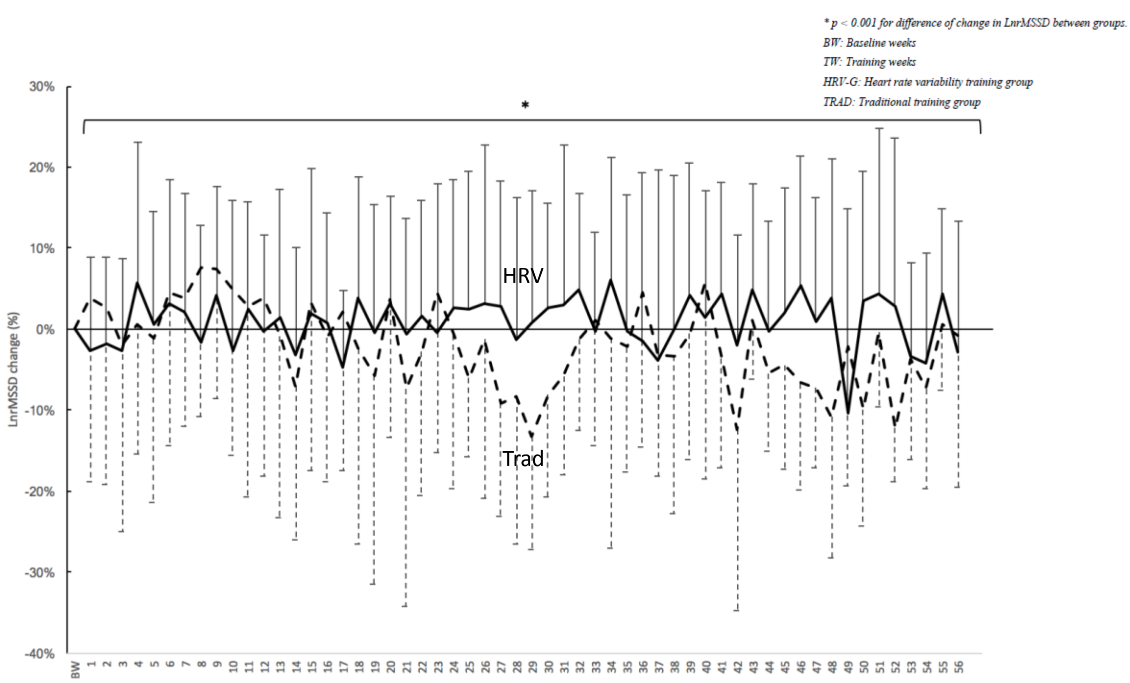


Figure 6. LnrMSSD change (%) during TW period for both, the HRV-G and TRAD groups.

Outils

Fréquence cardiaque

A comprehensive monitoring of fitness, fatigue, and performance is crucial for understanding an athlete's individual responses to training to optimize the scheduling of training and recovery strategies. Resting and exercise-related heart rate measures have received growing interest in recent decades and are considered potentially useful within multivariate response monitoring, as they provide non-invasive and time-efficient insights into the status of the autonomic nervous system (ANS) and aerobic fitness. In team sports, the practical implementation of athlete monitoring systems poses a particular challenge due to the complex and multidimensional structure of game demands and player and team performance, as well as logistic reasons, such as the typically large number of players and busy training and competition schedules. In this regard, exercise-related heart rate measures are likely the most applicable markers, as they can be routinely assessed during warm-ups using short (3–5 min) submaximal exercise protocols for an entire squad with common chest strap-based team monitoring devices.

- Rest
- Exercise
- Post-exercise

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Outils

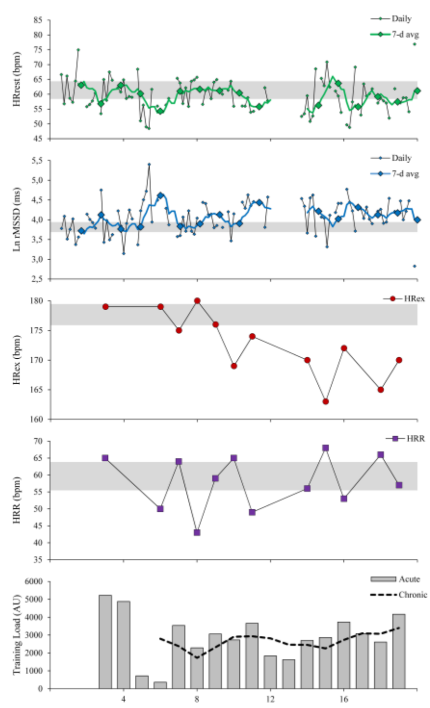
Fréquence cardiaque

HR Rest

HRV

HIMS

HIMS



TL (sRPE)

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque

3 methodes :

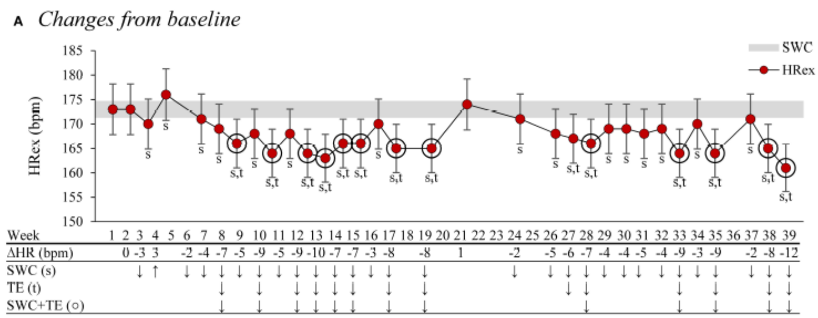


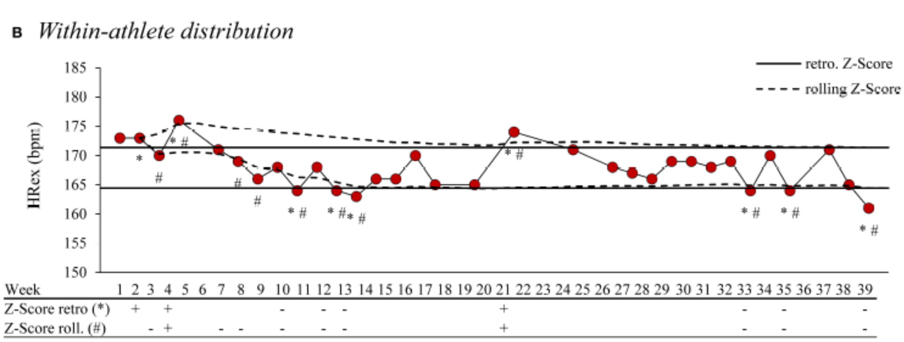
FIGURE 3 | Example of visualization and comparison of different analysis concepts and methods for assessing meaningful change in weekly exercise heart rate (HRex) in a semi-professional basketball player over an entire season. HRex was assessed on a weekly basis using a submaximal shuttle run during the warm-up (see **Figure 1**). In **(A)**, changes from baseline level (average of first 4 weeks of the preparation period) are rated and highlighted as *meaningful* with three different methods: First, when changes are larger than the smallest worthwhile change (SWC, gray horizontal bar, *s*), second, when changes are larger than the typical error (TE, error bars, *t*), or third, when changes are larger than both (SWC+TE, *circle*). The values for the SWC (>1%) and the TE (>3%) are derived from Buchheit (2014). In **(B)**,

SWC = 0.2 x SD

Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque

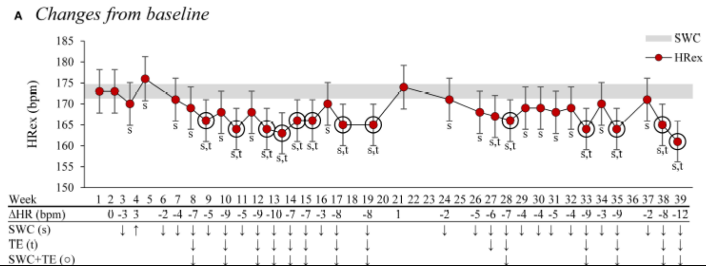


bars, *t*), or third, when changes are larger than both (SWC+TE, *circle*). The values for the SWC (>1%) and the TE (>3%) are derived from Buchheit (2014). In **(B)**, changes are analyzed with two within-athlete distributional approaches [Z-Scores: individual mean ± standard deviation (SD)]. The values are rated and highlighted as being *meaningfully* deviated when Z-Scores are >1. In the first approach, Z-Scores are calculated based on the entire data set (solid horizontal lines, *), which represents a retrospective analysis after the data collection was completed. In the second approach, Z-Scores are calculated on a "rolling" and additive basis and with all data available at each point in time (dashed lines, #). This likely represents a more realistic approach in sports practice, as monitoring data are analyzed as soon as available and therefore based on a steadily increasing data set. The analysis concepts and methods visualized illustrate a considerable disagreement between methods and concepts. Symbols: ↓: below baseline, ↑: above baseline, –: 1xSD below the mean, +: 1xSD above the mean.

