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Overtraining and Chronic Fatigue: The Unexplained Underperformance Syndrome (UPS)

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All athletes must train hard in order to improve their performance. Some athletes fail to recover from training, become progressively fatigued, and suffer from prolonged underperformance. They may also suffer from frequent minor infections (particularly respiratory infections). This has been called the over training syndrome, burnout, staleness, or sports fatigue syndrome, but in the absence of any medical cause is more accurately called the Unexplained Underperformance Syndrome (UPS). The condition is normally secondary to the stress of training, but the exact etiology and pathophysiology is not known, and many factors other than overtraining may lead to failure to recover from training or competition.

Changes in psychological, hormonal, and immune parameters have been shown in these underperforming athletes, some of which may be useful as markers when used on an individual basis. However, the importance of any of these changes, many of which are seen in athletes without UPS when training very hard, is not fully understood.

Athletes normally recover in 6 to 12 weeks with a programme of gentle exercise and regeneration strategies.

Key Words: athletes, underperformance, overtraining, chronic fatigue, staleness, burnout

Key Points:

• About 10% of endurance athletes may break down each year (not sprinters).

• Redefinition of Unexplained Underperformance Syndrome (UPS): “Persistent performance deficit despite 6 weeks relative rest.”

• Three main groups of symptoms: frequent infections, mood disturbance, and fatigue.

• Recovery normally takes 6–12 weeks with a light exercise regime and regeneration strategies.

Introduction

Despite a hard training program and progressive overload, some athletes fail to improve and their performance may even start to deteriorate. Unexplained underperformance in athletes is a common problem, occurring in around 10–20% of elite endurance squads, but is rarely seen in sprinters. In the absence of any other medical cause, this has been called the overtraining syndrome, burnout, staleness, “sports fatigue syndrome,” or chronic fatigue in athletes (1–3). The exact etiology and pathophysiology is not known, but the condition is often assumed secondary to the stress of training, or at least due to a failure to recover from training or competition (4). There has been some confusion in the literature on the definition and diagnostic criteria (5).

The term *overtraining syndrome* implies causation that limits investigations of this problem in athletes. There is confusion as to whether athletes suffering from frequent respiratory infections, depressed mood state, clinical depression, fatigue, or underperformance are all actually overtrained (6). In order to allow researchers and clinicians to investigate the problem, a broader definition was created at a round table discussion in St Catherine's College, Oxford on April 19, 1999 (7).

The Definition of Unexplained Underperformance Syndrome (UPS)

UPS is a persistent, unexplained performance deficit (recognized and agreed by coach and athlete) despite 2 weeks of relative rest (7). This contrasts with the definition of chronic fatigue syndrome, where symptoms must last at least 6 months (8).

In addition to fatigue and an unexpected sense of effort during training, the following symptoms have been reported in UPS (4, 6, 7, 9):

- history of heavy training and competition
- frequent minor infections
- unexplained or unusually heavy, stiff, and/or sore muscles
- mood disturbance
- change in expected sleep quality
- loss of energy
- loss of competitive drive
- loss of libido
- loss of appetite

The list of symptoms is included to give a background to the basic definition. If the underperformance can be explained in terms of a major disease, then the diagnosis cannot be made. For this reason, all athletes with a diagnosis of UPS should have a careful history and physical examination. In most cases, it will be the coach and athlete who are best able to measure performance that may be compared to previous weeks, months or years. The performance deficit may be agreed by the sports scientist or sports physician if appropriate ergometer or field tests have been carried out. It may be most appropriate to compare performance to the same stage of previous competition cycles. Relative rest cannot be defined exactly but should involve a significant reduction in training and increase in recovery time, for example, as would occur normally before a major competition.

