

Summary

Stress related problems are very common in our society and they can have many different causes. The overtraining syndrome (OTS) is an example of a stress related problem. OTS is caused by an imbalance between (training) stress and recovery in athletes. Not only physical stress plays a role in the development of OTS, also psychological and social stress do. The most important symptoms are performance decrements, persistent fatigue, altered eating and/or sleeping patterns and concentration problems. A lot of research has been devoted to this subject in the past 20 years. However, this effort has not yet resulted in a marker for OTS that is useable in the sports practice. The goal of this thesis is therefore to propose and investigate a new marker: psychomotor speed.

This new marker is introduced in the first chapter. This chapter starts with an explanation of new terminology. Functional overreaching (FO) is the term that will be used for short term performance decrements and fatigue. It is called functional, because there are no negative consequences in the long term. For example, FO can occur after a training camp.

When performance decrements and fatigue are not reversed within a pre-planned period, we speak of non-functional overreaching (NFO). The longer recovery period that is needed might interfere with planned matches or races and might result in deconditioning.

We only speak of OTS when performance decrements and fatigue are accompanied by clinical symptoms as depression, eating or sleeping disorders or hormonal deviations. The other distinction between NFO and OTS is the time that is needed for recovery. Whereas an athlete with NFO will be recovered within a couple of months, recovery from OTS might take years.

Estimates of the prevalence of OTS should be adjusted in the light of this new terminology. It is estimated that 20 to 60% of all athletes experience OTS at least once during their career. These numbers seem too high for OTS and might be more correct for NFO.

Psychomotor speed is possibly a good marker for NFO and OTS. This hypothesis is based on the similarities that exist between OTS on the one hand and major depression (MD) and chronic fatigue syndrome (CFS) on the other hand. It is also based on the fact that both MD and CFS patients show psychomotor slowness.

Symptoms of CFS and OTS are similar. Both groups of patients experience a combination of fatigue with other symptoms as concentration problems and/or depressed mood states. Also, in both groups a dysfunction of the hypothalamic-pituitary-adrenal axis has been found. Differences between healthy subjects and CFS and OTS patients are small at rest. Hormonal reactions to stress tests give more pronounced results. Additionally, dysfunctions of the immune system and the autonomic nervous system have been found in both CFS and OTS patients. Similarities between MD and OTS have been described by Armstrong and VanHeest (2002). Those mainly concern symptoms and hormonal patterns. It is concluded that there are similarities between both MD and CFS and OTS, but that the syndromes are different.

As has been shown in earlier studies, I show in my thesis that both MD and CFS patients show a consistent psychomotor slowness. Meta-

analyses show that this slowness is present in easy as well as in difficult reaction time tasks.

Difficult reaction time tasks seem most relevant for measuring psychomotor speed in sports. Therefore, I choose to use the Finger Pre-cuing Task (FPT) and the Determination Test (DT). The FPT is a four choice reaction time task. In three out of four conditions the number of choices is reduced to two by a cue. The actual stimulus appears after the cue. The subject should react as fast as possible to this stimulus. The difference between the conditions allows interpretation of the results in terms of selective stimulus detection and response preparation.

The DT is a very difficult reaction time task that consists of seven visual stimuli and one auditory stimulus to which six manual reactions and two pedal reactions are possible. The DT consists of two parts, the action mode and the reaction mode. During the action mode a new stimulus only appears after a correct reaction has been given. During the reaction mode stimuli occur at fixed time intervals.

To investigate whether psychomotor speed is a marker for OTS different research paradigms over the full training continuum should be used. Thus, studies were conducted ranging from investigating the effect of acute bouts of exercise on reaction time, the effect of a training camp to a full training season. At the end of the training continuum I conducted a study with patients with NFO.

In chapter 2 a study into the effects of acute bouts of exercise is described. Previous studies have shown that exercise facilitates reaction time. However, it is unknown if the ability to prepare responses is affected by exercise. As many athletes practice or compete more than once a day, the purpose of the present study was to investigate the effect of two maximal exercise bouts on reaction time with or without response cuing. Thirteen subjects performed the finger pre-cuing task before and after two maximal incremental graded treadmill runs on one day. This exercise trial was counterbalanced with a control trial in which the same subjects sat quietly instead of running. A significant interaction effect between time and trial was found, showing shorter reaction times on the finger pre-cuing task after exercise but not after rest. The facilitative effect of exercise was the same for all cuing conditions, indicating that exercise affected the motor and not the premotor component of reaction time. Furthermore, the facilitative effect was the same for the first and the second exercise bout, consistent with the fact that subjects showed full recovery between exercise bouts.

In chapter 3 a study into the effect of a training camp is described. The purpose of the study was to investigate whether FO athletes show psychomotor slowness after a period of high load training. Fourteen well trained cyclists (10 male, 4 female) performed a maximal graded exercise test on a cycle ergometer, filled out two questionnaires and performed two tests of psychomotor speed before and after high load training and after two weeks of recovery training. A control group performed the two tests of psychomotor speed on the same occasions without changing physical activity levels.