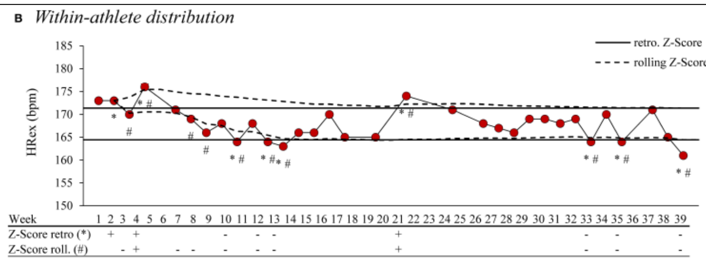
Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque



Quelle approche est la plus sensible ?

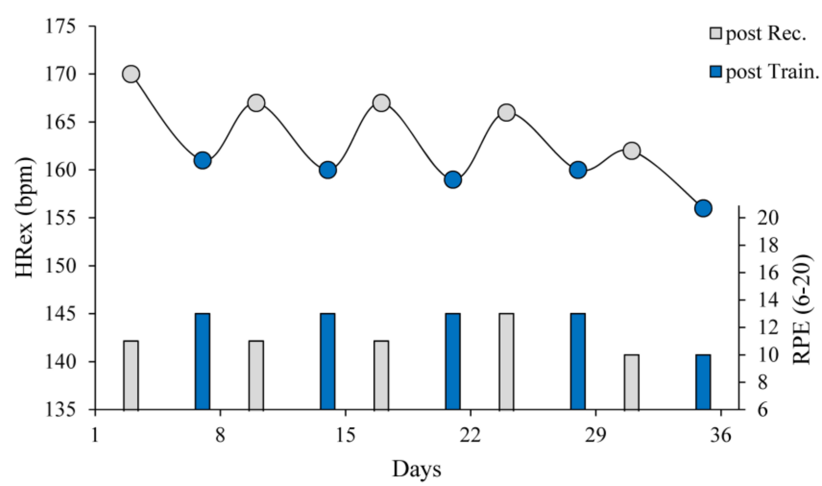


Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque

FIGURE 4 | Short-term changes in exercise heart rate (HRex) and rating of perceived exertion (RPE) in an elite, male badminton player (20-year-old) throughout a preparatory period. HRex (circles) and RPE (bars) were assessed on Mondays (post Rec., gray symbols) following 2 days of pronounced recovery, and on Fridays (post Train., blue symbols) following four consecutive days of training (with two sessions on several days) using a submaximal shuttle run (~1, 1, and 3 min at 8.2, 9.6, and 11.0 km/h, respectively; 12.8 m shuttle length) during the warm-up of the morning sessions. HRex was consistently reduced on Fridays (mean ± SD, −7 ± 1 bpm) and increased on Mondays (+5 ± 2 bpm), which may be interpreted as a result of short-term changes in training load between tests. Similarly, RPE during the shuttle runs was typically increased on Fridays and decreased on Mondays. When applying the presented heuristical logic to decision-making, in most cases the obvious conclusions are drawn corresponding to the general training plan: After several consecutive (intensive) training days, the training load should be reduced in the following days to encourage recovery, as the reduced HRex, and the increased RPE indicate acute fatigue. Likewise, the increased HR and reduced RPE on Mondays indicate recovery, which supports a resumption of (intense) training. However, according to the presented logic, one could have deviated from the training plan at two points in time: On day 24, the relatively high RPE indicates an incomplete recovery, and consequently further facilitating of recovery strategies or at least a reduction in planned workload seemed appropriate. In contrast, the low RPE and the somewhat less severe decline in HRex on day 35 point to the possibility of continuing to tolerate high training loads at least for another training session. Furthermore, the overall decline in HRex over the training weeks, while maintaining a constant or slightly decreasing RPE, indicates positive adaptation and appropriate training periodization.

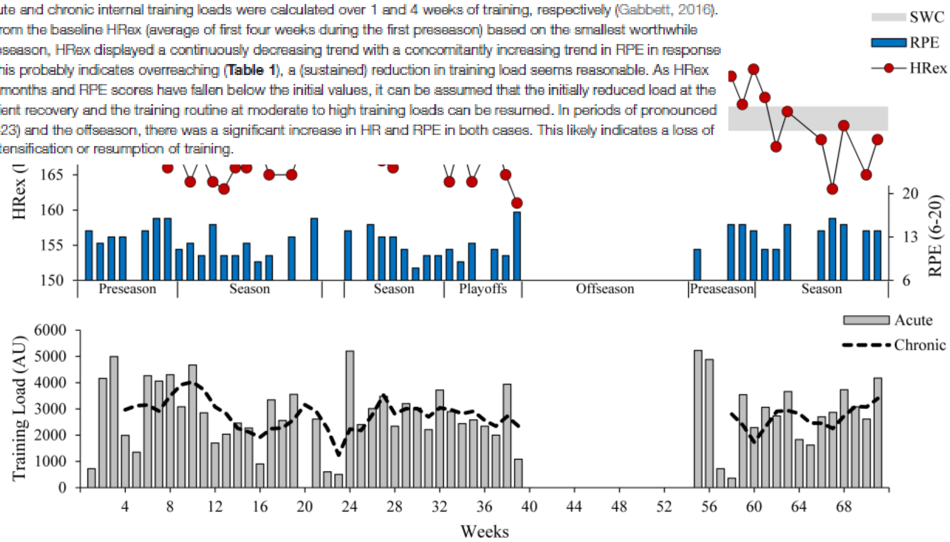


Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque

FIGURE 5 | Long-term changes in exercise heart rate (HRex), rating of perceived exertion (RPE) and training load in a semi-professional basketball player (26-year-old, 3rd highest German basketball league) throughout 1.5 competitive seasons. HRex and RPE were assessed on a weekly basis, using a submaximal shuttle run during the warm-up (see **Figure 1**). Acute and chronic internal training loads were calculated over 1 and 4 weeks of training, respectively (Gabbett, 2016). The gray horizontal bar represents trivial changes from the baseline HRex (average of first four weeks during the first preseason) based on the smallest worthwhile change (SWC; Buchheit, 2014). During the first preseason, HRex displayed a continuously decreasing trend with a concomitantly increasing trend in RPE in response to consecutive weeks of high training load. Since this probably indicates overreaching (**Table 1**), a (sustained) reduction in training load seems reasonable. As HRex remains substantially reduced during the following months and RPE scores have fallen below the initial values, it can be assumed that the initially reduced load at the beginning of the competitive season allowed sufficient recovery and the training routine at moderate to high training loads can be resumed. In periods of pronounced relief, such as the 2-week winter break (weeks 22–23) and the offseason, there was a significant increase in HR and RPE in both cases. This likely indicates a loss of (aerobic) fitness through detraining, and calls for intensification or resumption of training.



Outils

Schneider C, Hanakam F, Wiewelhove T, Döweling A, Kellmann M, Meyer T, Pfeiffer M, Ferrauti A. *Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription.* Frontiers in Physiology, 2018. **9**

Fréquence cardiaque

FIGURE 5 | Long-term changes in exercise heart rate (HRex), rating of perceived exertion (RPE) and training load in a semi-professional basketball player (26-year-old, 3rd highest German basketball league) throughout 1.5 competitive seasons. HRex and RPE were assessed on a weekly basis, using a submaximal shuttle run during the warm-up (see **Figure 1**). Acut
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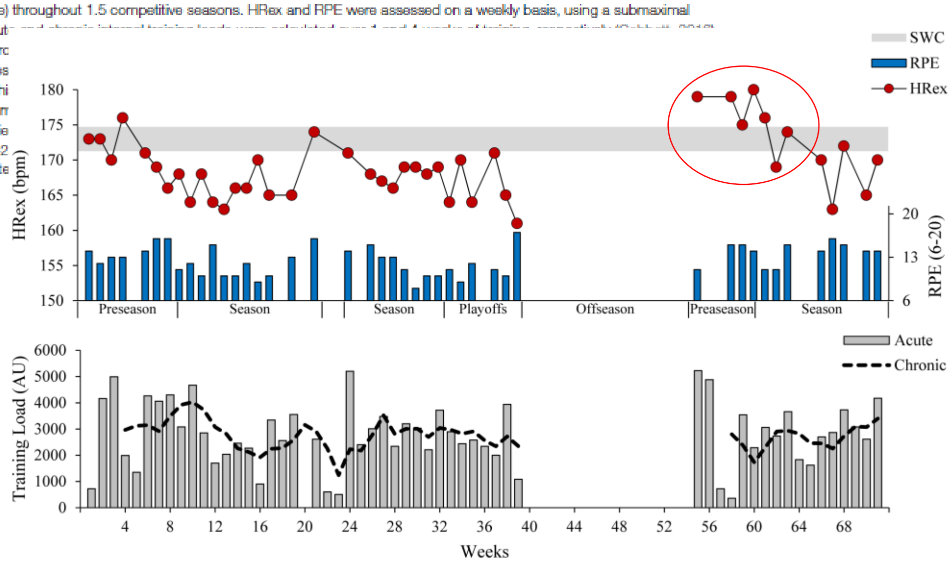

Outils

Fréquence cardiaque

Figure 1. Change in sleep quality (**A**); resting heart rate and resting peripheral oxygen saturation (**B**) relative to Day 1 over the course of a training camp at altitude. Data presented as mean ± SD. Symmetrical error bars above or below the mean values have been omitted for clarity.

