Hôpital
de
La Tour

swiss
olympic

Medical
Center

Journée annuelle ARPEM 2022

Fatigue & Sport

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Cas cliniques

H 49ans

Fatigue depuis 4 sem

Impression de baisse de performance avec augmentation de la difficulté pour un même effort

F 35ans

Fatigue globale depuis 3 mois

Chronos moins bons en compétition malgré intensification de l'entrainement

Plus souvent malade et irritable

F 20ans

Fatigue et troubles du sommeil depuis peu

Difficultés à tenir le rythme d'entrainement pour un objectif de marathon

Surcompensation

FOR

Fonctional Overreaching

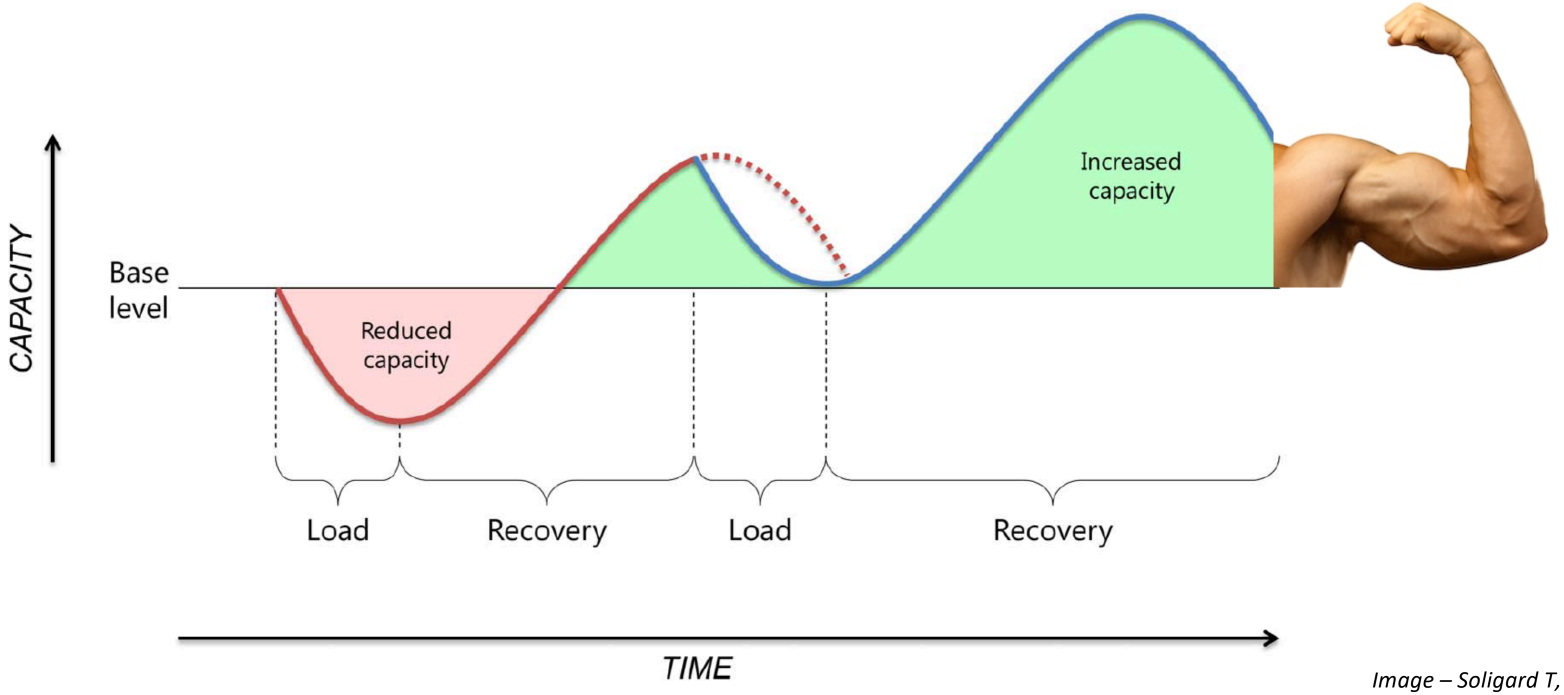

CAPACITY
Base level
Reduced capacity
Increased capacity
Load
Recovery
Load
Recovery
TIME

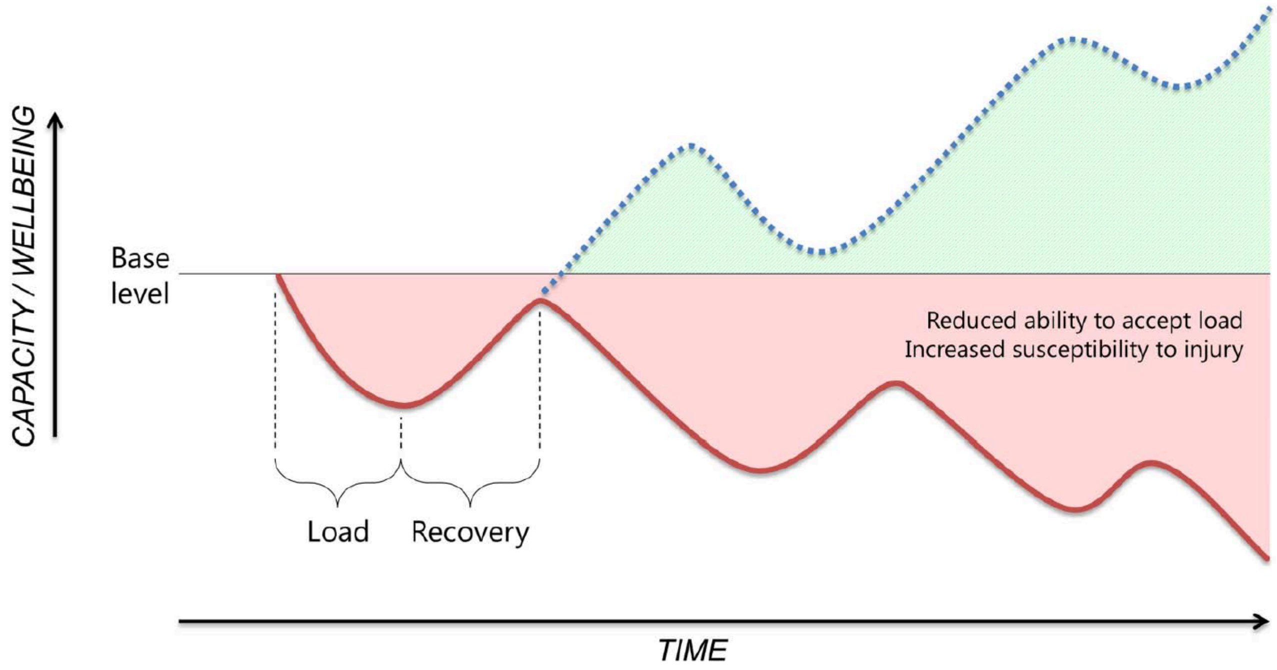
Image – Soligard T, et al. BJSM 2016

Surentrainement

FOR
Fonctional Overreaching

NFOR
Non-Fonctional Overreaching

OTS
Overtraining syndrome



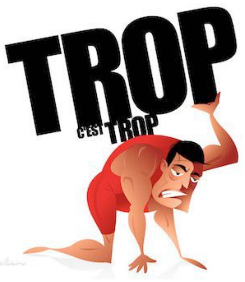
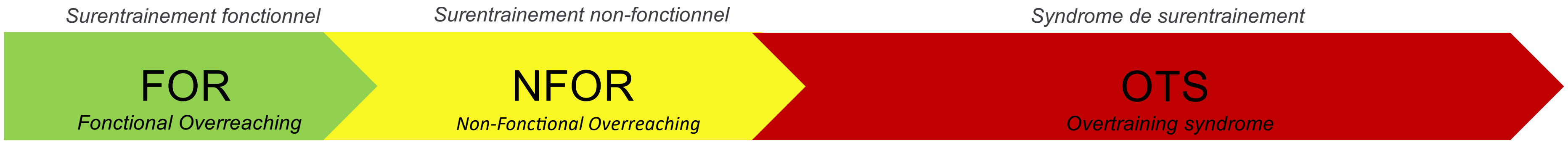


Image – Soligard T, et al. BJSM 2016

Définition



Surentrainement fonctionnel FOR *Fonctional Overreaching*	*Surentrainement non-fonctionnel* NFOR *Non-Fonctional Overreaching*	*Syndrome de surentrainement* OTS *Overtraining syndrome*
↓ Performance	↓ Performance	↓ Performance
Jours – 2 Semaines	2 Semaines – 2 Mois	>2 Mois
Surcompensation	~~Surcompensation~~	~~Surcompensation~~
	+/- signes physiques et/ou psychologiques	+/- signes physiques et/ou psychologiques
		Stresseur additionnel