Endurance athletes present with fatigue and underperformance with secondary changes in mood that is specific to the sport and individual (10). In addition, those runners who suffer from frequent minor infections particularly upper respiratory tract infections (URTI), may form a separate overlapping sub-group (11). Due to these overlapping groups and the confusion of definitions, our definition of unexplained

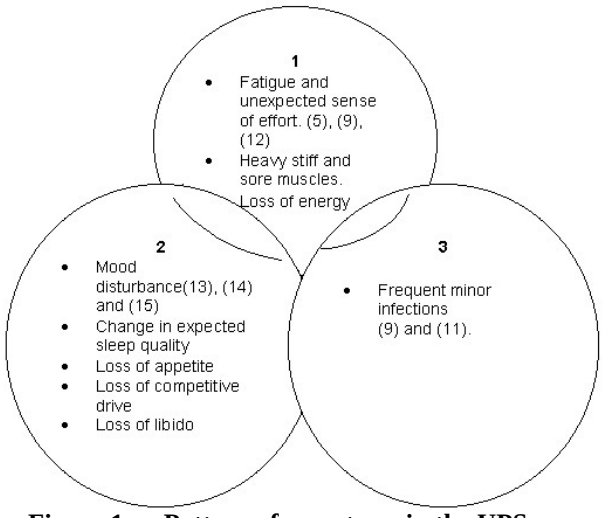

Figure 1 — Pattern of symptoms in the UPS.

underperformance is broad and all-inclusive. However, it does not include over-reaching or so-called short-term overtraining from which athletes make a full recovery with less than two weeks of relative rest (1).

It is likely that there are several distinct subgroups and that some of these subgroups overlap as represented in Figure 1.

It would be helpful if researchers and those writing case reports defined exactly which group(s) they were investigating or whether they had included all athletes with persistent unexplained underperformance.

The Normal Response to Training

All athletes must train hard in order to improve. Initial hard training causes underperformance but if recovery is allowed, there is supercompensation and improvement in performance (16). Training is designed in a cyclical way (periodisation) allowing time for recovery with progressive overload. During the hard training / overload period transient symptoms and signs and changes in diagnostic tests may occur; this is called overreaching (5).

There are changes in the profile of mood state (POMS) questionnaire that shows reduced vigour and increased tension, depression, anger, fatigue and confusion (15). Muscle glycogen stores are depleted and resting heart rate rises. The testosterone/cortisol ratio is reduced due to lower testosterone and high cortisol levels. Microscopic damage to muscle also leads to raised creatine kinase levels especially if there is eccentric exercise (17).

All these changes are physiological and normal if recovery occurs within two weeks. Overreaching will occur in most training programs and normally leads to improved performance despite the temporary underperformance and fatigue. The degree of overreaching necessary to enable an athlete to reach his/her maximum performance has been debated amongst coaches, athletes, doctors and sports scientists (6). Many feel that the ability to tolerate and recover from frequent hard training is one of the most important qualities in elite athletes. Nevertheless, it is debatable as to whether those athletes tolerating less training cannot reach the same level as their peers who can tolerate more.

Abnormal Response to Training

If the training is prolonged heavy and monotonous then there is a risk of UPS. Monotonous means lacking in variation or periodization and does not necessarily mean boring. Nevertheless, most athletes will recover fully after two weeks of adequate rest however hard the training. The cyclical nature of most training programs (periodization) allows this recovery and full benefit from hard exercise (16).

Eventually fatigue becomes so severe that recovery does not occur despite two weeks of relative rest. At this stage, a diagnosis of the UPS can be made.

Signs

Reported signs are often caused by associated illness and are inconsistent and generally unhelpful in making the diagnosis. Cervical lymphadenopathy is very common. There may be an increased postural drop in blood pressure and postural rise in heart rate, probably related to the underlying pathophysiology (18). Physiological testing may show a reduced $V0_2$ max and maximal power output and an increased sub-maximal oxygen

