A consistent goal of training athletes is to provide training loads that are effective in improving performance while at the same time avoiding injury and burnout. During this process athletes may go through several stages within a competitive season of periodised training. These phases of training range from undertraining, during the period between competitive seasons or during active rest and taper, to “overreaching” and “overtraining” which includes maladaptations and diminished competitive performance. In recent years, literature on the topic of overtraining has increased enormously; however, the major difficulty is the lack of common and consistent terminology as well as a gold standard for the diagnosis of overtraining. For purposes of this paper, we will utilize the definitions of Kreider et al;

- **Overreaching**: an accumulation of training and/or non-training stress resulting in short-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of maladaptation in which achievement of performance capacity may take from several days to several weeks.

- **Overtraining**: an accumulation of training and/or non-training stress resulting in long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of maladaptation in which achievement of performance capacity may take several weeks or months.

Athletes experience minor fatigue and acute reductions in performance as a consequence of any normal training program. When the balance between training stress and recovery is disproportionate, it is thought that overreaching and possibly overtraining may develop. Overreaching usually occurs as a result of intensified training and is often considered a normal outcome for elite athletes due to the relatively short time (typically two weeks or less) needed for recovery and the possibility of a supercompensatory effect. As the time needed to recover from the overtraining syndrome is considered to be much longer in duration (months to even years), it may be challenging to discern acute fatigue and decreased performance experienced from isolated training sessions, from the states of overreaching and overtraining. Nevertheless, the prevailing theory is that these definitions suggest that the difference between overtraining
and overreaching is the amount of time needed for performance restoration and not the type or duration of training stress or degree of impairment. As it is frequent to recover from a state of overreaching in two weeks (Jequendrup et al. 1992, Kreider et al. 1998, Steinacker et al. 2000), it may be argued that this condition is a relatively normal and harmless stage of the training process. However, athletes who are in an ‘overtrained’ state may take months or possible years to completely recover. Several confounding factors include inadequate nutrition (energy, carbohydrate and/or protein intake), illness (most commonly upper respiratory tract infections), psychological stressors (work-, team-, coach-, family) and sleep disorders may be present that in many instances are overlooked. Research has not been able to discern the relative importance of these confounding variables and they are likely different for each individual and play a critical role both in the development overtraining and in the recovery from this condition.

The true incidence and prevalence of overtraining is difficult to establish, particularly given the challenges of a unique definition of the condition and the spectrum of symptoms. Survey research in college swimmers and other endurance athletes has estimated the prevalence to be upwards of 20% (Raglin and Wilson). Perhaps more alarming is the recent suggestion that the same may be true in the pediatric population (Winsley and Matos). Moreover, these individuals report the same symptoms as adults diagnosed with overtraining; increased perception of effort during exercise, frequent upper respiratory tract infections, muscle soreness, sleep disturbances, loss of appetite, mood disturbances, shortness of temper, decreased interest in training and competition, decreased self-confidence, and inability to concentrate (Winsley and Matos). One must be cautious however not to over interpret these data given the challenges of making the diagnosis, systems for reporting, etc.

**Diagnosis of Overtraining**

Before a diagnosis of overtraining is given to an athlete, one should always exclude certain disease states that share many common qualities with the overtraining state including; endocrinological disorders (thyroid or adrenal gland, diabetes, vitamin D deficiency), iron deficiency with anaemia, or infectious diseases (including myocarditis, hepatitis, infectious
mononucleosis). Other major disorders such as anorexia nervosa and bulimia as well as depression should also be considered and excluded if any concerns exist for these problems. A bigger challenge may be in recognizing that it is quite possible to have some of these problems in conjunction with overtraining. In practical terms, overtraining is characterised by a “sports-specific” decrease in performance often together with disturbances in mood state. This underperformance persists despite a period of recovery lasting several weeks or months. Importantly, as there is no diagnostic tool to identify an athlete as suffering from overtraining, diagnosis can only be made by excluding all other possible influences on changes in performance and mood state. In other words, if no explanation for the observed changes can be found, overtraining is diagnosed. Despite decades of research on the syndrome of overtraining, early and unequivocal recognition is virtually impossible because the only consistent sign is typically a decrease in performance during competition or training. Nevertheless, everyone concerned with the care of athletes should remain vigilant to this problem. The borderline between under- and over-diagnosis is very difficult to judge.

One of the most certain triggers is a training error resulting in an imbalance between load and recovery. Other possible triggers might be the monotony of training, too many competitions, personal and emotional (psychological) problems and emotional demands of occupation. Less commonly cited possibilities are sleep disturbance, altitude exposure and exercise-heat stress. However, scientific evidence is not strong for most of these potential triggers.

For some time now it has been hypothesised that a hormonal mediated central dysregulation occurs during the development of overtraining. Accordingly, measurements of blood hormones could theoretically aid in the detection of overtraining (Fry & Kraemer 1997; Steinacker et al. 2000, 2004; Meeusen et al. 2004). The results of the research devoted to this subject is far from unanimous, mostly because of the difference in measuring methods, and/or detection limits of the analytical equipment used. Testing of central hypothalamic/pituitary regulation requires functional tests which are considered invasive and require diagnostic experience, and these tests are quite time consuming and expensive. For a long time the resting
plasma testosterone/cortisol ratio was considered as a good indicator of the overtrained state. This ratio decreases in relation to the intensity and duration of training and has become evident over time that this ratio indicates only the actual physiological strain of training and therefore should not be used for diagnosis of overreaching or overtraining (Lehmann et al. 1998; Urhausen et al. 1995; Duclos 2008). Other hormones including leptin, ghrelin, and adiponectin as well as cytokines such as IL-6 and TNF have also been investigated as a means to monitoring but with limited success to date (Jürimäe J., Mäestu et al. 2011)