Saw A, Halson S, Mujika I. *Monitoring Athletes during Training Camps: Observations and Translatable Strategies from Elite Road Cyclists and Swimmers.* Sports, 2018. **6**: p. 63

Outils

Fréquence cardiaque

Table 2. Measurements of elite swimmers on day 1 of training camps, smallest worthwhile change (SWC) and smallest real change (SRC) calculated from day 1, and mean changes observed during training camps.

Camp Details	**Camp 1**	**Camp 2**	**Camp 3**	**Camp 4**
	Early-season January 2012 Sea-level	Pre-London July 2012 Altitude	Pre-Kazan June 2015 Altitude	Pre-Rio May 2016 Altitude
Days	19	8	4	18
n	13	12	7	8
Body mass (kg)	65.0 ± 5.1 (F)	-	57.3 ± 7.5 (F) 73.1 ± 7.3 (M)	55.4 ± 4.3 (F) 77.2 ± 11.5 (M)
SWC/SRC	2.2/3.6	-	3.0/7.7	6.3/14.1
Daily change	−0.1 ± 0.1	-	−0.2 ± 0.1	−0.1 ± 0.1
Skinfolds (sum 7 mm)	67.1 ± 9.9 (F)	79.4 ± 15.6	57.1 ± 12.3 (F) 66.1 ± 20.7 (M)	47.8 ± 5.4 (M)
SWC/SRC	4.4/8.3	5.9/13.0	7.6/16.3	7.3/17.8
Weekly change	-	−8.1 ± 4.1	-	−2.0 ± 0.5
USG	1.0150 ± 0.0046	1.0215 ± 0.0054	1.0180 ± 0.0070	1.0172 ± 0.0060
SWC/SRC	0.1352/0.0035	0.1594/0.0043	0.2061/0.0073	0.1774/0.0059
Daily change	-	−0.0003 ± 0.0013	−0.0005 ± 0.0020	0.0001 ± 0.0002
Resting HR (bpm)	-	54 ± 7	54 ± 7	53 ± 8
SWC/SRC	-	4/6	4/7	5/8
Daily change	-	0 ± 1	0 ± 2	0 ± 0
SpO_2 (%)	-	95.3 ± 1.7	95.0 ± 1.6	94.0 ± 1.1
SWC/SRC	-	0.5/1.4	0.5/1.7	0.3/1.1
Daily change	-	0.2 ± 0.5	0.0 ± 0.5	0.1 ± 0.0
Sleep duration (h)	8.2 ± 0.2	-	-	7.5 ± 0.3
SWC/SRC	0.7/0.2	-	-	1.1/0.3
Daily change	0.0 ± 0.0	-	-	0.0 ± 0.0
Sleep quality (1–5)	3.7 ± 0.8	-	-	2.2 ± 0.7
SWC/SRC	6.3/0.6	-	-	9.4/0.7
Daily change	0.0 ± 0.1	-	-	0.1 ± 0.0

Saw A, Halson S, Mujika I. *Monitoring Athletes during Training Camps: Observations and Translatable Strategies from Elite Road Cyclists and Swimmers.* Sports, 2018. **6**: p. 63

Outils

Fréquence cardiaque

Table 3. Percent of athletes flagged against the smallest worthwhile change (SWC) and smallest real change (SRC) calculated from day 1, and z-scores calculated from the daily group change for each measure for all training camps.

Measure of Change	SWC	SRC	z-Score 1.0	z-Score 1.5
Body mass	0 ± 0	0 ± 0	33 ± 5	17 ± 8
USG	0 ± 0	27 ± 18	35 ± 8	18 ± 7
Resting HR	32 ± 16	22 ± 16	32 ± 5	11 ± 8
SpO_2	63 ± 8	25 ± 13	37 ± 4	16 ± 6
Sleep duration	20 ± 15	60 ± 10	30 ± 2	18 ± 7
Sleep quality	0 ± 0	49 ± 11	36 ± 9	19 ± 8

Data presented as mean ± SD. USG: Urinary specific gravity; HR: Heart rate; SpO_2: Peripheral oxygen saturation.

Saw A, Halson S, Mujika I. *Monitoring Athletes during Training Camps: Observations and Translatable Strategies from Elite Road Cyclists and Swimmers.* Sports, 2018. **6**: p. 63

Outils

Fréquence cardiaque

Collectively, the observed physiological responses to training camps reflect the fitness and experience of the elite cohort. Subjectively, the performance of athletes whilst training at the camps and in subsequent major competitions, where applicable, suggested that the athletes responded appropriately to a well-designed and managed training program, however we acknowledge this is speculative without objective performance data during the camps. The routine monitoring of body mass, skinfolds, sleep duration and quality, USG, resting HR, and SpO_2 may have contributed to the management of these athletes by providing additional insight to practitioners.

To facilitate the detection of possible maladaptation, practitioners may pre-set thresholds to 'flag' meaningful changes in measures. There is a need to balance the sensitivity and specificity of thresholds, whereby it is feasible to follow up with the number of flagged athletes. In the training camp scenario with limited numbers of athletes completing similar training, the z-score approach was most successful to identify a small number of athletes each day whose response deviated from the mean group response. Z-score thresholds of 1.0 and 1.5 remain arbitrary, and may be further refined to suit the measure and/or training camp scenario. Nevertheless, thresholds are only intended to assist the practitioner, and informal monitoring through conversations and observation of the athlete remains a large component of athlete management.

Saw A, Halson S, Mujika I. *Monitoring Athletes during Training Camps: Observations and Translatable Strategies from Elite Road Cyclists and Swimmers.* Sports, 2018. **6**: p. 63

Outils

VO2, seuils

The Physiology of the World Record Holder for the Women's Marathon

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E-mail: a.m.jones@exeter.ac.uk

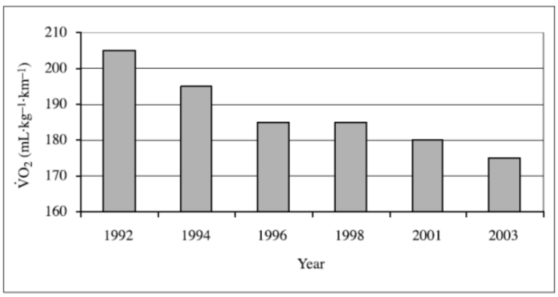


Figure 4. PR's $\dot{V}O_2$ While Running at 16.0 km·h^{-1}, 1992-2003

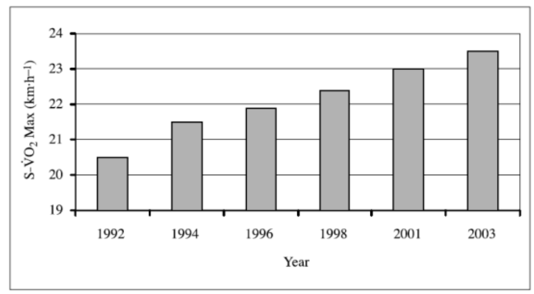


Figure 5. PR's Running Speed at $\dot{V}O_2$ max, 1992-2003

Outils

Efficacité

Improved muscular efficiency displayed as Tour de France champion matures

Edward F. Coyle
Human Performance Laboratory, Department of Kinesiology and Health Education, The University of Texas at Austin, Austin, Texas

Table 2. *Physiological characteristics of this individual from the ages of 21 to 28 yr*

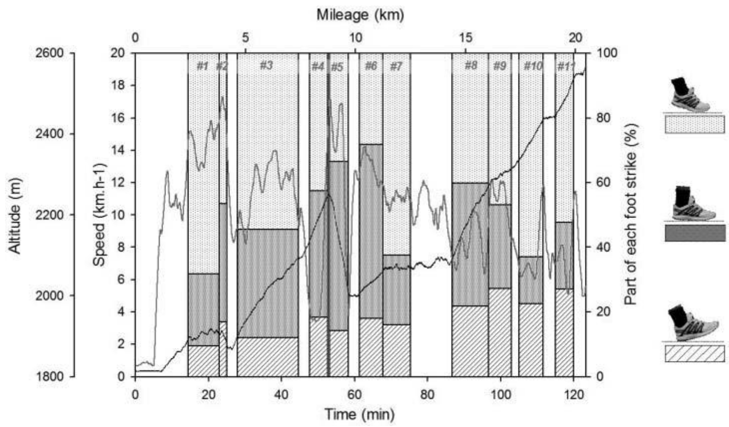
	Age, yr				
	21.1	21.4	22.0	25.9	28.2
Date: Month-Year	Nov 1992	Jan 1993	Sept 1993	Aug 1997	Nov 1999
Training stage	Preseason	Preseason	Racing	Reduced	Preseason
Anthropometry					
Body weight, kg	78.9	76.5	75.1	79.5	79.7
Lean body weight, kg	70.5	69.8		70.2	71.6
Body fat, %	10.7	8.8		11.7	
Maximal aerobic ability					
Maximal O_2 uptake, l/min	5.56	5.82	6.10	5.29	5.7
Maximal O_2 uptake, ml·kg^{-1}·min^{-1}	70.5	76.1	81.2	66.6	71.5
Maximal heart rate, beats/min	207	206	202	200	200
Maximal blood lactic acid, mM	7.5	6.3	6.5	9.2	
Lactate threshold					
Lactate threshold O_2 uptake, l/min	4.70	4.52	4.63	4.02	
Lactate threshold, % maximal O_2 uptake	85	78	76	76	
Mechanical efficiency					
Gross efficiency, %	21.18	21.61		22.66	23.05
Delta efficiency, %	21.37	21.75		22.69	23.12
Power at O_2 uptake of 5.0 l/min, W	374	382		399	404