Meeusen R, et al. Med Sci Sports Exerc 2013

Symptômes

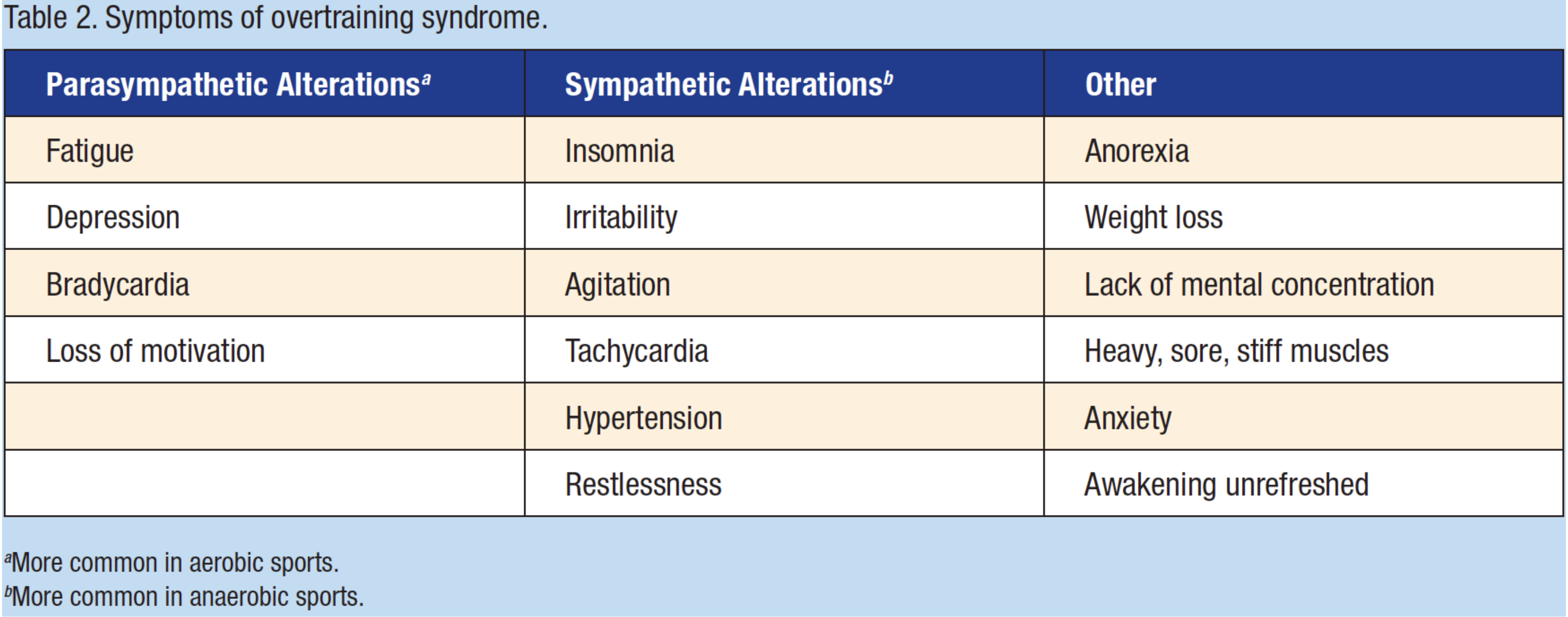


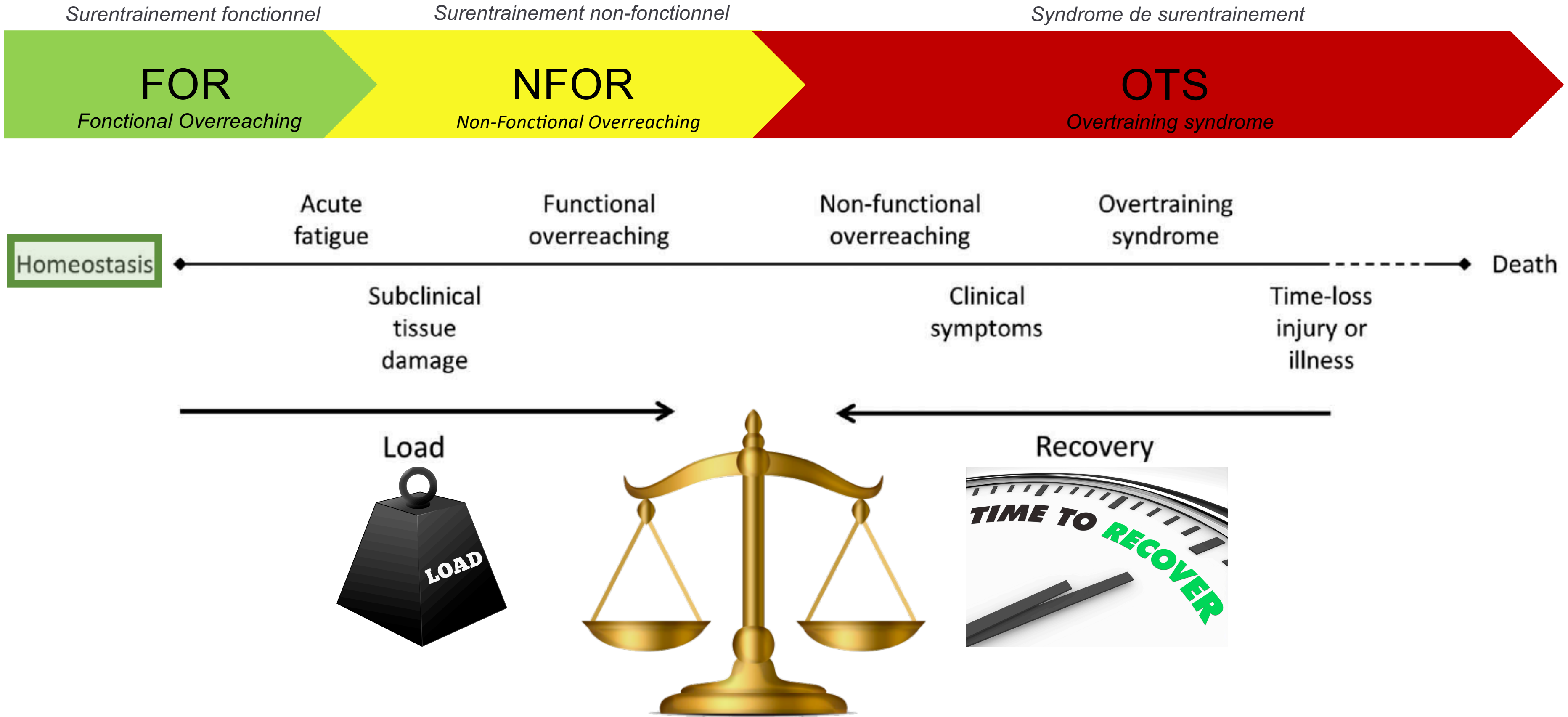
Table 2. Symptoms of overtraining syndrome.

Parasympathetic Alterations[a]	Sympathetic Alterations[b]	Other
Fatigue	Insomnia	Anorexia
Depression	Irritability	Weight loss
Bradycardia	Agitation	Lack of mental concentration
Loss of motivation	Tachycardia	Heavy, sore, stiff muscles
	Hypertension	Anxiety
	Restlessness	Awakening unrefreshed

[a] More common in aerobic sports.
[b] More common in anaerobic sports.

Kreher JB, et al. Sports Health 2012

Déséquilibre



Surentrainement fonctionnel

FOR

Fonctional Overreaching

Surentrainement non-fonctionnel

NFOR

Non-Fonctional Overreaching

Syndrome de surentrainement

OTS

Overtraining syndrome

Homeostasis

Acute fatigue

Subclinical tissue damage

Functional overreaching

Non-functional overreaching

Clinical symptoms

Overtraining syndrome

Time-loss injury or illness

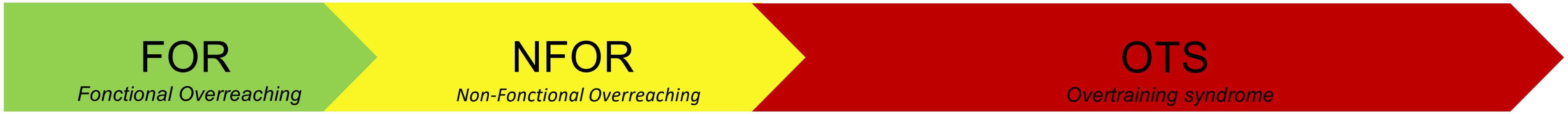
Death

Load

Recovery

Image – Soligard T, et al. BJSM 2016

Charge



Surentrainement fonctionnel

FOR

Fonctional Overreaching

Surentrainement non-fonctionnel

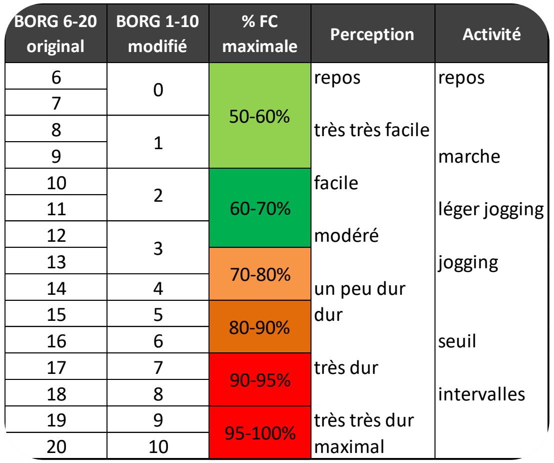
NFOR

Non-Fonctional Overreaching

Syndrome de surentrainement

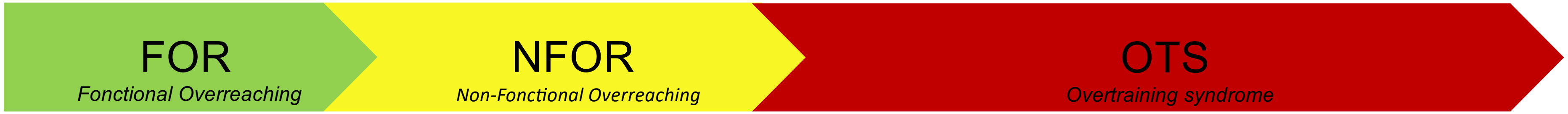
OTS

Overtraining syndrome



BORG 6-20 original	BORG 1-10 modifié	% FC maximale	Perception	Activité
6	0	🟩 50-60%	repos	repos
7				
8	1		très très facile	
9				marche
10	2	🟩 60-70%	facile	
11				léger jogging
12	3		modéré	
13		🟧 70-80%		jogging
14	4		un peu dur	
15	5	🟧 80-90%	dur	
16	6			seuil
17	7	🟥 90-95%	très dur	
18	8			intervalles
19	9	🟥 95-100%	très très dur	
20	10		maximal	

Récupérer de quoi? La fatigue



Surentrainement fonctionnel	*Surentrainement non-fonctionnel*	*Syndrome de surentrainement*
FOR *Fonctional Overreaching*	NFOR *Non-Fonctional Overreaching*	OTS *Overtraining syndrome*

TIME TO RECOVER

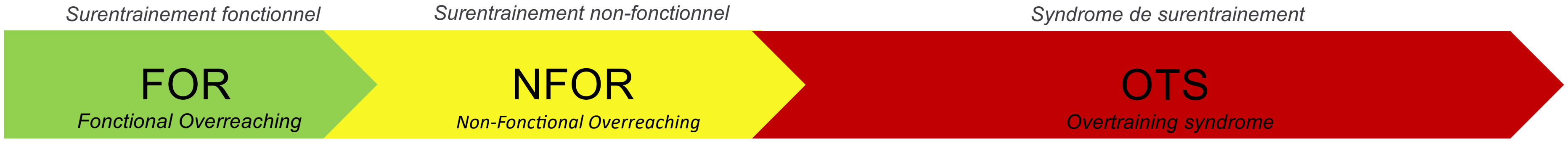
Réhydrater

Recharger/Restocker

Régénérer/Réparer

Ressourcer/Relaxer

Définition



Surentrainement fonctionnel

FOR

Fonctional Overreaching

Surentrainement non-fonctionnel

NFOR

Non-Fonctional Overreaching

Syndrome de surentrainement

OTS

Overtraining syndrome

↓ Performance	↓ Performance	↓ Performance
Jours – 2 Semaines	2 Semaines – 2 Mois	>2 Mois
Surcompensation	~~Surcompensation~~	~~Surcompensation~~
	+/- signes physiques et/ou psychologiques	+/- signes physiques et/ou psychologiques
		Stresseur additionnel