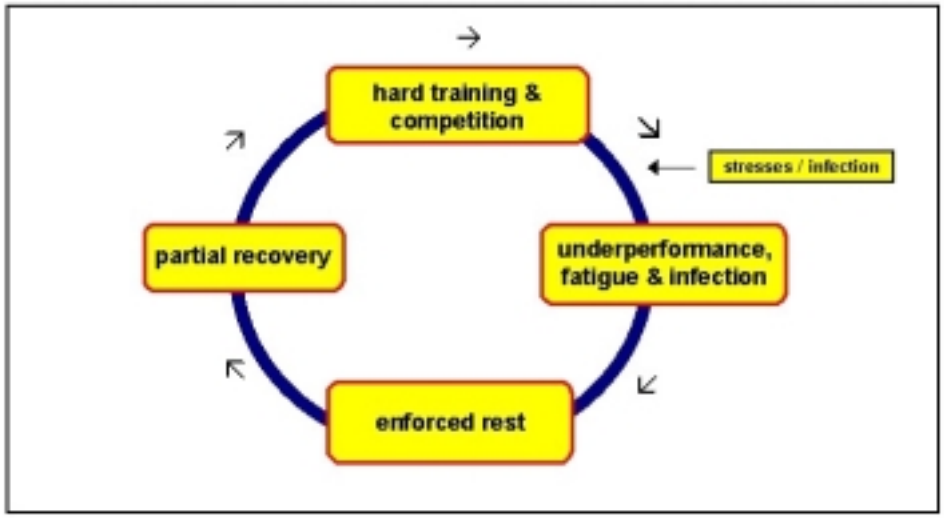

Figure 2 — Overtraining or under-recovery, leading to Unexplained Underperformance Syndrome (UPS).

consumption and pulse rate, with a slow return of the pulse rate to normal after exercise, and a surprising shift of the lactate curve to the right (15). This is the so-called “lactate paradox”, and has been shown unlikely to be due to glycogen depletion, and may be due to a downregulation of the peripheral adrenoreceptors (4).

Prevention and Early Detection

Athletes tolerate different levels of training, competition and stress at different times, depending on their level of health and fitness through the season. The training load must therefore be individualized and reduced or increased,