Outils

Pose de pied

Foot strike pattern and impact continuous measurements during a trail running race: proof of concept in a world-class athlete

Marlène Giandolini[a,b]*, Sébastien Pavailler[a,b], Pierre Samozino[a], Jean-Benoît Morin[c] and Nicolas Horvais[b]



Outils

Autres outils…

International Journal of Sports Physiology and Performance, 2017, 12, S2-42-S2-49
http://dx.doi.org/10.1123/ijspp.2016-0334

Human Kinetics
BRIEF REVIEW

Managing the Training Load in Adolescent Athletes

Andrew Murray

International Journal of Sports Physiology and Performance, 2017, 12, S2-153-S2-156
http://dx.doi.org/10.1123/ijspp.2016-0316

Human Kinetics
BRIEF REPORT

Predictive Indicators of Overuse Injuries in Adolescent Endurance Athletes

Daniel Martínez-Silván, Jaime Díaz-Ocejo, and Andrew Murray

Enfants pré-pubères métaboliquement similaires a adultes endurants

Peu d'impact de l'entrainement en endurance sur masse Hb

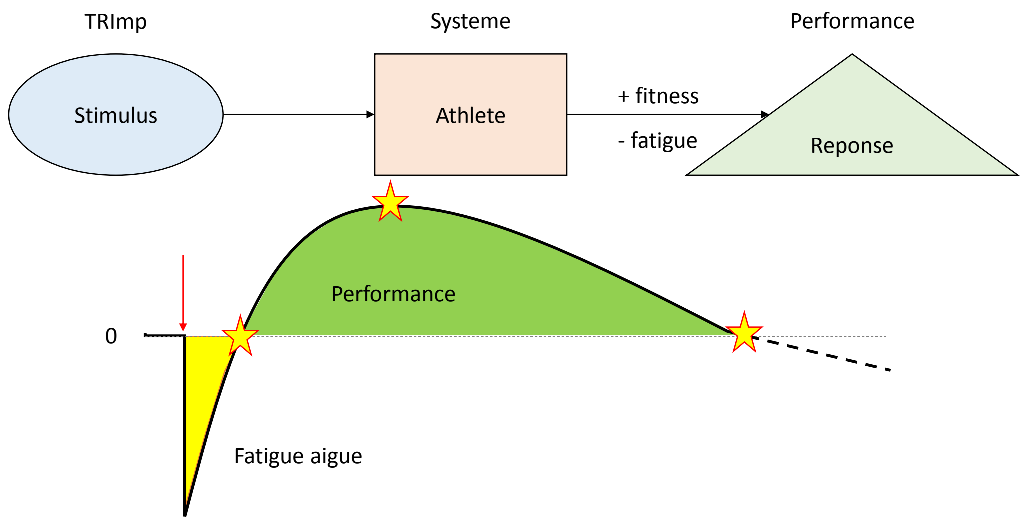
Besoin d'apprendre = comment s'entrainer (intensités)
comment courir (pacing)

+

Cricket = risque +3.1% si < 3,5 jours entre lancers (~14 ans)
Volley = relation ~ linéaire volume / blessure genou (16 ans)
Aviron = relation volume sur ergomètre / blessure dos

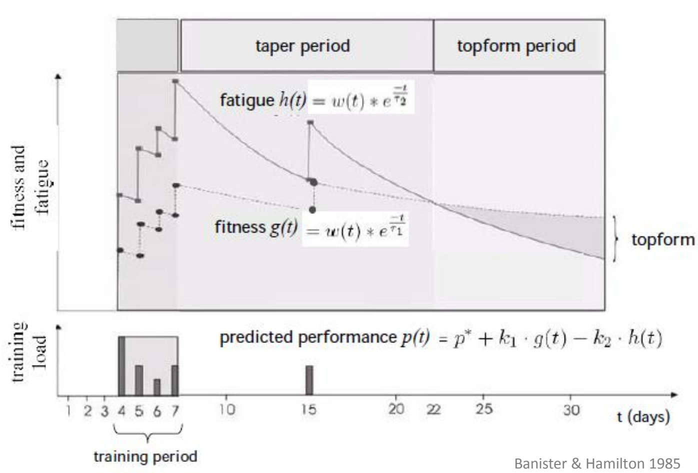
Fatigue / Forme

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)



Fatigue / Forme

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)



Banister & Hamilton 1985

<u>A déterminer pour chaque athlète</u>

τ_1 et τ_2 = constantes de temps (F-F)

k_1 et k_2 = effets de l'entrainement (F-F)
- Processus iteratif
- Pas de base physiologique

Fatigue / Forme

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)

The model described herein is based on a systems model initially proposed by Banister et al. (4). The subject is represented by a system, the input of which is the daily total exercise level and time and the output is the performance. The working of the system is described by a transfer function, which is the sum of two first-order transfer functions. The impulse response [$g(t)$] of such a function is

$$g(t) = k_1 e^{-t/\tau_1} - k_2 e^{-t/\tau_2} \quad (1)$$

where k_1 and k_2 are gain terms ($k_1 < k_2$), and τ_1 and τ_2 are time constants ($\tau_1 > \tau_2$). The model performance is obtained by convolving the training doses, quantified from exercise level and time, to the impulse response $g(t)$. The model parameters are determined by fitting the model performances to actual performances by the least square method. k_1 and k_2 were in arbitrary units, depending on the units used to measure the training load and performance in our studies (7–10, 21), whereas in studies of Banister's group (3–6, 20) k_1 and k_2 were dimensionless. Only the ratio k_2/k_1 can be thus

return performance to the pretraining level (13, 20). Thereafter, the performance will exceed its pretraining level. t_n is estimated by

$$t_n = \frac{\tau_1 \tau_2}{\tau_1 - \tau_2} \ln\left(\frac{k_2}{k_1}\right) \quad (2)$$

The t_n was 23 days for an elite hammer thrower who trained once or twice a day and had trained for 7 yr (7). This was greater than the 8 and 11 days reported for two subjects following an intensive program of running 40–50 min at least once each day for 28 days (20). The lowest values for t_n were 1–3 days for eight subjects performing a moderate endurance

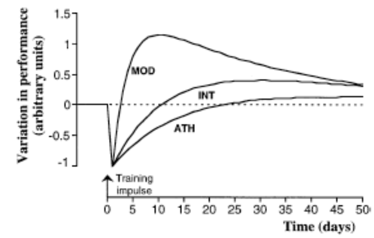


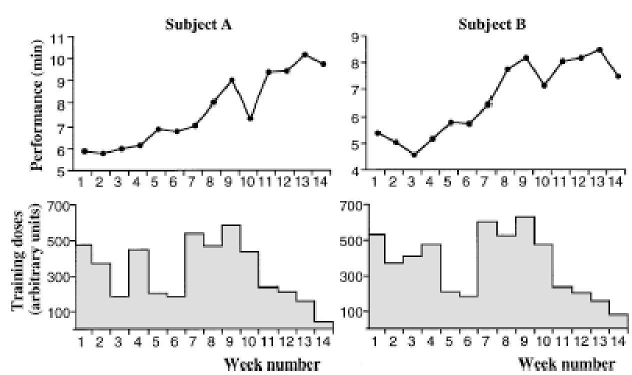
Fig. 1. Response of performance to a training dose leading to a decrease of 1 arbitrary unit 1 day after training completion. MOD, subject doing moderate training (data from Ref. 8); INT, subject doing intensive training (data from Ref. 20); ATH, athlete (data from Ref. 7).

Fatigue / Forme

Busso T, Denis C, Bonnefoy R, Geyssant A, Lacour J-R. *Modeling of adaptations to physical training by using a recursive least squares algorithm.* Journal of Applied Physiology, 1997. **80**: p. 1685-1693

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)

Therefore, the linear time-invariant functions used in the model could be unsuitable for describing responses to training with varied regimens. The model parameters were assumed to be constant throughout the experimental period in the above-cited studies. However, day-to-day variations in model parameters, which would lead to a better fit of the performances, might describe more precisely adaptations to training and long-term fatigue. The present study investigates the relevance of a model with parameters (gain terms and time constants) free to vary over time, using a recursive least square method.