Meeusen R, et al. Med Sci Sports Exerc 2013

Triggers

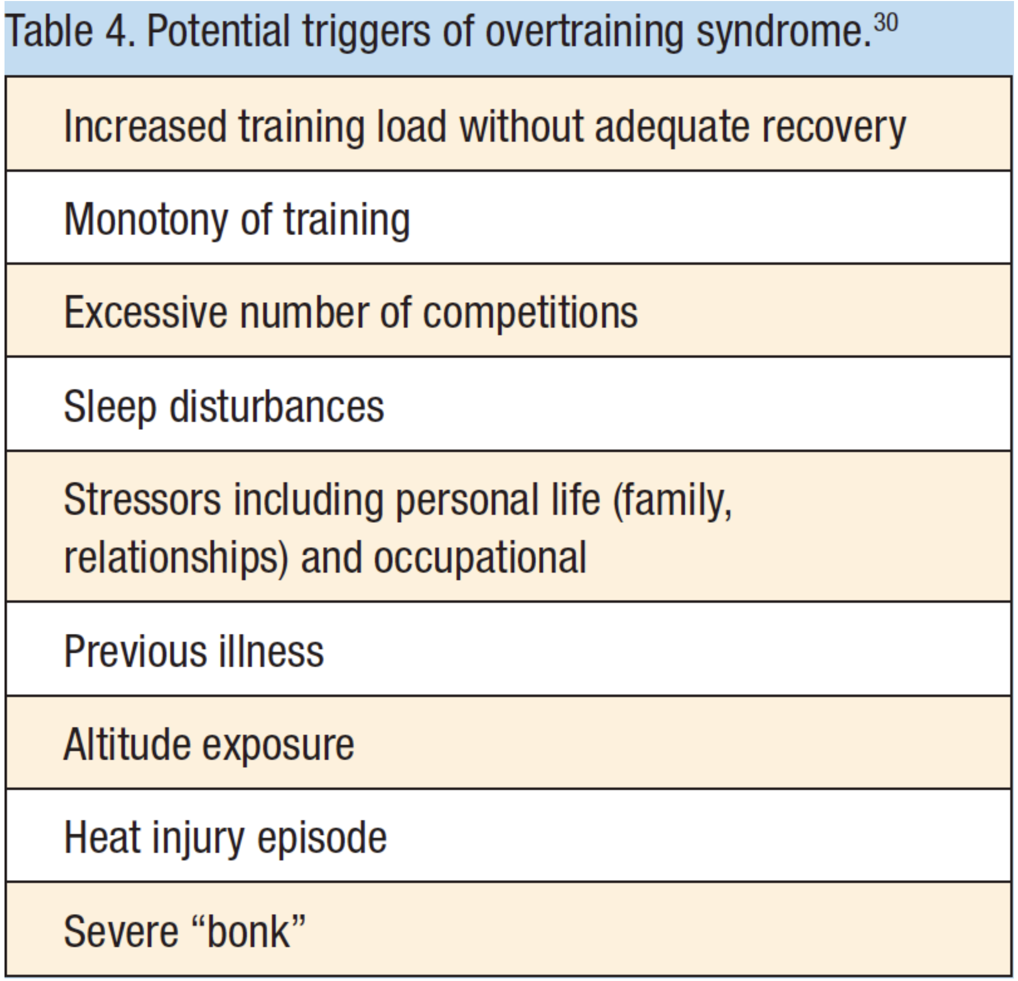


Table 4. Potential triggers of overtraining syndrome.[30]

Increased training load without adequate recovery
Monotony of training
Excessive number of competitions
Sleep disturbances
Stressors including personal life (family, relationships) and occupational
Previous illness
Altitude exposure
Heat injury episode
Severe “bonk”

Kreher JB, et al. Sports Health 2012

Cas cliniques

H 49ans

Charge:

- Course à pied 3x/sem
- Cyclisme 1-2x/sem
- Renforcement 1x/sem

Récupération:

- Pas de régime particulier
- Poids stable
- Sommeil bon

Triggers:

- Marié, 1 fils de 4ans
- Bureautique
- Cours d'aérobic 2x/sem et de danse chorégraphique

F 35ans

Charge:

- Athlétisme (demi-fond) 5x/sem, 60-120'
- ↑ intensité depuis 4sem

Récupération:

- Pas de régime particulier
- Poids stable
- Sommeil 6-7h/nuit

Triggers:

- Mariée, 2 enfants
- Entrepreneuse
- Stress au travail

F 20ans

Charge:

- Course à pied 5x/sem
- Natation 1x/sem
- Vélo pour déplacements

Récupération:

- Végétarienne mais fait attention à ses apports
- Réveils nocturnes, dort peu

Triggers:

- Etudiante EPFZ
- Période d'examens

Epidémiologie

Prévalence de 15-60% (OTS)

- 30% chez les athlètes d'endurance non-élites (NFOR/OTS)
- 60% chez les athlètes d'endurance élites (NFOR/OTS)
- Athlètes suisses: 9% de NFOR, 21% de OTS

Le plus souvent dans les sports:

- D'endurance (course à pied, cyclisme, natation)
- A demande physique moyenne à importante

Pas de différence:

- Sports individuels et d'équipe
- Femmes vs Hommes

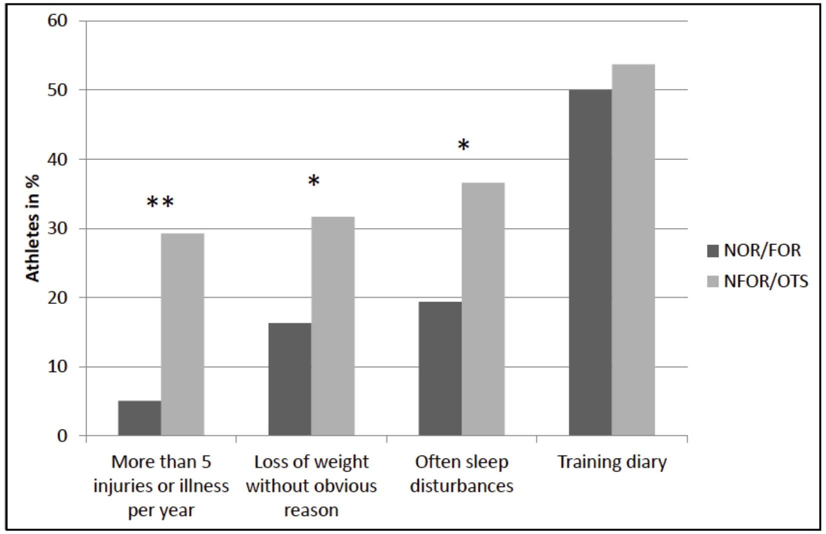


Figure 1: Accompanying symptoms of overreaching/overtraining for the NOR/FOR and NFOR/OTS groups. *Significant difference between groups ($p < .05$). **Significant difference between groups ($p < .01$).

Cadegiani FA, et al. BMJ Open Sport Exerc Med 2019
Cardoos N, et al. Curr Sports Med Rep 2015
Meeusen R, et al. Med Sci Sports Exerc 2013
Birrer D, et al. Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie 2013