Five cyclists were classified as FO, seven cyclists were classified as well trained and two cyclists were excluded from analysis. Results showed no significant differences in psychomotor speed between the control, well

trained and FO groups on the three measurements. A trend towards psychomotor slowness was found for the FO compared to the control group after high load training. Additional research with more subjects and a greater degree of overload training is necessary to more conclusively determine if psychomotor speed can be used as an early marker for overtraining.

The purpose of the study in chapter 4 was to investigate if psychomotor speed can predict perceived performance. It was hypothesised that lower perceived performance was related to longer reaction times. A total of 85 measurements at five measurement occasions over the course of the rowing season were taken. Perceived performance was measured with the scale 'Reduced Sense of Accomplishment' of the Athlete Burnout Questionnaire. Reaction times were measured with the FPT and with two parts of the DT, the action and reaction modes. The complex structured data were analysed with multilevel modelling using the program MLwiN. Random intercept linear models showed that perceived performance was not related to reaction times on the FPT. Lower perceived performance significantly predicted reaction times on the action and reaction modes of the DT. In rowers who were not selected for the team after participating in two measurements, this relation did not exist in the action mode; deselection was a moderator. In conclusion, a significant relation between reaction times on the DT and perceived performance was found.

In chapter 5 four possible confirmative tools have been examined in three female speed skaters between 16 and 19 years old. A NFO athlete, an athlete who was recovering from NFO and a healthy control athlete were examined. The NFO athlete showed high stress and low regeneration levels at the Recovery Stress Questionnaire for Athletes (RESTQ-sport). The recovering athlete showed a more favorable profile, although she still showed higher stress and lower recovery than the control athlete. On the Profile of Mood States (POMS) the NFO athlete showed an unfavorable profile. The control athlete showed the typical iceberg profile. The recovering athlete showed a profile similar to sedentary individuals. Hormonal reactions to two maximal exercise bouts also differed between the three subjects with an overreaction after the second exercise bout of the NFO athlete as the most remarkable finding. Results on the DT, which are most interesting in light of the current thesis, showed shortest reaction times for the recovering athlete and longest reaction times for the NFO athlete. When reaction times on the reaction mode were expressed as a percentage of initial reaction time results showed decreased performance under pressure for the NFO athlete. The healthy control athlete showed increased performance under pressure, which was also found in the previous chapters. Reaction times of the recovering athlete did not change under pressure. This could be due to the fact that her initial reaction time was faster than the shortest presentation time. Thus, she probably never had to perform under pressure.

The purpose of the two studies in chapter 6 was to investigate reliability and validity of a Dutch translation of the RESTQ-sport. Test-retest reliability, internal consistency and factor structure were assessed in both studies. Criterion validity was assessed in the first study only, with

the POMS as criterion measure. The test-retest reliability of the Dutch RESTQ-sport was acceptable, especially as the RESTQ-sport aims to measure stress and recovery states. Internal consistency was good for most scales. In both studies, internal consistency was higher at the second compared to the first measurement. Factor analyses confirmed the stress-recovery structure of the Dutch RESTQ-sport. Criterion validity was also supported. Overall, it was concluded that the Dutch RESTQ-sport has sufficient reliability and validity. This gives support to the cross-cultural usefulness of the scale.

Results of the different studies are compared in the general discussion. Following the results of the studies in chapter 3 and 4 it is concluded that psychomotor speed could indeed be an early marker for NFO and/or OTS. A notable difference between these two studies is the fact that in chapter 3 significant results were found on the FPT whereas in chapter 4 significant results were found on the DT. This discrepancy could be explained by differences between the studies. First, in chapter 3 training loads doubled during the training camp, whereas in chapter 4 reaction times were studied during a normal training season. Secondly, there is a difference in performance assessment between the studies. In chapter 3 a maximal exercise test was used to measure maximal performance capacity, whereas in chapter 4 a questionnaire was used to assess perceived performance. The FPT and the DT measure different aspects of reaction time. The FPT measures selective stimulus detection and response preparation, the DT measures stimulus identification. Whether these aspects are influenced differently over the training continuum could be the subject of future studies.

Another issue that is discussed is the usefulness of reaction time tasks in sports practice. In chapter 2 it was shown that assessment of reaction time after an exercise bout will not lead to false warnings. Reaction time measurements are also affordable, which makes the practical useability high. However, at this moment there are still too many uncertainties for including reaction time tasks in a training monitor. For example, it is not known how many measurements the practice effect lasts. Above all, we will have to know what the effect of external disturbances and the use of different setups is. Additionally, as a scientist, I would like pose a more fundamental question. What mechanism causes psychomotor slowness in overtraining athletes?