Fatigue / Forme

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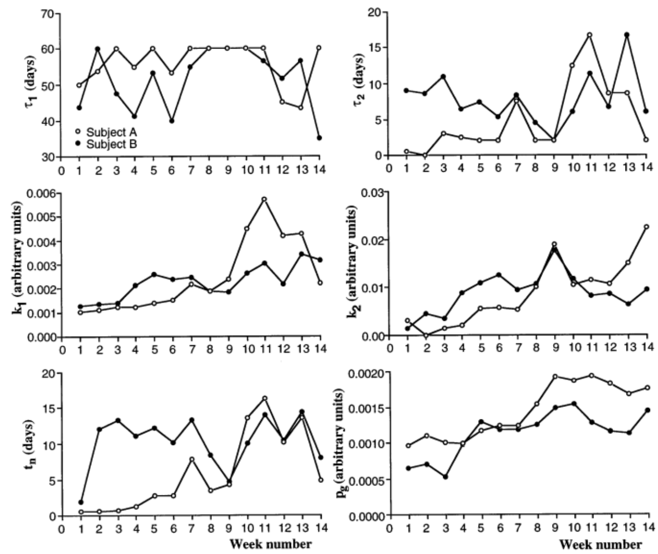
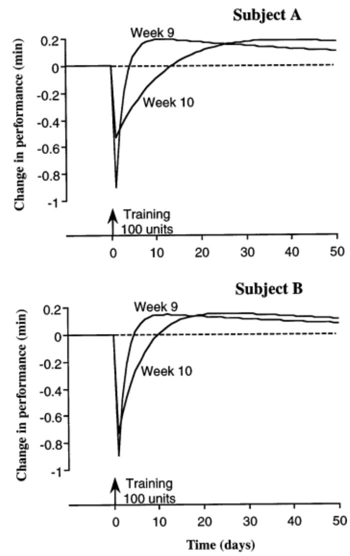
Modéliser la relation fatigue / forme ? (ou fatigue / fitness)





Fatigue / Forme

Busso T, Benoit H, Bonnefoy R, Féasson L, Lacour J-R. *Effects of training frequency on the dynamics of performance response to a single training bout.* Journal of Applied Physiology, 2002. **92**: p. 572-580

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)

The purpose of the present investigation was to analyze the dynamic variations of performance response to exercise with stepwise changes in training frequency. Changes over time in the responses to training loads were assessed using the systems model with time-varying parameters. More precisely, the aim of this study was to determine whether an increase in training frequency and thus a decrease in recovery time between training sessions would induce a progressive increase in the magnitude and duration of long-term fatigue induced by an identical training load.

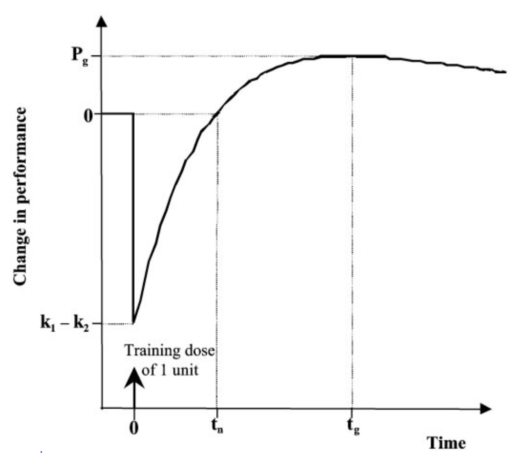


Fig. 1. Response of performance to a training dose of 1 unit. p_g, Maximal gain in performance; $k_1 - k_2$, difference between gain terms for positive component (k_1) and negative component (k_2) of the model; t_n, time needed to recover performance after training completion; t_g, time needed to reach maximal performance after training completion.

Fatigue / Forme

Busso T, Benoit H, Bonnefoy R, Féasson L, Lacour J-R. *Effects of training frequency on the dynamics of performance response to a single training bout.* Journal of Applied Physiology, 2002. **92**: p. 572-580

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)

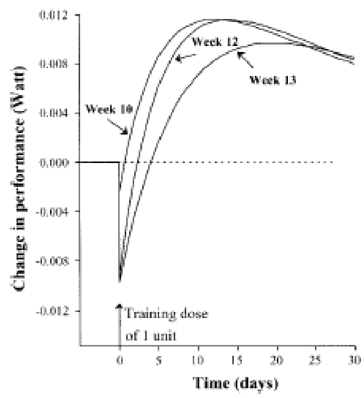


Fig. 4. Response of performance to a single training dose of 1 unit computed from mean model parameters estimated in *weeks 10, 12,* and *13* using a model with time-varying gain terms and time constants.

In conclusion, this study showed that the reduction in recovery time between training sessions yielded a progressive increase in the magnitude and duration of fatigue induced by each bout of training stimulus and also led to a decrease in the resulting adaptations. Reduced adaptation to training loads could arise from lower tolerance to exercise, from higher fitness level, or from a limitation on the body's capacity to adapt to greater training loads.

Fatigue / Forme

Busso T, Benoit H, Bonnefoy R, Féasson L, Lacour J-R. *Effects of training frequency on the dynamics of performance response to a single training bout.* Journal of Applied Physiology, 2002. **92**: p. 572-580

Modéliser la relation fatigue / forme ? (ou fatigue / fitness)

Limites objectives

- Peu pratique
- Mathématiquement intensif
- Peu « réactif »
- Peu prédictif
- Différences notoires entre performances prédites et réelles

Fatigue / Forme

Relation monitoring et blessures ?

Dans quel sport ?
Locomotion : impacts au sol >> distance courue
Surf : fractures, piqures, otites...
Grand terrain : traumatismes >> ?

Liens les plus évidents : surentrainement
blessures de non-contact

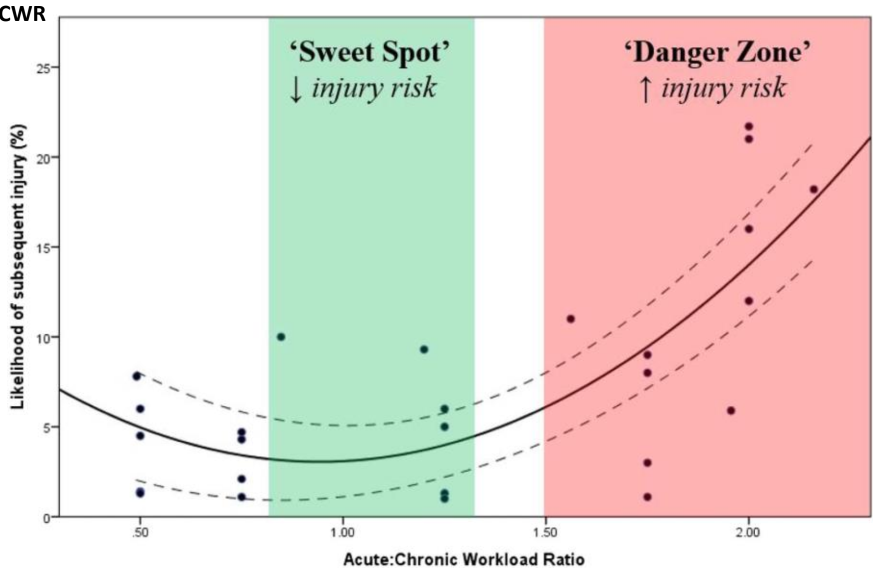
Risque de blessure dans sports de grand terrain augmente quand ratio charge aigue/chronique > 1.5
Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter and harder? *Br J Sports Med*. 2016;50(5):273–280

Paradoxe : le risque de blessure augmente si on s'entraine trop ET pas assez…
« sweet spot » = effet protecteur du volume…

Fatigue / Forme

Gabbett TJ. The training—injury prevention paradox: should athletes be training smarter *and* harder? *British Journal of Sports Medicine* 50: 273-280, 2016.

Ratio « linéaire » ACWR



Fatigue / Forme

Impellizzeri FM, Woodcock S, McCall A, Ward P, Coutts AJ. The acute-chronic workload ratio-injury figure and its 'sweet spot' are flawed. *SportRxiv Preprint*, 2019. https://osf.io/preprints/sportrxiv/gs8yu/

Ratio « linéaire » ACWR

Œil critique

Request of retraction or errata corrige to British Journal of Sports Medicine

The acute-chronic workload ratio-injury figure and its 'sweet spot' are flawed

Franco M. Impellizzeri[1], Stephen Woodcock[2], Alan McCall[1,3], Patrick Ward[1], Aaron J. Coutts[1]

1, Human Performance Research Centre, Faculty of Health, University of Technology Sydney (UTS), Australia
2, School of Mathematical and Physical Sciences, University of Technology Sydney (UTS), Australia
3, Arsenal Performance and Research Team, Arsenal Football Club, London, UK

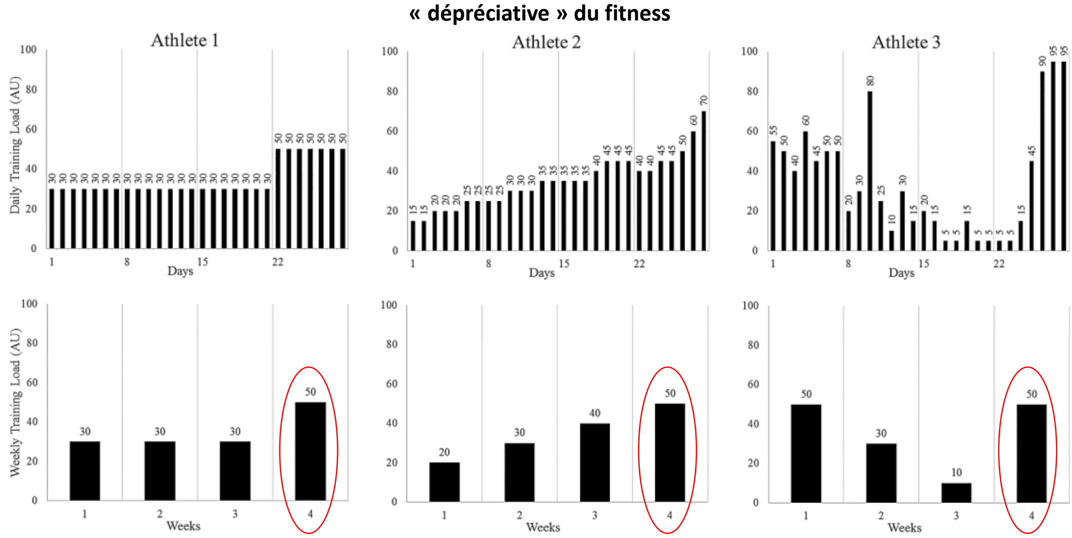
Résumez le problème soulevé par ces auteurs

Fatigue / Forme

Menaspà P. Are rolling averages a good way to assess training load for injury prevention? *British Journal of Sports Medicine* 51: 618-619, 2016.