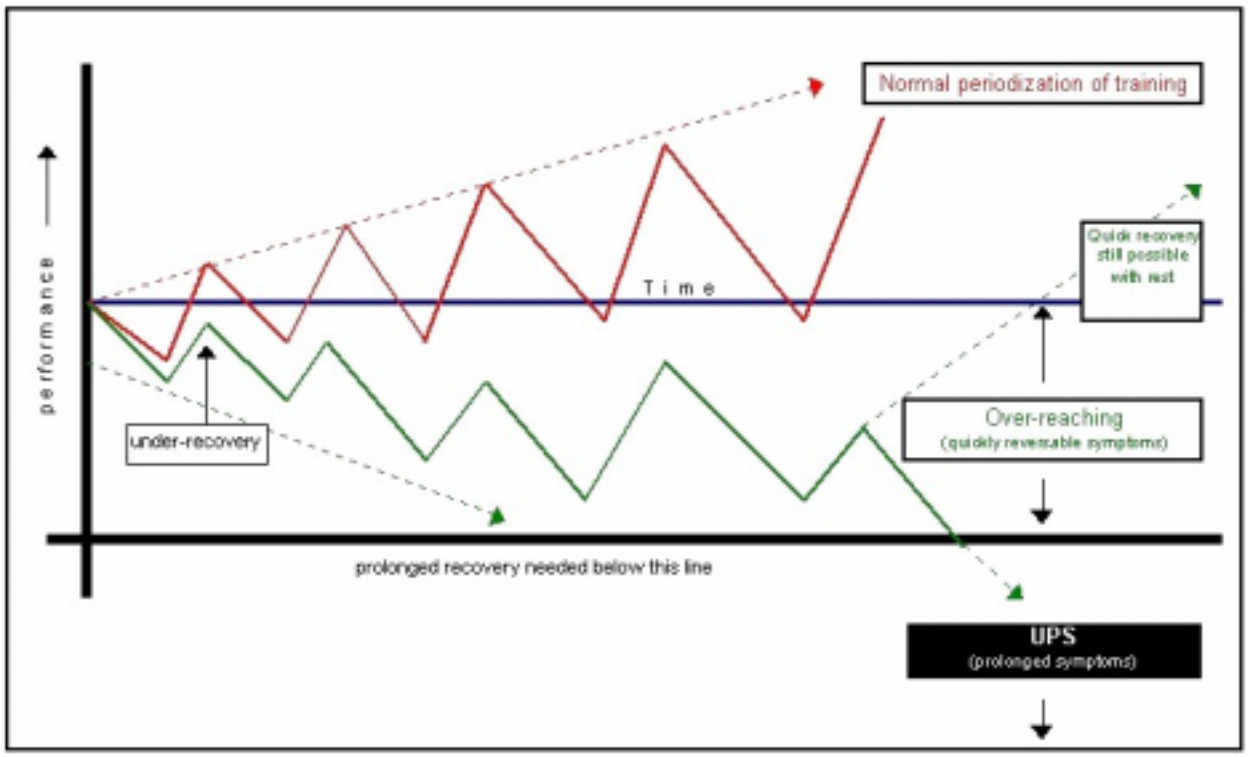

Figure 3 — The cycle of recurrent minor infections.

depending on the athlete’s response. Other stresses, such as exams, need to be taken into account (10).

In practice it is very difficult to distinguish between overreaching and UPS. Researchers have attempted to follow blood parameters, such as hemoglobin, hematocrit and white cell count which alter acutely in exercise and are often low anyway in regularly training athletes due to a dilution effect caused by their increased blood volume. There was hope for urea and creatine kinase but these measure the stress of training and do not predict who will fail to recover. Mood state profiling on a regular basis can give useful guidance (19).

Many runners monitor their heart rate. This is non-specific but does provide objective evidence that something is wrong if the resting pulse is more than 10 beats per minute higher than the athlete’s normal consistent base (20). Other prevention strategies are a good diet, full hydration and rest between training sessions. It is more difficult for athletes who have a full-time job and other commitments to recover quickly after training. Many sports scientists and coaches are advising alternate day hard and light training within the normal cyclical programme (12).

Training intensity and spacing the training are the most important factors in optimizing performance and minimizing the risk of UPS. Morton used a complex mathematical model to optimize periodization of athletic training leading up to a major event such as a marathon. In this, he suggested intensive training on alternate days over a 150-day season, building up over the first two-thirds and tapering over the last third. This was more effective than moderate training throughout the whole year (16).

Many athletes use supplements but these do not seem to offer any protection from chronic fatigue. Trace elements and minerals, such as magnesium, have been investigated but there is no proven link to UPS or chronic fatigue syndrome (5).

Pathophysiology

Training and Psychology

Researches have shown a drop in the "lactate: rating of perceived exertion (RPE)" ratio with heavy training (21). Thus for a set lactate level the perceived exertion is higher. This may represent central fatigue, but could be because of glycogen depletion causing lower lactate levels or the "lactate paradox".

Fry et al (2) tried to induce overtraining by short, near-maximum, high-intensity exercise but failed, suggesting that this is a safe regime. This may be because of the frequent long periods of rest between efforts. This supports our own observations that sprinters and power athletes do not suffer from the UPS (36).

The mood state is most significant if it does not improve during tapering in the lead up to a competition, but unfortunately it may then be too late to prevent underperformance. The advice is therefore to taper and recover regularly through the season to enable regular monitoring of recovery.

At the British Olympic Medical Centre, it has been shown that both performance and mood state improve with five weeks of physical rest. Low level exercise has also been shown to speed recovery from the chronic fatigue syndrome (15).

The profile of mood state (POMS) questionnaire was used on a group of collegiate swimmers in the USA by Morgan (19). Training was increased whenever the mood state improved and reduced whenever the POMS deteriorated. The incidence of burnout, which was previously around 10% per year, reduced to zero (22).