Physiopathologie – Hypothèses

Glycogène/Dysbalance énergétique

Fatigue centrale/BCAA

Glutamine

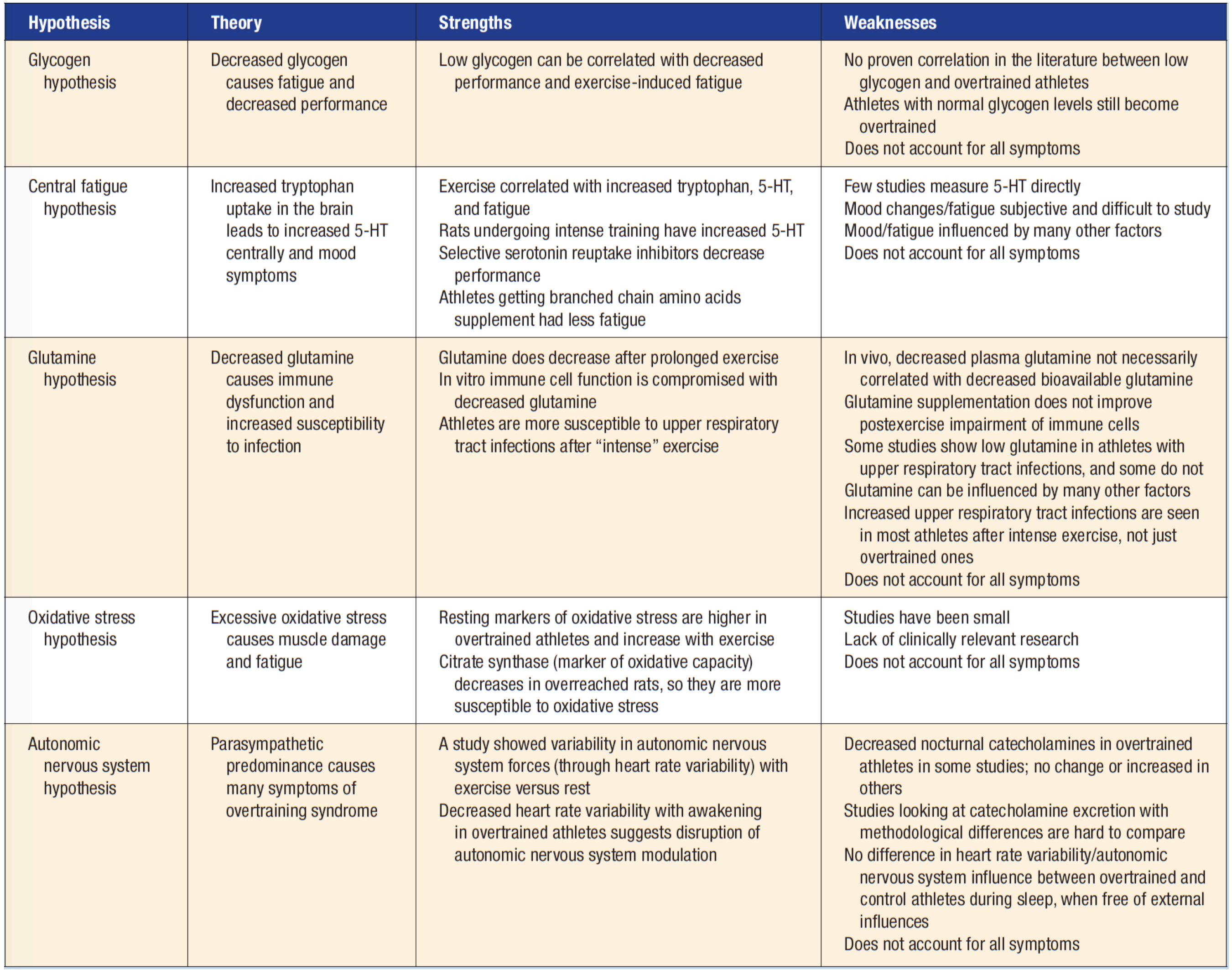
Stress oxydatif

Système nerveux autonome

Axe hypothalamo-hypophyso-surrénalien

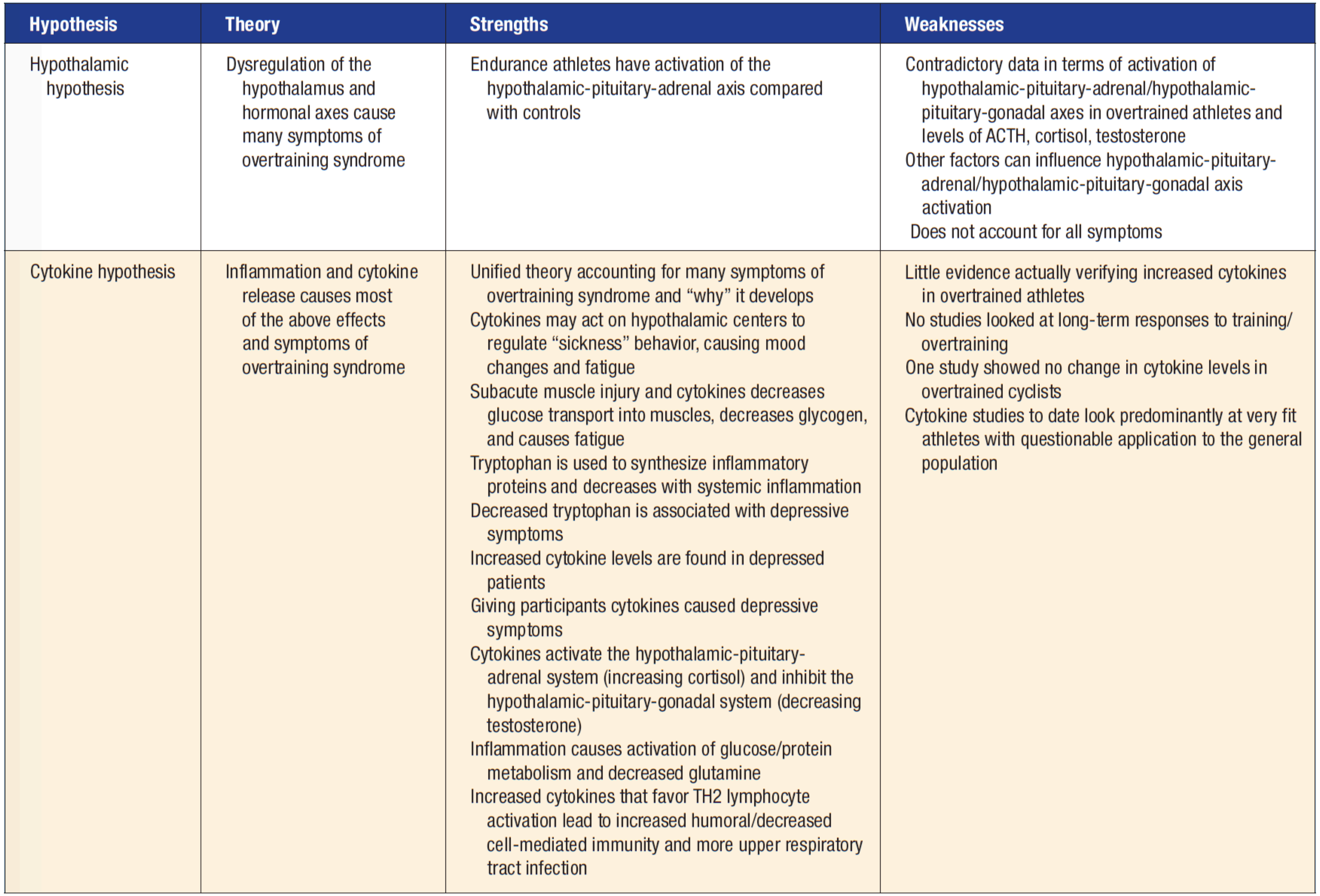
Cytokines/Inflammation

Dysfonction immunitaire



Hypothesis	Theory	Strengths	Weaknesses
Glycogen hypothesis	Decreased glycogen causes fatigue and decreased performance	Low glycogen can be correlated with decreased performance and exercise-induced fatigue	No proven correlation in the literature between low glycogen and overtrained athletes Athletes with normal glycogen levels still become overtrained Does not account for all symptoms
Central fatigue hypothesis	Increased tryptophan uptake in the brain leads to increased 5-HT centrally and mood symptoms	Exercise correlated with increased tryptophan, 5-HT, and fatigue Rats undergoing intense training have increased 5-HT Selective serotonin reuptake inhibitors decrease performance Athletes getting branched chain amino acids supplement had less fatigue	Few studies measure 5-HT directly Mood changes/fatigue subjective and difficult to study Mood/fatigue influenced by many other factors Does not account for all symptoms
Glutamine hypothesis	Decreased glutamine causes immune dysfunction and increased susceptibility to infection	Glutamine does decrease after prolonged exercise In vitro immune cell function is compromised with decreased glutamine Athletes are more susceptible to upper respiratory tract infections after “intense” exercise	In vivo, decreased plasma glutamine not necessarily correlated with decreased bioavailable glutamine Glutamine supplementation does not improve postexercise impairment of immune cells Some studies show low glutamine in athletes with upper respiratory tract infections, and some do not Glutamine can be influenced by many other factors Increased upper respiratory tract infections are seen in most athletes after intense exercise, not just overtrained ones Does not account for all symptoms
Oxidative stress hypothesis	Excessive oxidative stress causes muscle damage and fatigue	Resting markers of oxidative stress are higher in overtrained athletes and increase with exercise Citrate synthase (marker of oxidative capacity) decreases in overreached rats, so they are more susceptible to oxidative stress	Studies have been small Lack of clinically relevant research Does not account for all symptoms
Autonomic nervous system hypothesis	Parasympathetic predominance causes many symptoms of overtraining syndrome	A study showed variability in autonomic nervous system forces (through heart rate variability) with exercise versus rest Decreased heart rate variability with awakening in overtrained athletes suggests disruption of autonomic nervous system modulation	Decreased nocturnal catecholamines in overtrained athletes in some studies; no change or increased in others Studies looking at catecholamine excretion with methodological differences are hard to compare No difference in heart rate variability/autonomic nervous system influence between overtrained and control athletes during sleep, when free of external influences Does not account for all symptoms

Kreher JB, et al. Sports Health 2012



Hypothesis	Theory	Strengths	Weaknesses
Hypothalamic hypothesis	Dysregulation of the hypothalamus and hormonal axes cause many symptoms of overtraining syndrome	Endurance athletes have activation of the hypothalamic-pituitary-adrenal axis compared with controls	Contradictory data in terms of activation of hypothalamic-pituitary-adrenal/hypothalamic-pituitary-gonadal axes in overtrained athletes and levels of ACTH, cortisol, testosterone Other factors can influence hypothalamic-pituitary-adrenal/hypothalamic-pituitary-gonadal axis activation Does not account for all symptoms
Cytokine hypothesis	Inflammation and cytokine release causes most of the above effects and symptoms of overtraining syndrome	Unified theory accounting for many symptoms of overtraining syndrome and "why" it develops Cytokines may act on hypothalamic centers to regulate "sickness" behavior, causing mood changes and fatigue Subacute muscle injury and cytokines decreases glucose transport into muscles, decreases glycogen, and causes fatigue Tryptophan is used to synthesize inflammatory proteins and decreases with systemic inflammation Decreased tryptophan is associated with depressive symptoms Increased cytokine levels are found in depressed patients Giving participants cytokines caused depressive symptoms Cytokines activate the hypothalamic-pituitary-adrenal system (increasing cortisol) and inhibit the hypothalamic-pituitary-gonadal system (decreasing testosterone) Inflammation causes activation of glucose/protein metabolism and decreased glutamine Increased cytokines that favor TH2 lymphocyte activation lead to increased humoral/decreased cell-mediated immunity and more upper respiratory tract infection	Little evidence actually verifying increased cytokines in overtrained athletes No studies looked at long-term responses to training/overtraining One study showed no change in cytokine levels in overtrained cyclists Cytokine studies to date look predominantly at very fit athletes with questionable application to the general population

Kreher JB, et al. Sports Health 2012

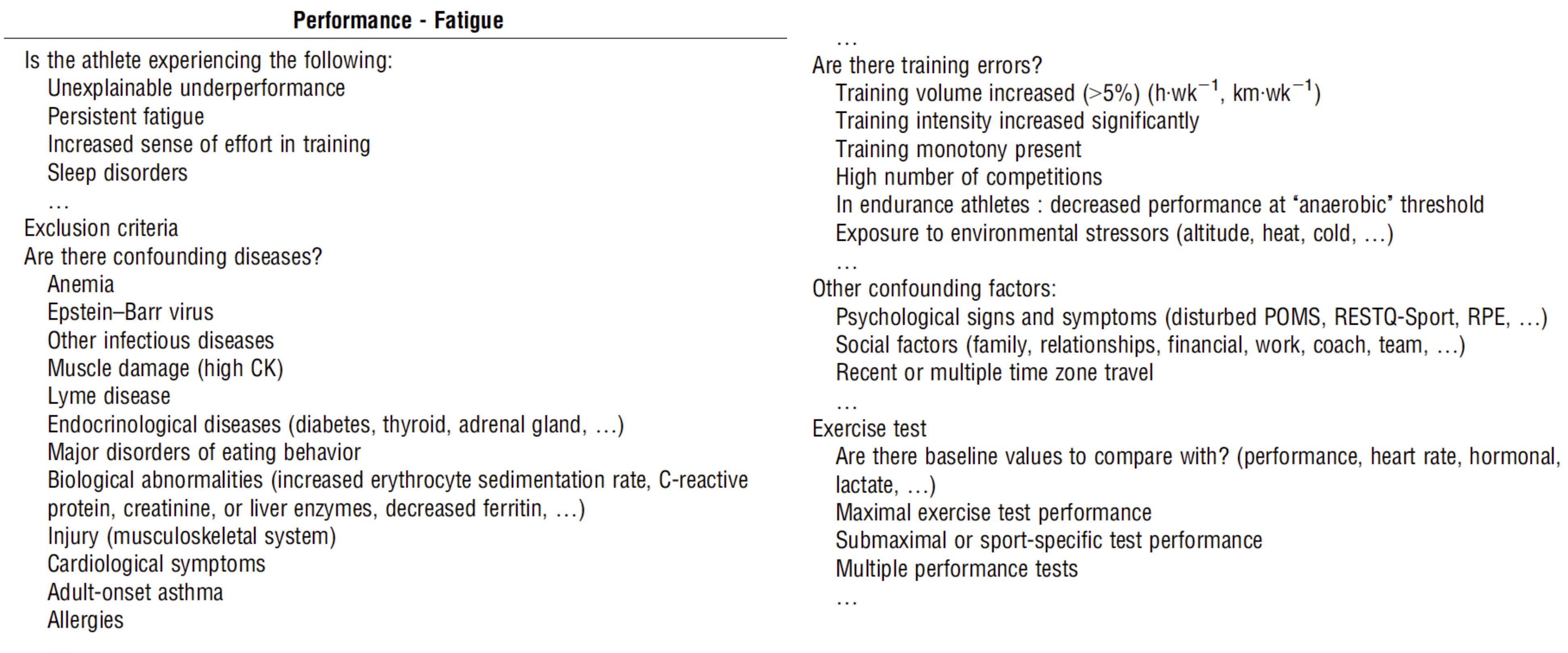
Diagnostic

1. Perte de performance sport-spécifique malgré un repos adéquat de 14-21 jours
2. Des signes et symptômes physiques +/- psychologiques compatibles
3. Absence d'autre cause → Diagnostic d'exclusion!
   - Maladies infectieuses, métaboliques, cardio-vasculaires, respiratoires, hématologiques, immunologiques, endocriniennes, …
   - Troubles du sommeil
   - Troubles du comportement alimentaire
   - Affections psychiatriques

Carfagno DG, et al. Curr Sports Med Rep 2014

Diagnostic

TABLE 1. Diagnosis of OTS—checklist.