Ratio simple ACWR

Mais le ratio simple ACWR ne tient pas compte de la nature « dépréciative » du fitness



Fatigue / Forme

Williams S, West S, Cross MJ, and Stokes KA. Better way to determine the acute:chronic workload ratio? *British Journal of Sports Medicine* 51: 209-210, 2017.

Ratio « exponentiel » EWMA

EWMA (« exponentially-weighted moving averages ») **= EWMA^{jour} aigue / EWMA^{jour} chronique**

EWMA^{jour} = Charge^{jour} x α + (1 - α) x Charge^{jour-1})

α = 2 / (N + 1)

Fatigue / Forme

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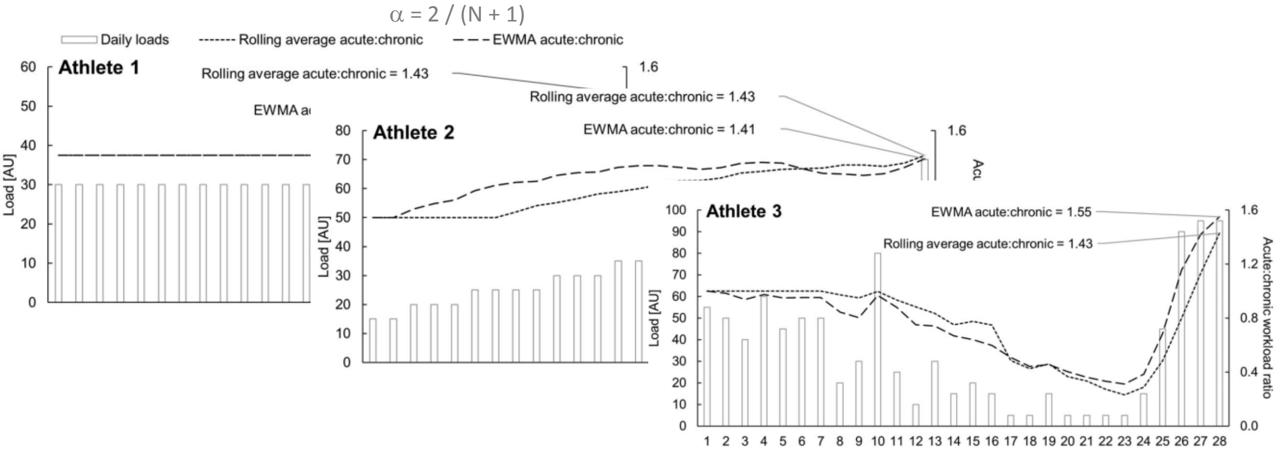
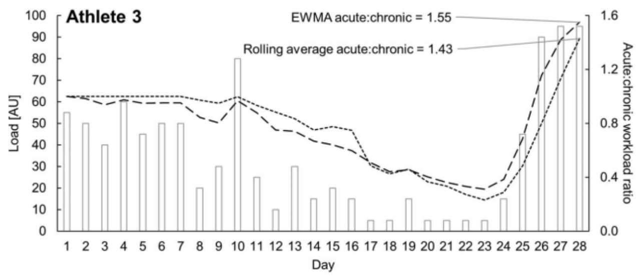


Fatigue / Forme

Ratio « linéaire » ACWR *vs.* « exponentiel » EWMA

Œil critique



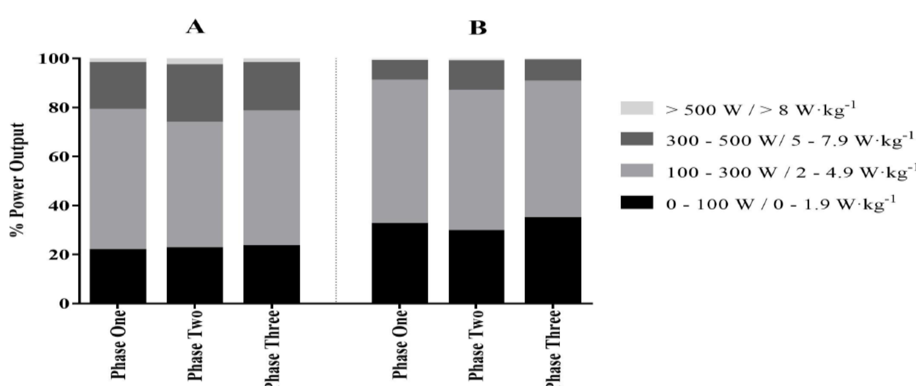
Lequel est le meilleur ?
Le ratio EWMA solutionne t'il les problèmes soulevés par Impellizzeri *et al.* ?
Dans quelles disciplines ces considérations sont-elles les plus efficaces ?

Fatigue / Forme

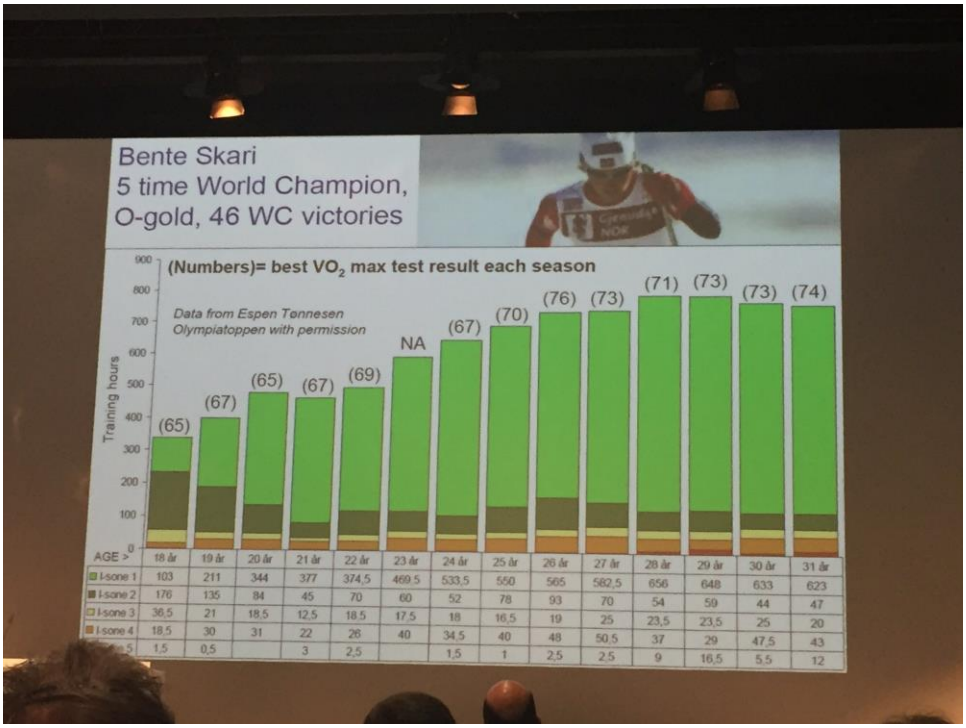
Répartition des zones d'intensité

Within-Season Distribution of External Training and Racing Workload in Professional Male Road Cyclists

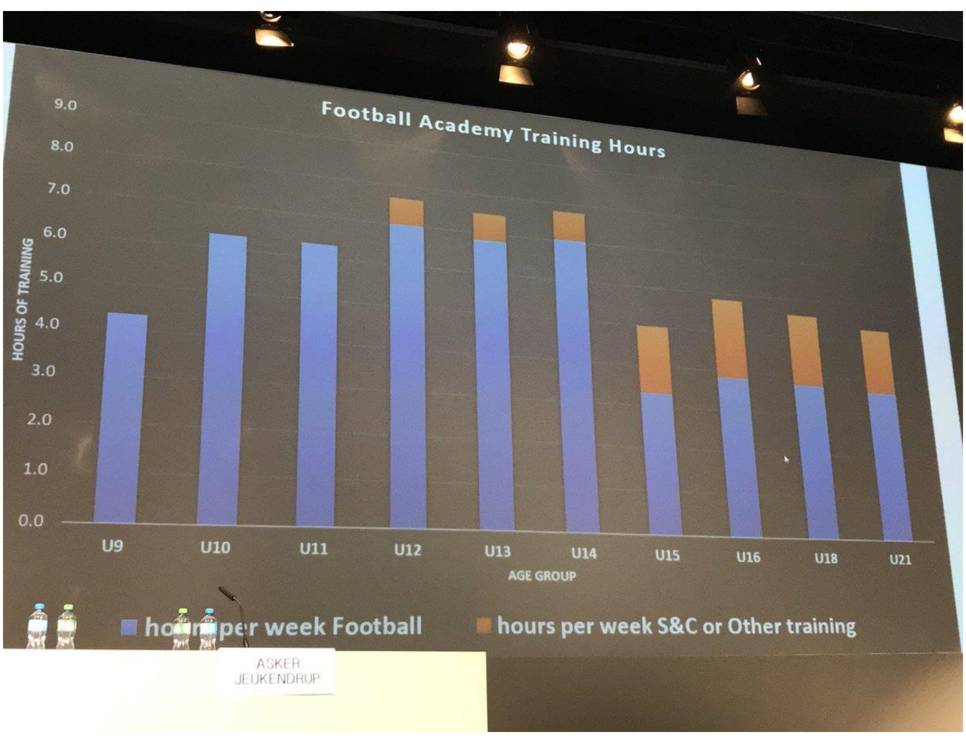
Alan J. Metcalfe, Paolo Menaspà, Vincent Villerius, Marc Quod, Jeremiah J. Peiffer, Andrew D. Govus, and Chris R Abbiss