Hormonal Changes

The role of hormones in the UPS is still not fully understood. Stress hormones, such as adrenaline and cortisol have been shown to rise more in underperforming athletes than in controls. Salivary cortisol levels (reflecting free cortisol levels) in a group of swimmers were significantly higher in stale, underperforming athletes and this correlated with the depressed mood state (23).

A low testosterone:cortisol ratio has been suggested as a marker of UPS, reflecting a change in the balance of anabolism to catabolism. This ratio falls in response to overreaching, so only a very low ratio is useful. In some athletes there is no significant change, despite all the symptoms of UPS (23).

A reduced response to insulin induced hypoglycaemia was demonstrated by Barron and Noakes suggesting hypothalamic dysfunction (24).

Noradrenaline levels have been shown to be higher in fatigued underperforming swimmers than controls, particularly during tapering, but levels were generally proportional to the training stress. There was no change in cortisol levels (25). Plasma catecholamine levels and stress ratings (by questionnaire) were a useful predictor of staleness and a well-being rating questionnaire during tapering predicted performance (26).

The rise in noradrenaline levels and fall in basal nocturnal plasma dopamine, noradrenaline and adrenaline levels has been proposed as a method of monitoring training. These levels correlate with symptoms. There may be a reduction in the sensitivity of beta-adrenergic receptors due to overstimulation, which could lead to undermobilisation of glucose in exercise and explain the lactate paradox (27).

Amino Acids and Central Fatigue

Many of the symptoms seen in underperforming athletes point to a cause within the brain. In 1987, Professor Eric Newsholme from Oxford University proposed a theory of central fatigue involving increased levels of 5HT. The neurotransmitter 5-hydroxytryptamine (5HT, serotonin) has been widely studied, is widespread in the central nervous system, and has been linked to determining tiredness and sleep. The amino acid, tryptophan, the precursor of 5HT, competes with the branched-chain amino acids for entry into the brain on the same amino acid carrier. Transport across the blood brain barrier is the rate-limiting step because the rate-limiting enzyme in 5HT synthesis is non-saturated. Thus a decrease in levels of branched-chain amino acids in the blood, due to an increased rate of

utilization by muscle, will increase the ratio of tryptophan to branched-chain amino acids in the bloodstream and favor the entry of tryptophan into the brain. This may result in fatigue originating in the brain. Free tryptophan concentrations are further increased by a rise in plasma fatty acid levels. In endurance activity, free fatty acid concentrations rise and the branched-chain amino acid concentrations fall. In rats, it has been shown that this increases the concentration of 5HT in the hypothalmus and brainstem (28).

A study of runners in the Stockholm marathon showed that those receiving branched-chain amino acids rather than placebo suffered less from a sensation of effort in the second half of the marathon and maintained cognitive function, unlike the controls. The fall in plasma branched-chain amino acids and glutamine levels, associated acutely with hard training and chronically in runners with UPS, may lead to an increase in brain levels of the neurotransmitter 5HT (serotonin) (28,29). This could lead to down-regulation of 5HT receptors and account for many of the symptoms of UPS.

When tested on an isokinetic dynamometer, fatigued athletes did not produce the same concentric power as controls at the higher speeds but there was no difference in eccentric contraction. In addition, during an isometric contraction, superimposed tetanic stimulation increased force output (30). Thus, it seems that athletes with UPS have difficulty in maximally recruiting all muscle fibers when tested in the laboratory and this effect may be due to central fatigue.

5HT re-uptake inhibitors, such as fluoxetine, when given acutely to athletes reduce performance (time to exhaustion) consistent with the widespread effects of HT in the brain. It is possible that the anecdotal improvement of some athletes with these types of antidepressants is either due to the treatment of an undiagnosed depression or due to a slow fall in 5HT-receptor sensitivity.

5HT-containing cells are widespread in the central nervous system, and changes in 5HT receptor levels could account for many of the symptoms of overtraining affecting sleep, causing central fatigue, loss of appetite and inhibiting the release of factors from the hypothalmus which control pituitary hormones (28, 29).