Performance - Fatigue

Is the athlete experiencing the following:
  - Unexplainable underperformance
  - Persistent fatigue
  - Increased sense of effort in training
  - Sleep disorders
  - …

Exclusion criteria

Are there confounding diseases?
  - Anemia
  - Epstein–Barr virus
  - Other infectious diseases
  - Muscle damage (high CK)
  - Lyme disease
  - Endocrinological diseases (diabetes, thyroid, adrenal gland, …)
  - Major disorders of eating behavior
  - Biological abnormalities (increased erythrocyte sedimentation rate, C-reactive protein, creatinine, or liver enzymes, decreased ferritin, …)
  - Injury (musculoskeletal system)
  - Cardiological symptoms
  - Adult-onset asthma
  - Allergies
  - …

Are there training errors?
  - Training volume increased (>5%) ($h{\cdot}wk^{-1}$, $km{\cdot}wk^{-1}$)
  - Training intensity increased significantly
  - Training monotony present
  - High number of competitions
  - In endurance athletes : decreased performance at ‘anaerobic’ threshold
  - Exposure to environmental stressors (altitude, heat, cold, …)
  - …

Other confounding factors:
  - Psychological signs and symptoms (disturbed POMS, RESTQ-Sport, RPE, …)
  - Social factors (family, relationships, financial, work, coach, team, …)
  - Recent or multiple time zone travel
  - …

Exercise test
  - Are there baseline values to compare with? (performance, heart rate, hormonal, lactate, …)
  - Maximal exercise test performance
  - Submaximal or sport-specific test performance
  - Multiple performance tests
  - …

Meeusen R, et al. Med Sci Sports Exerc 2013

Diagnostic – Test de performance

Altération de paramètres physiologiques

- ↓ du time to fatigue
- ↓ VO2max

Altération de paramètres physiologiques CV

- ↓ FC sub max
- ↓ FC max

Biomarqueurs

- ↓ production max de lactate sanguin

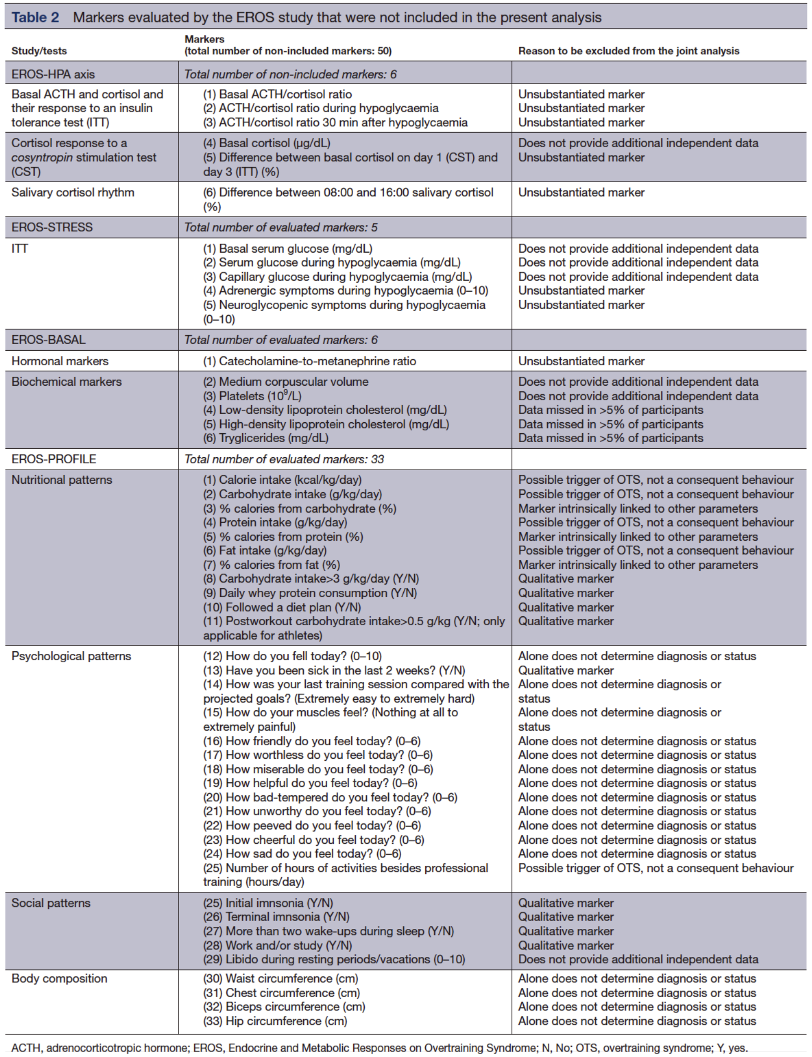


Table 2 Markers evaluated by the EROS study that were not included in the present analysis

Study/tests	Markers (total number of non-included markers: 50)	Reason to be excluded from the joint analysis
EROS-HPA axis	*Total number of non-included markers: 6*	
Basal ACTH and cortisol and their response to an insulin tolerance test (ITT)	(1) Basal ACTH/cortisol ratio (2) ACTH/cortisol ratio during hypoglycaemia (3) ACTH/cortisol ratio 30 min after hypoglycaemia	Unsubstantiated marker Unsubstantiated marker Unsubstantiated marker
Cortisol response to a *cosyntropin* stimulation test (CST)	(4) Basal cortisol (µg/dL) (5) Difference between basal cortisol on day 1 (CST) and day 3 (ITT) (%)	Does not provide additional independent data Unsubstantiated marker
Salivary cortisol rhythm	(6) Difference between 08:00 and 16:00 salivary cortisol (%)	Unsubstantiated marker
EROS-STRESS	*Total number of evaluated markers: 5*	
ITT	(1) Basal serum glucose (mg/dL) (2) Serum glucose during hypoglycaemia (mg/dL) (3) Capillary glucose during hypoglycaemia (mg/dL) (4) Adrenergic symptoms during hypoglycaemia (0–10) (5) Neuroglycopenic symptoms during hypoglycaemia (0–10)	Does not provide additional independent data Does not provide additional independent data Does not provide additional independent data Unsubstantiated marker Unsubstantiated marker
EROS-BASAL	*Total number of evaluated markers: 6*	
Hormonal markers	(1) Catecholamine-to-metanephrine ratio	Unsubstantiated marker
Biochemical markers	(2) Medium corpuscular volume (3) Platelets (10^9/L) (4) Low-density lipoprotein cholesterol (mg/dL) (5) High-density lipoprotein cholesterol (mg/dL) (6) Tryglicerides (mg/dL)	Does not provide additional independent data Does not provide additional independent data Data missed in >5% of participants Data missed in >5% of participants Data missed in >5% of participants
EROS-PROFILE	*Total number of evaluated markers: 33*	
Nutritional patterns	(1) Calorie intake (kcal/kg/day) (2) Carbohydrate intake (g/kg/day) (3) % calories from carbohydrate (%) (4) Protein intake (g/kg/day) (5) % calories from protein (%) (6) Fat intake (g/kg/day) (7) % calories from fat (%) (8) Carbohydrate intake>3 g/kg/day (Y/N) (9) Daily whey protein consumption (Y/N) (10) Followed a diet plan (Y/N) (11) Postworkout carbohydrate intake>0.5 g/kg (Y/N; only applicable for athletes)	Possible trigger of OTS, not a consequent behaviour Possible trigger of OTS, not a consequent behaviour Marker intrinsically linked to other parameters Possible trigger of OTS, not a consequent behaviour Marker intrinsically linked to other parameters Possible trigger of OTS, not a consequent behaviour Marker intrinsically linked to other parameters Qualitative marker Qualitative marker Qualitative marker Qualitative marker
Psychological patterns	(12) How do you fell today? (0–10) (13) Have you been sick in the last 2 weeks? (Y/N) (14) How was your last training session compared with the projected goals? (Extremely easy to extremely hard) (15) How do your muscles feel? (Nothing at all to extremely painful) (16) How friendly do you feel today? (0–6) (17) How worthless do you feel today? (0–6) (18) How miserable do you feel today? (0–6) (19) How helpful do you feel today? (0–6) (20) How bad-tempered do you feel today? (0–6) (21) How unworthy do you feel today? (0–6) (22) How peeved do you feel today? (0–6) (23) How cheerful do you feel today? (0–6) (24) How sad do you feel today? (0–6) (25) Number of hours of activities besides professional training (hours/day)	Alone does not determine diagnosis or status Qualitative marker Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Possible trigger of OTS, not a consequent behaviour
Social patterns	(25) Initial imnsonia (Y/N) (26) Terminal imnsonia (Y/N) (27) More than two wake-ups during sleep (Y/N) (28) Work and/or study (Y/N) (29) Libido during resting periods/vacations (0–10)	Qualitative marker Qualitative marker Qualitative marker Qualitative marker Does not provide additional independent data
Body composition	(30) Waist circumference (cm) (31) Chest circumference (cm) (32) Biceps circumference (cm) (33) Hip circumference (cm)	Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status Alone does not determine diagnosis or status

ACTH, adrenocorticotropic hormone; EROS, Endocrine and Metabolic Responses on Overtraining Syndrome; N, No; OTS, overtraining syndrome; Y, yes.

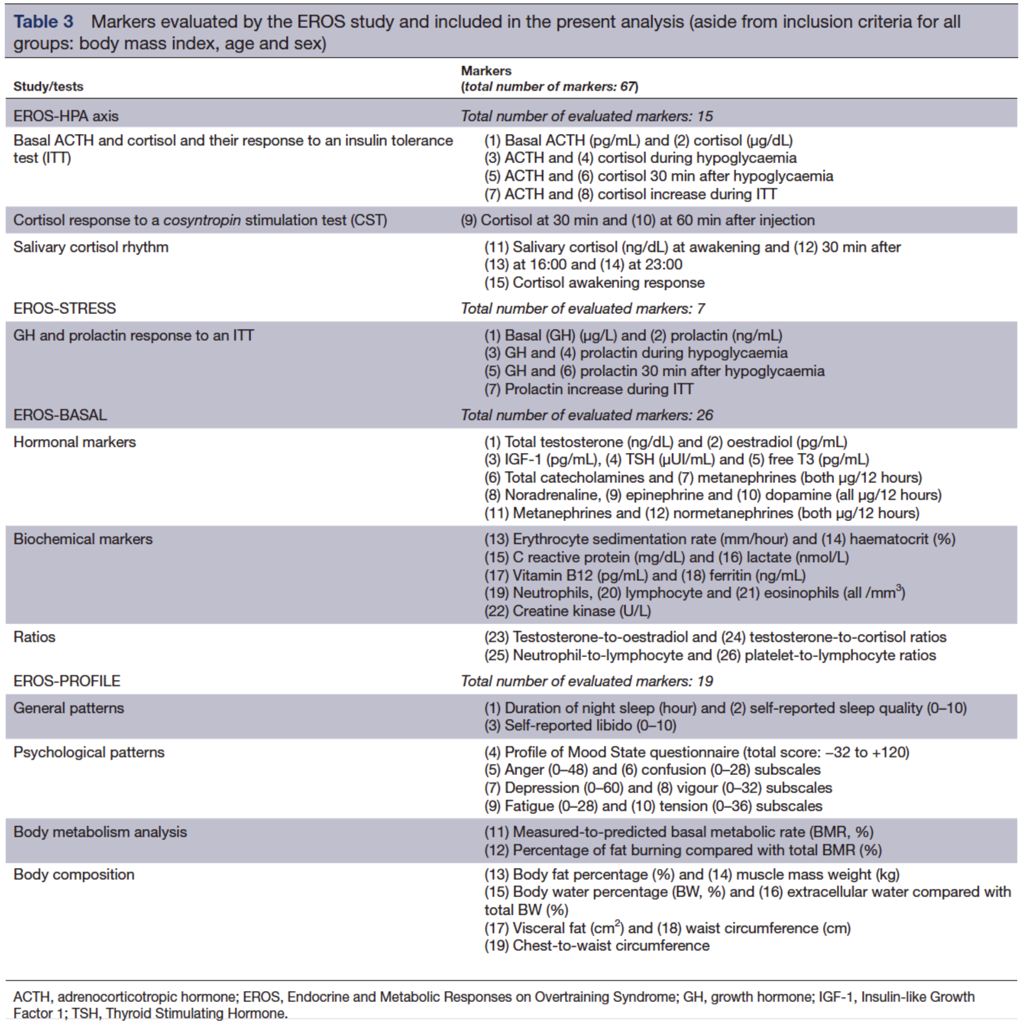


Table 3 Markers evaluated by the EROS study and included in the present analysis (aside from inclusion criteria for all groups: body mass index, age and sex)