Outils



Outils



Autres systèmes

A Coggan

Training Stress Score (TSS) (2003) *= charge d'entrainement/TRImp*
Utilise une mesure de puissance (précise et disponible sur ergomètres, certains vélos…)

TSS = Durée x Puissance Moyenne (en NP) x coefficient d'intensité (puissance)

Coefficient d'intensité = basé sur relation [La]/puissance
[La] en % du seuil lactique = Puissance au seuil

La puissance utilisée est la NP (« normalised power »)

- *La puissance est lissée sur 30 s (demie-vie de processus physio : FC, adrénaline…)*
- *Valeurs élevées a la puissance ~4*
- *Moyenne (sur les 30 s)*
- *Racine 4^e du resultat*

Possible sans test invasif : puissance sur 1 h = puissance au SL (FTP)

Autres systèmes

A Coggan

Training Peaks – WKO4 (payant)

Performance Management Chart (PMC)	Carnet d'entrainement
Training Stress Score (**TSS**)	Duree x IF (puissance, et maintenant aussi FC, vitesse, RPE) TSS = 100 si 60 min max *TSS = (sec x NP® x IF®)/(FTP x 3600) x 100*
Test Functional Threshold Power (**FTP**)	Test 20 min max x 0.95 Test 60 min max
Normalized power (**NP**)	Pondération de la puissance de tous segments > 30 s
Intensity factor (**IF**)	Ratio de NP par puissance au seuil (FTP)
Fatigue / Acute Training Load (ATL)	Moyenne pondérée (exp) sur 10 j (de base, modifiable)
Fitness / Chronic Training Load (CTL)	Moyenne pondérée (exp) sur 42 j (de base, modifable)
Form / Training Stress Balance (**TSB**)	previous day CTL - ATL

Autres systèmes

A Coggan

Matthew Hayman
Paris-Roubaix 2016

257.5 km (52.8 km pavés)
Vitesse seulement 177 km

401 de TSS
313 W de moyenne (3.82 W/kg)
430 W de moy dans l'échappée (~4 h)
351 W de NP
1.12 de variability index

Attaques dans les 5 derniers km
- 1198 W
- 1294 W
- 1227 W (T Boonen)
- 1145 W (réponse a Boonen)
- 1234 W (sprint final)

Autres systèmes

A Coggan

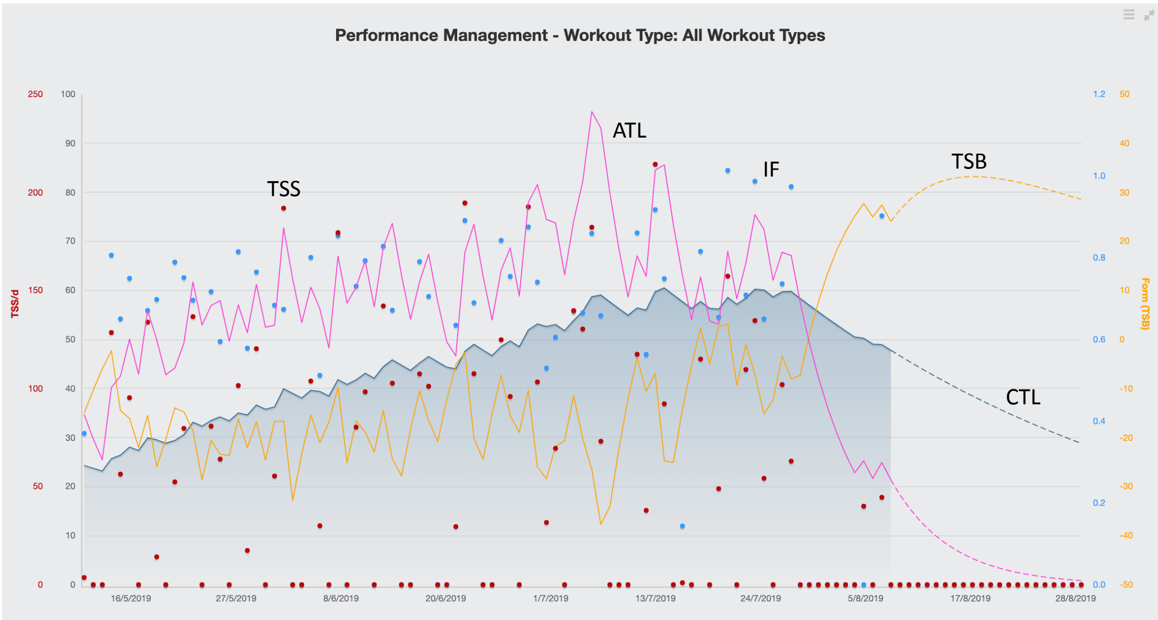
Lionel Sanders
Ironman Kona 2016

180 km
40.6 km/h

264 de TSS
303 W de moyenne (4.20 W/kg)
0.77 d'IF (%de FTP)
306 W de NP
1.02 de variability index

Autres systèmes

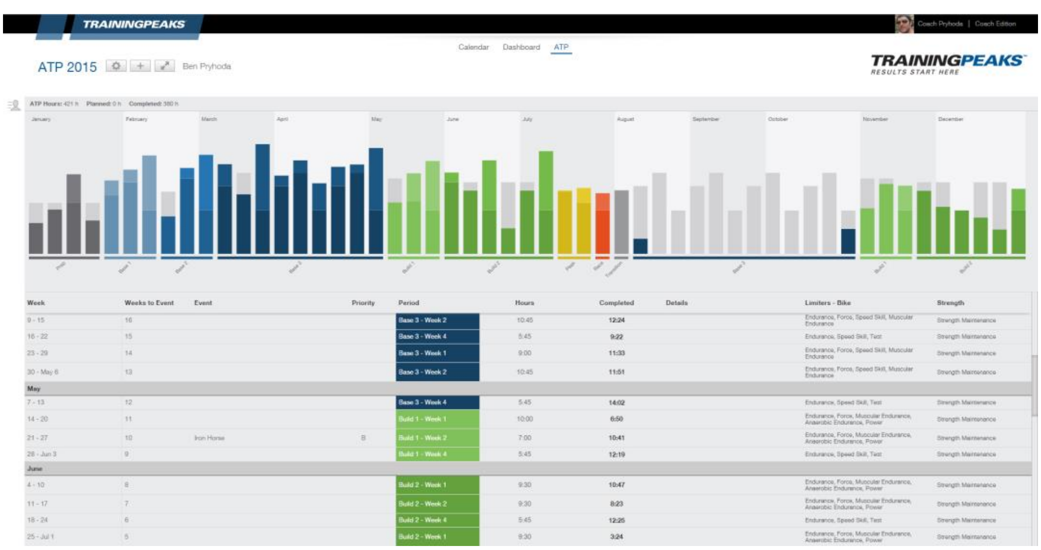
TRAINING PEAKS



Autres systèmes

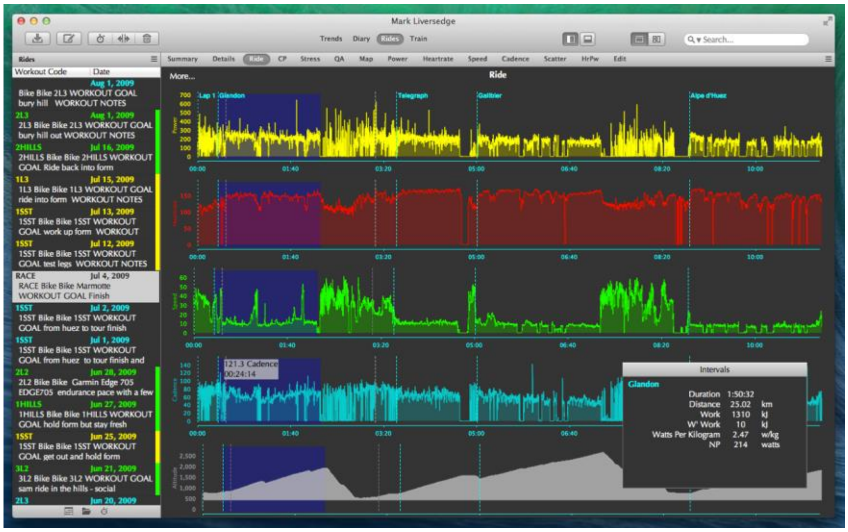
TRAINING PEAKS

A Coggan



Autres systèmes

Golden Cheetah (gratuit)