Imunosuppression and Glutamine

There is evidence that moderate regular exercise helps reduce the level of infection in normal individuals. However, intense heavy exercise increases the incidence of infections (11). Upper respiratory tract infections have been shown more likely with higher training mileage and after a marathon (31). A number of factors probably contribute to this apparent immunosuppression, such as raised cortisol levels, reduced salivary immunoglobulin levels and low glutamine levels. Glutamine is an essential amino acid for rapidly dividing cells such as lymphocytes. Low levels of glutamine have been found in chronically fatigued and underperforming athletes, including marathon runners, compared to controls and levels are known to be lower after hard training (32). Thus, in addition to a possible role in Central Fatigue, glutamine may have a role in immunosuppression.

Glutamine intervention studies have been carried out, and there is some evidence that the incidence of infection in endurance athletes after prolonged exercise is reduced after taking glutamine compared to placebo. Recovery from a period of intense training (overreaching) is also quicker (33).

Lowered salivary immunoglobulins, reduced NK cell activity, and changes to the T helper/suppresser cell ratios are just some of the other immune parameters that may contribute to the apparent immunosuppression in many of these athletes (11).

Management

Athletes suffering from prolonged unexplained underperformance (UPS) are different from sedentary individuals with chronic fatigue because they present earlier, they tend to recover more quickly, and there is an opportunity to alter the major stress in their lives (training and competition). Nevertheless, management is similar to any individual with chronic fatigue and requires a holistic approach. Rest and regeneration strategies are central to recovery (1).

At the British Olympic Medical Centre it has been shown that both performance and mood state improve with five weeks of physical rest (15). Low level exercise has also been shown to speed recovery from the chronic fatigue syndrome (34,35).

If told to rest for several weeks athletes are unlikely to comply. Thus they should be given positive advice and told to exercise aerobically at a pulse rate of 120 - 140 beats per minute for 5 to 10 minutes each day, ideally in divided sessions, and slowly build this up over 6 - 12 weeks. The exercise program has to be individually designed and

depends on the clinical picture and rate of improvement. The cycle of partial recovery followed by hard training and recurrent breakdown needs to be stopped. It is often necessary to avoid the athlete's own sport using cross training because of the tendency to increase the exercise intensity too quickly. A positive approach is essential, with an emphasis on slowly building up volume rather than intensity to about one hour per day. Once this volume is tolerated, then more intense work can be incorporated above the onset of blood lactate accumulation (OBLA) (21).

Very short (less than 10 seconds) sprints / power sessions with at least 3 - 5 minutes of rest are safe and allow some hard training to be done. Athletes can normally add in two to three 30-minute sprint sessions per week after 2 weeks of gentle endurance exercise (36).

There are no trials of regeneration strategies that were widely used in the old Eastern Block countries (30). These include rest, relaxation, counseling and psychotherapy. Massage and hydrotherapy are used and nutrition is looked at carefully. Large quantities of vitamins and supplements are given, but there is no evidence that they are effective. Stresses outside sport are reduced as much as possible. Depression may need to be treated with anti-depressants but normally drugs are of no value, although any concurrent illness must be treated. There is one report of the (prohibited) use of anabolic steroids to treat UPS (37).

Athletes who have been underperforming for many months are often surprised at the good performance they can produce after six to twelve weeks of extremely light exercise. At this point care must be taken not to increase the intensity of training too fast and to allow full recovery after hard parts of their training cycle. We recommend that athletes recover completely at least once a week.

Summary

UPS is relatively common in endurance athletes. It is a condition of underperformance with persistent fatigue, and an increased vulnerability to infection leading to recurrent infections in some athletes. Central, peripheral, hormonal and immunological factors may all contribute to the failure of recovery from exercise. The extent to which the stress of hard training and competition leads to the observed spectrum of symptoms is not known and probably very variable in each case.

Optimizing training and careful monitoring of athletes may help prevent UPS. With regeneration strategies and a structured exercise program, symptoms normally resolve in 6–12 weeks.

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