Study/tests	Markers (*total number of markers: 67*)
EROS-HPA axis	*Total number of evaluated markers: 15*
Basal ACTH and cortisol and their response to an insulin tolerance test (ITT)	(1) Basal ACTH (pg/mL) and (2) cortisol (µg/dL) (3) ACTH and (4) cortisol during hypoglycaemia (5) ACTH and (6) cortisol 30 min after hypoglycaemia (7) ACTH and (8) cortisol increase during ITT
Cortisol response to a *cosyntropin* stimulation test (CST)	(9) Cortisol at 30 min and (10) at 60 min after injection
Salivary cortisol rhythm	(11) Salivary cortisol (ng/dL) at awakening and (12) 30 min after (13) at 16:00 and (14) at 23:00 (15) Cortisol awakening response
EROS-STRESS	*Total number of evaluated markers: 7*
GH and prolactin response to an ITT	(1) Basal (GH) (µg/L) and (2) prolactin (ng/mL) (3) GH and (4) prolactin during hypoglycaemia (5) GH and (6) prolactin 30 min after hypoglycaemia (7) Prolactin increase during ITT
EROS-BASAL	*Total number of evaluated markers: 26*
Hormonal markers	(1) Total testosterone (ng/dL) and (2) oestradiol (pg/mL) (3) IGF-1 (pg/mL), (4) TSH (µUI/mL) and (5) free T3 (pg/mL) (6) Total catecholamines and (7) metanephrines (both µg/12 hours) (8) Noradrenaline, (9) epinephrine and (10) dopamine (all µg/12 hours) (11) Metanephrines and (12) normetanephrines (both µg/12 hours)
Biochemical markers	(13) Erythrocyte sedimentation rate (mm/hour) and (14) haematocrit (%) (15) C reactive protein (mg/dL) and (16) lactate (nmol/L) (17) Vitamin B12 (pg/mL) and (18) ferritin (ng/mL) (19) Neutrophils, (20) lymphocyte and (21) eosinophils (all /mm^3) (22) Creatine kinase (U/L)
Ratios	(23) Testosterone-to-oestradiol and (24) testosterone-to-cortisol ratios (25) Neutrophil-to-lymphocyte and (26) platelet-to-lymphocyte ratios
EROS-PROFILE	*Total number of evaluated markers: 19*
General patterns	(1) Duration of night sleep (hour) and (2) self-reported sleep quality (0–10) (3) Self-reported libido (0–10)
Psychological patterns	(4) Profile of Mood State questionnaire (total score: –32 to +120) (5) Anger (0–48) and (6) confusion (0–28) subscales (7) Depression (0–60) and (8) vigour (0–32) subscales (9) Fatigue (0–28) and (10) tension (0–36) subscales
Body metabolism analysis	(11) Measured-to-predicted basal metabolic rate (BMR, %) (12) Percentage of fat burning compared with total BMR (%)
Body composition	(13) Body fat percentage (%) and (14) muscle mass weight (kg) (15) Body water percentage (BW, %) and (16) extracellular water compared with total BW (%) (17) Visceral fat (cm^2) and (18) waist circumference (cm) (19) Chest-to-waist circumference

ACTH, adrenocorticotropic hormone; EROS, Endocrine and Metabolic Responses on Overtraining Syndrome; GH, growth hormone; IGF-1, Insulin-like Growth Factor 1; TSH, Thyroid Stimulating Hormone.

Cadegiani FA, et al. BMJ Open Sport Exerc Med 2019

Diagnostic – Biomarqueurs

Pas de bon biomarqueur pour le diagnostic de NFOR et OTS

Repos: ↑ CK

A l’exercice: ↓ production max de lactate sanguin à l’exercice

Post-exercice: ⦸ ↑ de la prolactine, l’ACTH, la GH, du cortisol

Diagnostic

Test de performance

Altération de paramètres physiologiques CV

Biomarqueurs (lactate)

Perturbations de l'humeur

Diagnostic – Perturbations de l'humeur

Profile of Mood States (POMS)

- 65 items: fatigue, vitalité, irritabilité, dépression, anxiété/tension, confusion

Daily Analysis of Life Demands for Athletes (DALDA)

Recovery-stress questionnaire for athletes (REST-Q)

- 77 items: stress général, stress émotionnel, stress social, conflits/pression, fatigue, manque d'énergie, plaintes physiques, récupération, stress spécifiques au sport

Training Distress Scale (TDS)

- 7 items: dépression, irritabilité

Questionnaire de dépistage Société Française de Médecine du Sport

Diagnostic – Perturbations de l'humeur

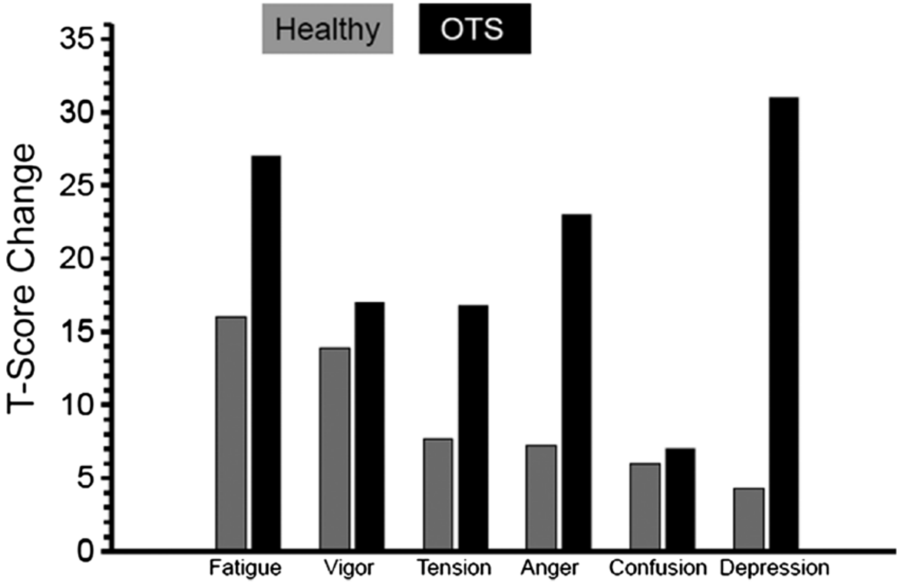


FIGURE 2—Magnitude of changes in POMS mood states from easy to maximal overload training in collegiate varsity swimmers who develop OTS or remain free of symptoms (i.e., "healthy"). (Adapted from Raglin and Morgan [114]).

Meeusen R, et al. Med Sci Sports Exerc 2013

Diagnostic

Test de performance

Altération de paramètres physiologiques CV

Biomarqueurs (lactate)

Perturbations de l’humeur (POMS)

Altérations du métabolisme de base / de la composition corporelle

Atteinte de l’axe hypothalamo-hypophysaire (TOP test)

Titre

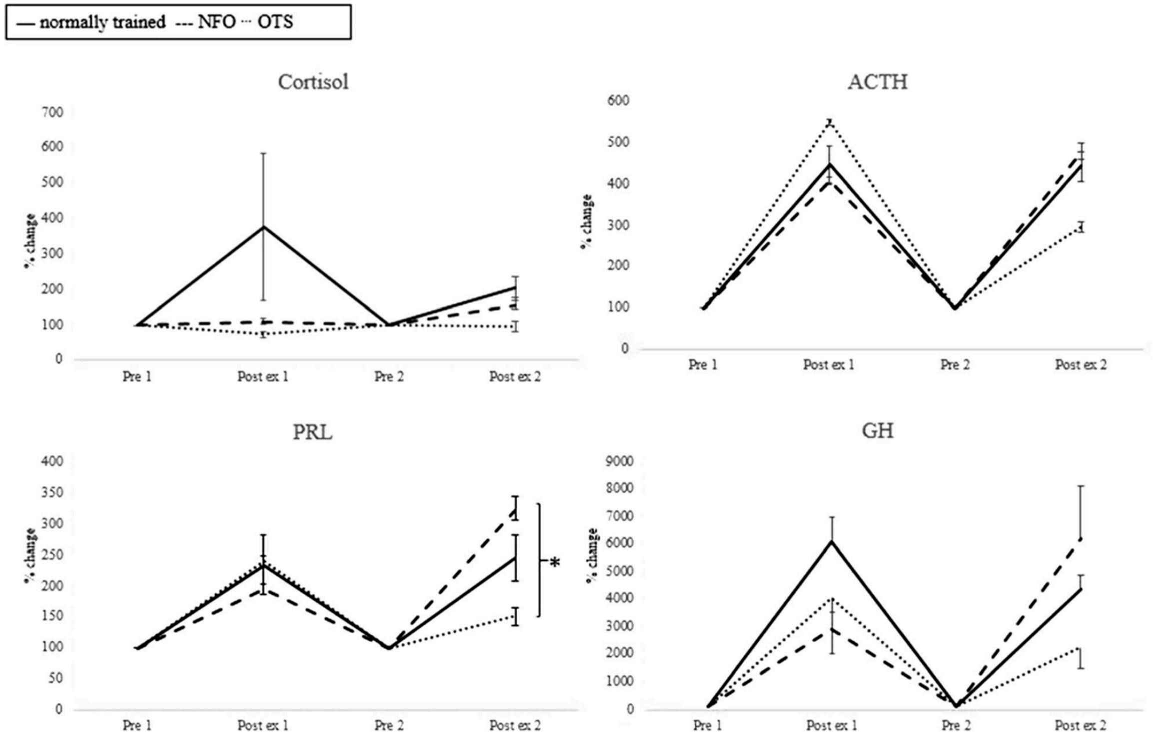


FIGURE 1—Relative changes of cortisol, ACTH, PRL and GH responses to the TOP test for normally trained (*solid lines*), NFO (*dashed lines*) and OTS (*pointed lines*) group. Data are presented as percentage increase from both baseline values (SE) of the mean. *Significant main effect of diagnosis $P < 0.05$.

TABLE 1. Sensitivity for detecting NFO vs OTS based on the cutoff values determined by Meeusen et al. (3).

Measure	**Cutoff for OTS**	**OTS (*n* = 15)**	**NFO (*n* = 39)**
Cortisol response to second exercise test	<200% increase*	93% [80%*]	15% [60%*]
ACTH response to second exercise test	<200% increase*	67% [80%*]	74% [80%*]
PRL response to second exercise test	<200% increase*	93% [100%*]	74% [100%*]
GH response to second exercise test	<1000% increase*	47% [40%*]	62% [40%*]

*Cutoff values by Meeusen et al. (3).