Autres systèmes

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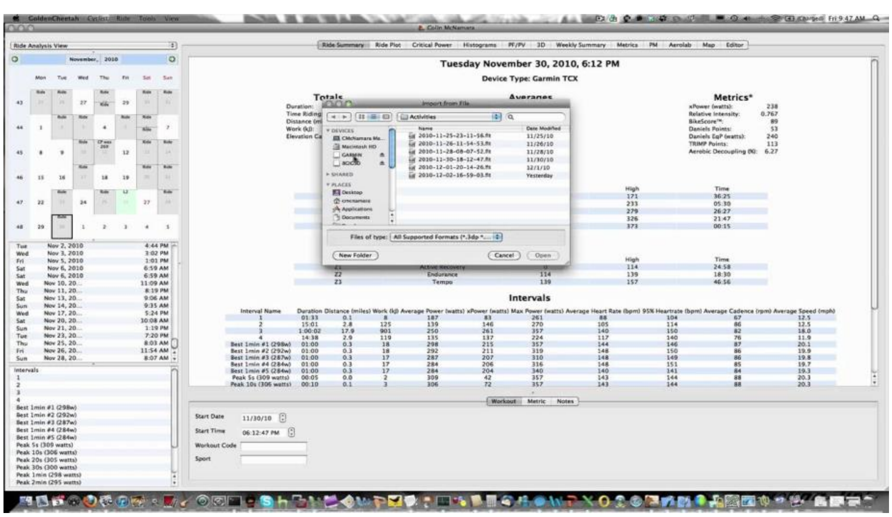

Autres systèmes

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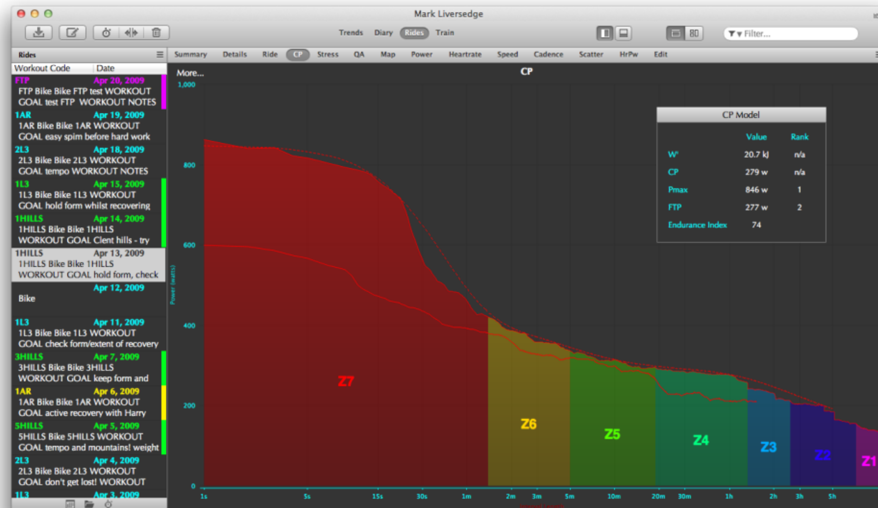


Application

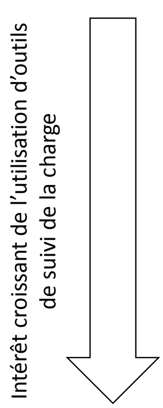
Efficacité de la phase d'entrainement ?

Sur la séance

Sur le microcycle

Sur le macrocycle

Carrière



Nature "additive"

Application

Efficacité de la phase d'entrainement ?

Premier rôle du suivi de la charge : Rétrospectif

- Tout le temps : Permet de décrire les conditions de l'entrainement consenti
  dresser un état des lieux sur relativement long terme (cumulatif)
  déterminer ce qu'est le niveau de base d'un athlète (sans blessure…)
  suivre le niveau de forme et de fatigue des athlètes pour mieux les connaitre
  attirer l'attention sur des phases critiques ou des évènements marquants (en **+** et en **-**)

- Parfois : Permet d'expliquer certains évènements dans la préparation des athlètes
  si fatigue trop intense
  si réponses perceptuelles hors norme
  si variations soudaines de charge (ratios, variabilité de la charge) ?
  si facteurs de risque propre a l'activité (nb de lancers [cricket], km parcourus [locomotion],..)

Attention ! => pas vouloir tout expliquer avec le monitoring, ou sauter a des conclusions hâtives ! (blessures…)

Application

Efficacité de la phase d'entrainement ?

Second rôle du suivi de la charge : Prospectif

- Domaine ou l'on a le moins de recul…
- **Attention !** Les humains ne sont pas des robots

- Analyse de l'activité : besoins dans le développement des capacités de performance ?
  besoin de minimiser des variations soudaines de charge ? (ratios, variabilité de la charge)

- Développement des variables associées a la durabilité dans l'entrainement (rôle protecteur du volume)
- Tentative de prédiction de la fatigue résiduelle
- Approche rationnelle pour augmenter la précision dans l'organisation de l'entrainement
  => timing des entrainements ?
  => timing dans l'augmentation ou la diminution (affutage) de la charge ?
  => prise de risque ? Ex. Implémenter des variations soudaines de charge ?

Application

Principe : Efficacité du stimulus

1) implique que la charge doit dépasser un seuil déterminé pour permettre d'obtenir une amélioration de la capacité de performance.

2) dépend du niveau d'entrainement de l'athlète !

2bis) le stimulus doit correspondre au seuil de résistance / tolérance (physique + psychique)
= **individualisation du stimulus**

ex. développement de la force
Non-entrainé : besoin de ~30% de 1RM minimum
Entrainé : besoin d'au moins ~70% de la 1RM

Application

Principe : Progressivité de la charge

1) dépend de la capacité d'adaptation de l'organisme a la charge dans l'objectif de l'amélioration de la capacité de performance

2) augmentation progressive visant à + : condition physique, coordination motrice, ressources attentionnelles

3) dépend du niveau et de l'âge de la personne ! (+ périodisation)

- Charge : Volume, Intensité de l'exercice
- Charge bis : nature de la récupération (duree, active ou passive)
- Mode de contraction musculaire ou type de travail musculaire

- Qualité des coordinations motrices
- Nombre, niveau des compétitions

- Stratégie d'augmentation de la charge : linéaire ou par à-coups…

Application

Récapitulatif des variables (par ex. pour construire un Tableur excel…)

- **Durée** de l'effort, dans chaque discipline, par jour
- Mesure d'intensité = **%FC, sRPE**
- Le cas échéant, **kilométrage** dans chaque discipline
- Le cas échéant, **nombre** de lancers, de sauts…

- Charge journalière (**TRImp**)
- Charge aigue, charge chronique = ratios **ACWR**, **EWMA**
- Indices de variabilité de la charge : **Monotonie**, **Stimulus hebdomadaire**

- Mesure d'efficacité cardiovasculaire durant l'effort : **ICP**, perf au **HIMS**
- Mesure de **récupération de FC** post-effort (maximal), typiquement sur 1 min
- Mesure de fatigue accumulée : **RMSSD de FC** au réveil

Application

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- **PERFORMANCE** →

Sauts verticaux
Sprints
Sprints répétés
VO2max, Seuils

Précision des Passes, Tirs
Possession de balle
Cinématique
COD + Agilité

Application

Keep It Simple Stupid

mais avec une limite importante : ne pas utiliser un nombre faible d'outils…

"if all you have is a hammer, everything looks like a nail"

Proverbe

"Despite both the increasing amounts of research and the popularity of load monitoring in high-performance programs, a single definitive tool that is accurate and reliable is not evident"

Halson, 2014

…que l'on ne maitrise pas forcement

"Despite the increased interest in training-load quantification, research and practice seem to focus mostly on what is easy to measure rather than developing a holistic approach to the quantification of workloads experienced by athletes with particular reference to the biological responses."

Cardinale 2017

Application

Balance holistique (charge interne individuelle) vs. descriptive (charge externe)

"Sport scientists and coaches should be aware of the limitations of every device/method used."

"Although a wide range of metrics are available, practitioners should limit their use to those that they understand and that can affect their training program."

Cardinale 2017

"<u>If accurate and easy-to-interpret feedback is provided to the athlete and coach</u>, load monitoring can result in enhanced knowledge of training responses, aid in the design of training programs, provide a further avenue for communication between support staff and athletes and coaches and ultimately enhance an athlete's performance"

Halson, 2014

Application

Futures directions ?

Connaitre ses athletes de mieux en mieux
Questionnaires sur l'humeur, place de l'observation (tête dans le bol)

Veille technologique
Qualité du sommeil, fatigue mentale, amélioration Accéléromètrie

Recherche
Relation [charge x périodisation x variation (monotonie)] ???

Difficultés
Exécution du programme par les athlètes
Immense majorité de recherche sur population pas ou peu athlétiques
Très peu d'études longitudinales sur des athlètes de très haut niveau…