In essence, it is generally thought that symptoms of overtraining, such as fatigue, performance decline, and mood disturbances, are more severe than those seen with overreaching. However, there is no scientific evidence to either confirm or refute this potentially important distinction. In practical terms, there is often no objective evidence that the athlete is indeed suffering from overtraining. Additionally, in the studies that have attempted to induce a state of overtraining, many of the physiological and biochemical responses to the increased training were highly variable, with some measures in some studies demonstrating changes and others remaining unaltered. This is most likely due to the fact that the signs and symptoms of overtraining vary from individual to individual. Definitive prospective studies are lacking and we are therefore left to draw conclusions from retrospective reviews and case studies of athletes diagnosed with overtraining. Of note, whether one is predisposed to further episodes of overtraining after an initial diagnosis is unclear at this point in time.

Nutrition as a mediator of overreaching and overtraining

The physical adaptations and stressors of athletes make their energy needs for weight maintenance and normal physiological function substantially different from a “healthy” sedentary person. Training relies heavily on an athlete’s tolerance to repetitive tissue and psychological stress and strain. Both structural and functional tissues are significantly modified by only a few weeks of training, and under certain conditions, within days. Collectively, these factors are known to increase energy requirements. It is recognized more and more that athletes should follow appropriate nutritional principles and practices in order to recover and
prepare for daily training and remain injury free and healthy. Rehydration after exercise, together with the timing and method of increased food intake to cope with heavy training, are essential for optimal performance.

Despite the elevated energy requirements of frequent training and increased lean mass, some research indicates that the many athletes fail to consume enough calories to maintain energy balance (Gleeson and Nicolette 2000). A recent survey of elite junior athletes revealed that a high proportion were not in energy balance, failed to meet carbohydrate and micronutrient recommendations, and presented with depleted stories of iron and vitamin D (Gibson JC et al). Initiating large energy expenditure by athletes does not necessarily induce a compensatory increase in food consumption. Possible reasons for poor intake include; lack of appetite and lack of awareness about the importance of food consumption.

As noted above, it is important to first exclude organic diseases or infections when making the diagnosis of overtraining. Recently, nutrition factors such as dietary caloric restriction (negative energy balance) and insufficient carbohydrate and/or protein intake, iron deficiency, and magnesium deficiency have been recognized as important mediators in the spectrum of overreaching and overtraining. Other triggers including glycogen deficiency or infections may contribute to both overreaching and overtraining, however might not be present at the time the athlete presents to a physician. Furthermore, even with the identification of these possible initiating events, the underlying causative mechanism(s) of overtraining are yet to be elucidated. Nevertheless, the nutritional contributions to training, and in particular high-level and elite training, are being increasingly recognized as important not only to performance, but the avoidance of overtraining.

**Dietary Protein And Overtraining**

Dietary protein and select amino acids present possible corrective measures against the effects of overtraining and underperformance. The addition of protein to a moderate-carbohydrate meal has been reported to improve rate of glycogen synthesis and enhance exercise performance after an initial exercise bout, when compared to a moderate-carbohydrate meal alone (Ivy et al 2002). Moreover, post-exercise, particularly post-resistance
training ingestion of protein in a recovery snack decreases tissue breakdown and promotes muscle growth. Branched-chain amino acids, although often ineffective during acute performance tests, have been reported to reduce visceral fat while maintaining performance among in-training athletes experiencing a negative energy balance (Mero).

Increased protein needs for both endurance athletes (1.2 – 1.4 g/kg.d\(^{-1}\)) and resistance training athletes (1.7 – 2 g/kg.d\(^{-1}\)) are still controversial and conclusions depend upon training status and research methodology. Nevertheless, amino acid supplementation has been shown to reduce decrements in performance (bench press and squats) during periods of subjective overreaching (Ratamess et al). Whether increased protein intake can help to prevent or mitigate the symptoms of overtraining is unknown at this time.

Considerations for Coaches, Physicians, and Athletes

Despite the significance of overtraining, there is no gold standard test for diagnosis. Therefore, the following considerations may be useful in screening and monitoring for overtraining:

a) Maintain accurate training and competition records.

b) Avoid repetitive and monotony in training.

c) Encourage optimal nutrition and hydration, along with sleep.

d) Maintain vigilance on effects of jet lag (avoid if possible).

e) Monitor mood of your athletes; get to know their baseline personalities and behaviours.

f) Allow proper recovery from injury; ensure athlete is adequately reassured about safe return to sport.

g) Always rule out organic diseases before arriving at diagnosis of overtraining.

h) Treat overtraining with rest!
Future Research Opportunities

Despite tireless effort to discover a gold standard for diagnosis of overtraining, one still eludes us. Future efforts will likely remain challenging due to the variability of symptoms and causes of overtraining. The key will likely be an individualized approach to the problem and continued vigilance by coaches and medical personnel for the problem. The increased energy requirements of exercising individuals have been increasingly appreciated in recent studies. Optimal utilization of all food groups remains an important area of investigation for athletes diagnosed with overtraining. An animal model of overtraining that would allow scientists to study the relative importance of various food groups and their contribution to both treatment and prevention of this potentially career threatening problem would be invaluable. Interrelations among dietary patterns; social, psychological and physiological profiles; and the neuroendocrine, immune, and central nervous systems are complex and not adequately elucidated.
References