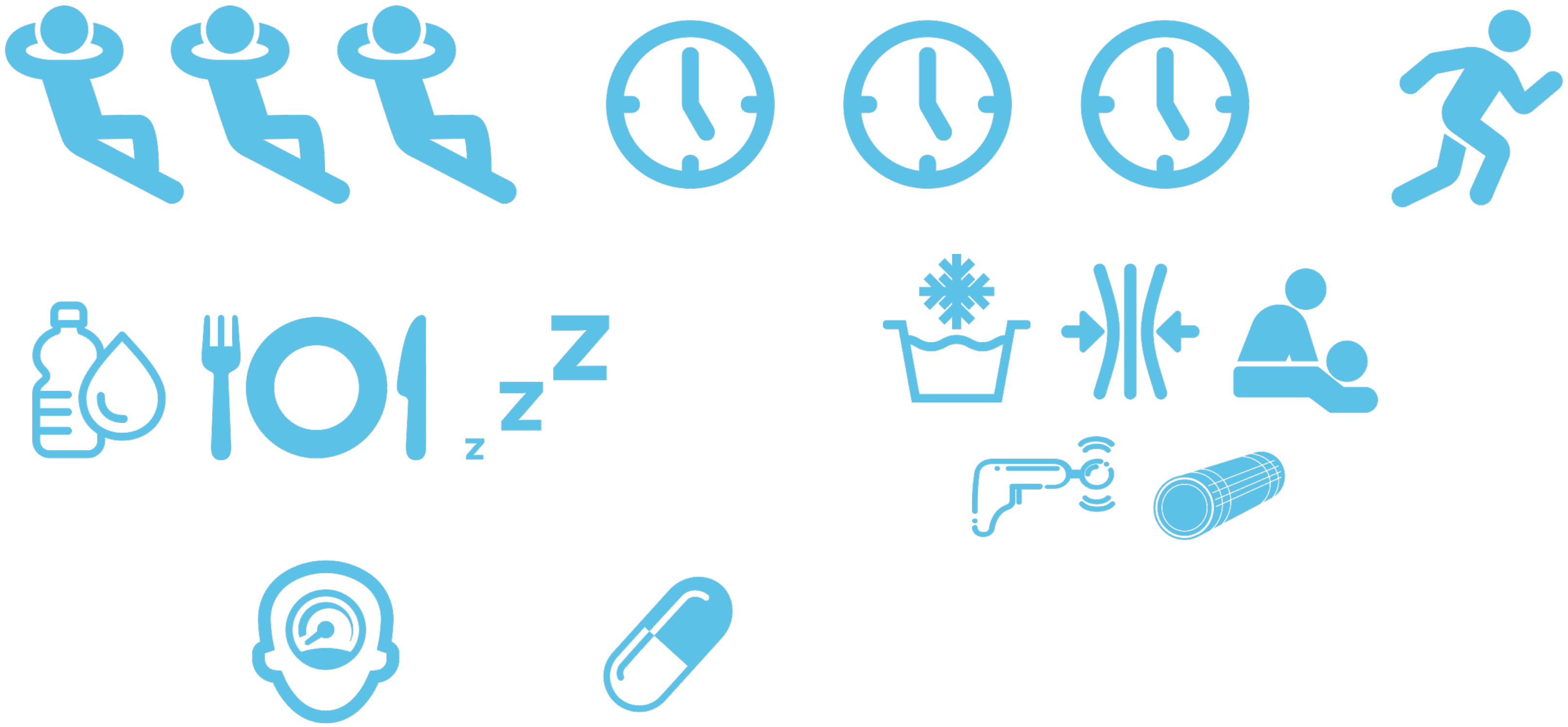
Buyse L, et al. Med Sci Sports Exerc 2019

Diagnostic

1. Perte de performance sport-spécifique malgré un repos adéquat de 14-21 jours
2. Des signes et symptômes physiques +/- psychologiques compatibles
3. Absence d'autre cause → Diagnostic d'exclusion!
4. Examens paracliniques

- Test de performance
- Altération de paramètres physiologiques CV
- Biomarqueurs (lactate)
- Troubles de l'humeur (POMS)
- Altérations du métabolisme de base / de la composition corporelle
- Atteinte de l'axe hypothalamo-hypophysaire (TOP test)

Traitement



Cas cliniques

H 49ans

Repos:

- Quelques jours off

Éducation:

- Gestion de la charge
- Périodisation
- Stratégies de récupération

F 35ans

Repos

Éducation

Multiples stresseurs:

- Famille, travail
- Alimentation:
  - Shake multivitaminé comme petit déjeuner
  - Repas « légers » sans protéines et peu de féculents
  - Quasi pas de produits laitiers

F 20ans

Repos

Éducation

Multiples stresseurs:

- Trajets
- Période d'examens
- Alimentation pas tout à fait optimale

Mesures préventives

Education

- Planification et périodisation de l'entrainement
- Variations importantes de charges et monotonie = facteurs de risque

Récupération adéquate

- Hydratation, alimentation (CHO, PRO), sommeil, repos
- Monitoring de l'équilibre charge-récupération

Screening médical

- Entrainement, récupération, humeur, stresseurs personnels

Table 5. Preventative measures for nonfunctional overreaching/overtraining syndrome.[2,44]

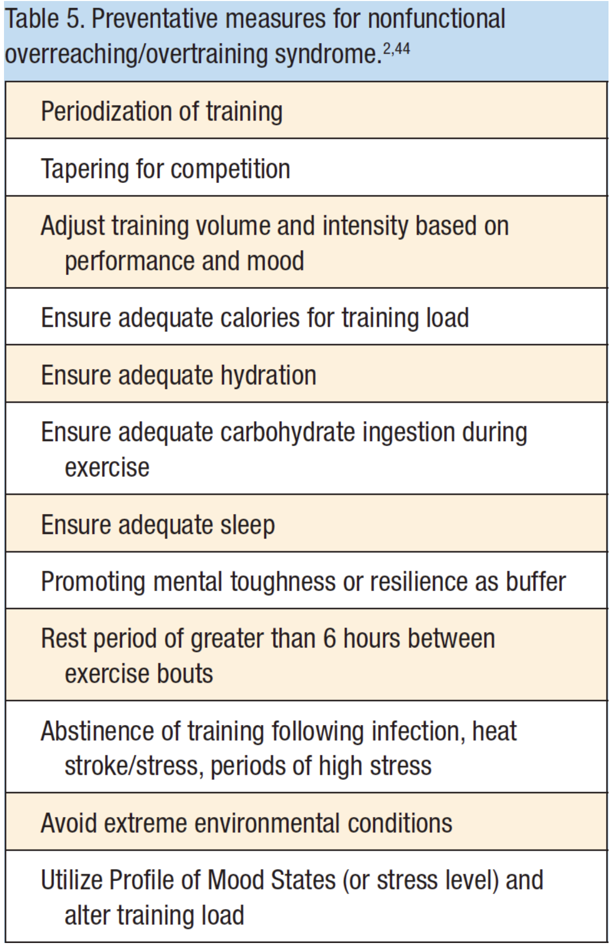
Periodization of training
Tapering for competition
Adjust training volume and intensity based on performance and mood
Ensure adequate calories for training load
Ensure adequate hydration
Ensure adequate carbohydrate ingestion during exercise
Ensure adequate sleep
Promoting mental toughness or resilience as buffer
Rest period of greater than 6 hours between exercise bouts
Abstinence of training following infection, heat stroke/stress, periods of high stress
Avoid extreme environmental conditions
Utilize Profile of Mood States (or stress level) and alter training load

Kreher JB, et al. Sports Health 2012

Mesures préventives

Monitoring de certains paramètres

- Charge subjective (méthode Foster)
- FC à l’effort
- Questionnaires psychologiques (POMS) - 1x/mois
- Mesure de performance avec lactatémie - 1x/trimestre
- Métabolisme de base, ou données anthropométriques
- Eventuels biomarqueurs, hormones (?)
- Tests psychomoteurs ralentis (?)



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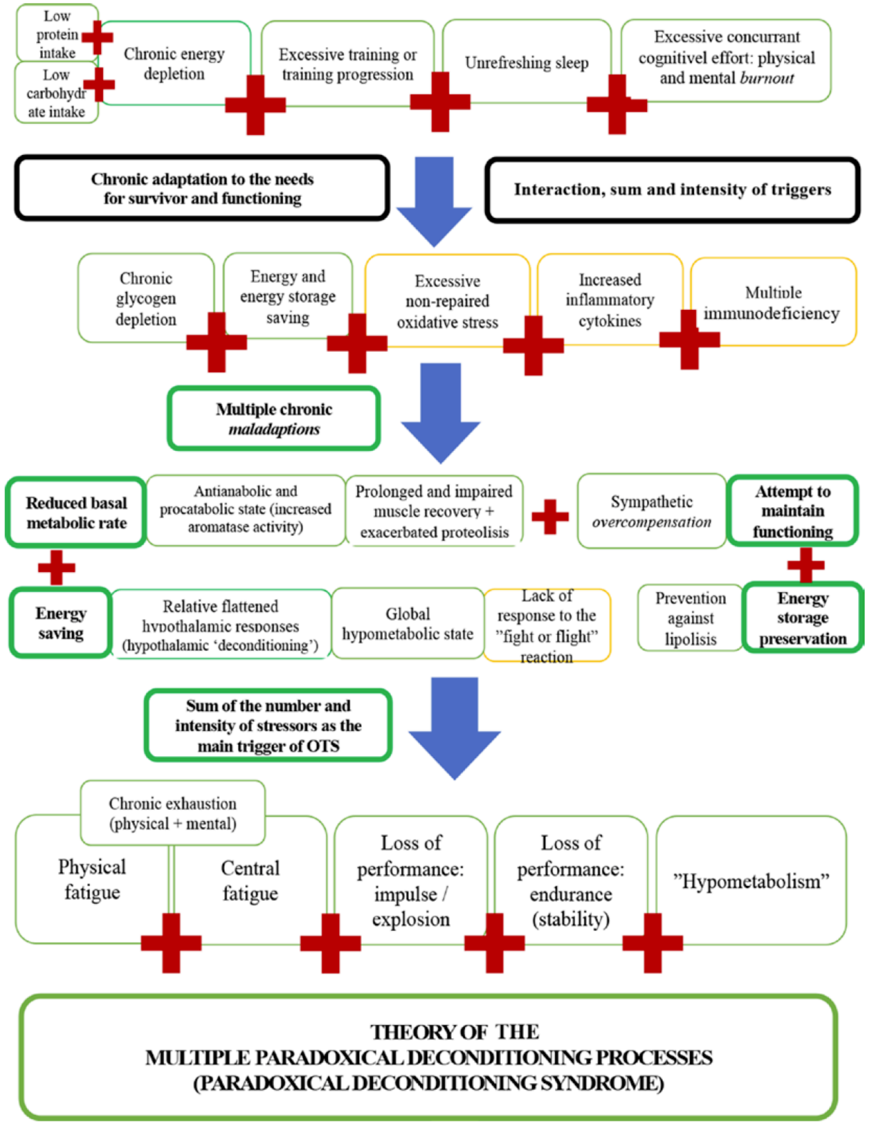

Low protein intake
Low carbohydrate intake
Chronic energy depletion
Excessive training or training progression
Unrefreshing sleep
Excessive concurrent cognitivel effort: physical and mental *burnout*
Chronic adaptation to the needs for survivor and functioning
Interaction, sum and intensity of triggers
Chronic glycogen depletion
Energy and energy storage saving
Excessive non-repaired oxidative stress
Increased inflammatory cytokines
Multiple immunodeficiency
Multiple chronic *maladaptions*
Reduced basal metabolic rate
Antianabolic and procatabolic state (increased aromatase activity)
Prolonged and impaired muscle recovery + exacerbated proteolisis
Sympathetic *overcompensation*
Attempt to maintain functioning
Energy saving
Relative flattened hypothalamic responses (hypothalamic 'deconditioning')
Global hypometabolic state
Lack of response to the "fight or flight" reaction
Prevention against lipolisis
Energy storage preservation
Sum of the number and intensity of stressors as the main trigger of OTS
Chronic exhaustion (physical + mental)
Physical fatigue
Central fatigue
Loss of performance: impulse / explosion
Loss of performance: endurance (stability)
"Hypometabolism"
THEORY OF THE MULTIPLE PARADOXICAL DECONDITIONING PROCESSES (PARADOXICAL DECONDITIONING SYNDROME)

Figure 4 Triggers, pathophysiology and consequences of overtraining syndrome (OTS).

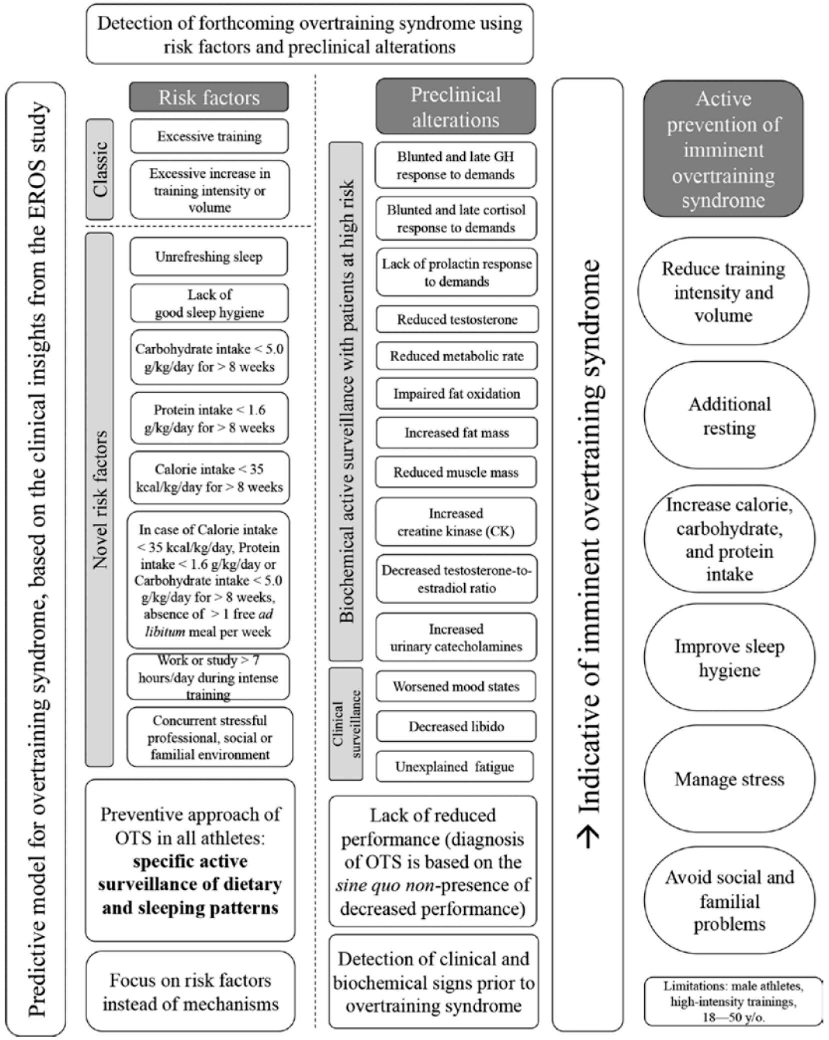
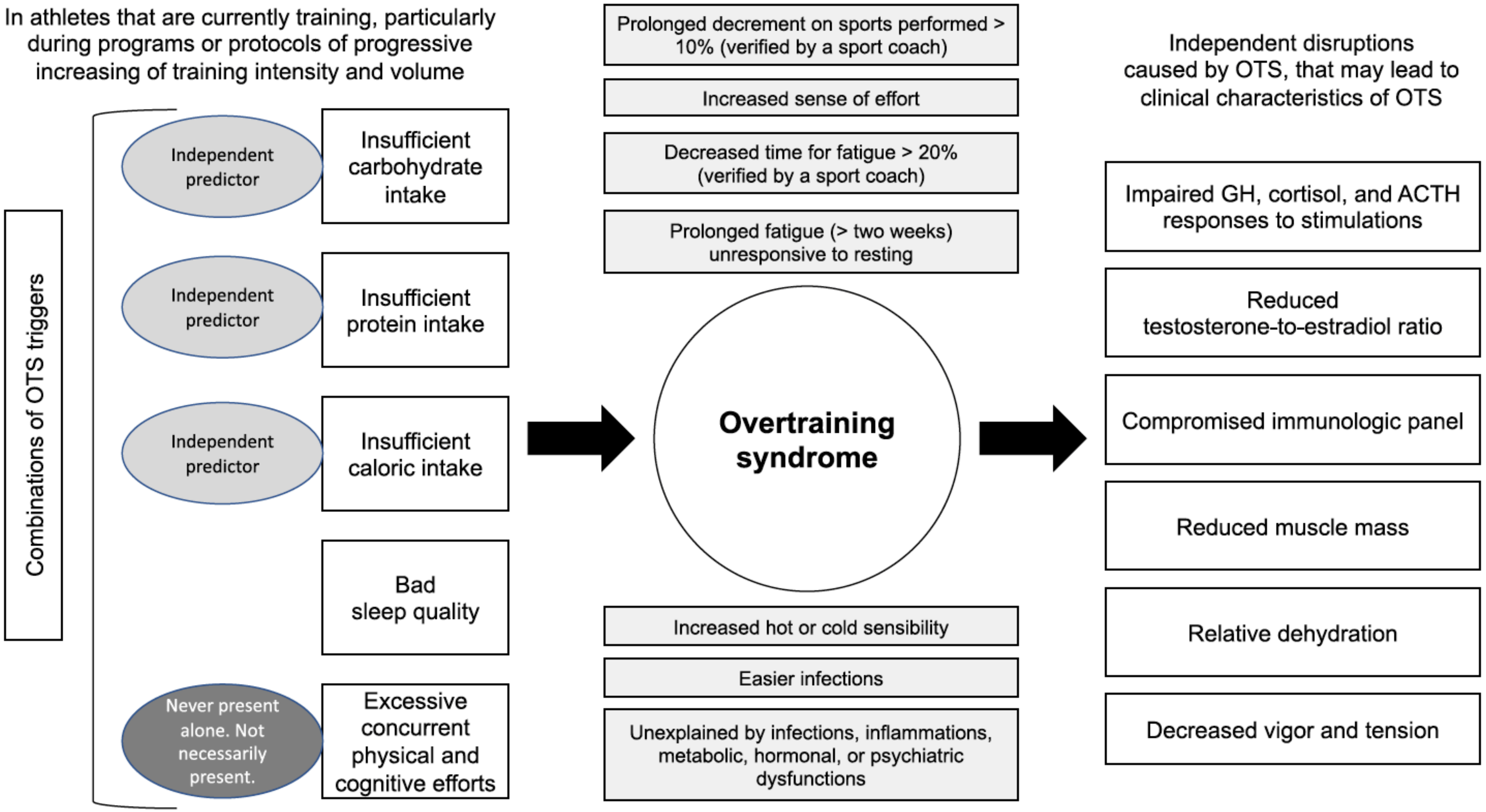

Detection of forthcoming overtraining syndrome using risk factors and preclinical alterations
Predictive model for overtraining syndrome, based on the clinical insights from the EROS study
Risk factors
Classic
Excessive training
Excessive increase in training intensity or volume
Novel risk factors
Unrefreshing sleep
Lack of good sleep hygiene
Carbohydrate intake < 5.0 g/kg/day for > 8 weeks
Protein intake < 1.6 g/kg/day for > 8 weeks
Calorie intake < 35 kcal/kg/day for > 8 weeks
In case of Calorie intake < 35 kcal/kg/day, Protein intake < 1.6 g/kg/day or Carbohydrate intake < 5.0 g/kg/day for > 8 weeks, absence of > 1 free *ad libitum* meal per week
Work or study > 7 hours/day during intense training
Concurrent stressful professional, social or familial environment
Preventive approach of OTS in all athletes: **specific active surveillance of dietary and sleeping patterns**
Focus on risk factors instead of mechanisms
Preclinical alterations
Biochemical active surveillance with patients at high risk
Blunted and late GH response to demands
Blunted and late cortisol response to demands
Lack of prolactin response to demands
Reduced testosterone
Reduced metabolic rate
Impaired fat oxidation
Increased fat mass
Reduced muscle mass
Increased creatine kinase (CK)
Decreased testosterone-to-estradiol ratio
Increased urinary catecholamines
Clinical surveillance
Worsened mood states
Decreased libido
Unexplained fatigue
Lack of reduced performance (diagnosis of OTS is based on the *sine quo non*-presence of decreased performance)
Detection of clinical and biochemical signs prior to overtraining syndrome
→ Indicative of imminent overtraining syndrome
Active prevention of imminent overtraining syndrome
Reduce training intensity and volume
Additional resting
Increase calorie, carbohydrate, and protein intake
Improve sleep hygiene
Manage stress
Avoid social and familial problems
Limitations: male athletes, high-intensity trainings, 18—50 y/o.

Figure 5 Predictive model for the identification of overtraining syndrome (OTS). EROS, Endocrine and Metabolic Responses on Overtraining Syndrome; GH, growth hormone; y/o, years old.

Cadegiani FA, et al. BMJ Open Sport Exerc Med 2019



In athletes that are currently training, particularly during programs or protocols of progressive increasing of training intensity and volume

Combinations of OTS triggers

Independent predictor — Insufficient carbohydrate intake

Independent predictor — Insufficient protein intake

Independent predictor — Insufficient caloric intake

Bad sleep quality

Never present alone. Not necessarily present. — Excessive concurrent physical and cognitive efforts

Prolonged decrement on sports performed > 10% (verified by a sport coach)

Increased sense of effort

Decreased time for fatigue > 20% (verified by a sport coach)

Prolonged fatigue (> two weeks) unresponsive to resting

Overtraining syndrome

Increased hot or cold sensibility

Easier infections

Unexplained by infections, inflammations, metabolic, hormonal, or psychiatric dysfunctions

Independent disruptions caused by OTS, that may lead to clinical characteristics of OTS

Impaired GH, cortisol, and ACTH responses to stimulations

Reduced testosterone-to-estradiol ratio

Compromised immunologic panel

Reduced muscle mass

Relative dehydration

Decreased vigor and tension

Fig. 2 Summary of the predictions of Overtraining syndrome (OTS) and its implications

Cadegiani FA, et al. BMC Sports Sci Med Rehabil 2019

Conclusion

Diagnostic d’exclusion

Maladaptation à l’exercice

- Inflammation systémique avec des répercussions neuro-hormonales et immunologiques
- Etat hyporéactif et hypométabolique avec une diminution de la réponse hormonale à l’exercice
  → état anti-anabolique et pro-catabolique

Attentif

- Méthodologie d’entrainement, récupération, stresseurs additionnels, (év. monitoring, screening médical)

Traitement passe par le repos, l’accompagnement, l’éducation, et le traitement des facteurs confondants

Dénominations alternatives?

Underperformance syndrome

Syndrome de déconditionnement paradoxal de l'athlète

Cas cliniques

H 49ans

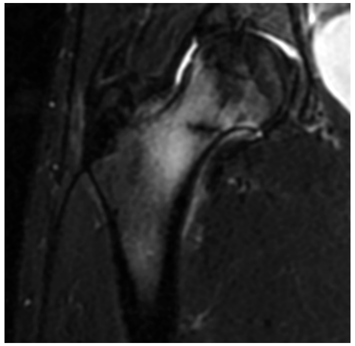
Amélioration dans semaines suivantes

Optimisation de son régime d'entrainement

F 35ans

A continué à s'entrainer

Repos forcé en raison d'une douleur de hanche



N'a pas pu reprendre ses volumes d'entrainements depuis

F 20ans

Adaptation de l'alimentation

Réduction transitoire du volume d'entrainement

Pas couru le marathon

Résolution quelques semaines après la période d'examens

Pause pendant l'été et augmentation progressive du volume ensuite

Merci pour votre attention

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