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Monitoring endurance athletes

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GENERAL DISCUSSION

The aim of this thesis was to gain more insight into the ongoing interactions between physical and psychosocial stress and recovery and the influence on endurance performance parameters and sustained injuries.

Key findings

The aim of chapter 1 was to investigate the association between psychosocial stress, recovery and cycling performance of female athletes. The main findings were that several indicators of decreased stress and improved recovery are independently related to improved performance parameters. These results indicate that a higher individual stress level and reduced individual recovery can have a negative influence on indicators of performance. Previous research in which the relationship between stress, health and performance outcomes [4,10,14] was investigated showed similar results.

In the second chapter the influence of a negative life event on psychosocial stress, recovery and submaximal performance of runners is described. In this chapter it has been confirmed that a negative life event is a source of sudden changes in psychosocial stress and recovery of runners [4,10]. It has also been shown that the negative life event impairs submaximal performance of runners slightly but significantly. These findings confirm that changes in psychosocial stress and recovery have an influence on performance parameters of athletes [1,14]. The importance of monitoring psychosocial stress and recovery on a regular basis was shown, because a negative life event initiates changes in psychosocial stress and recovery of athletes in a relatively short period of time. Moreover, it seems that a disturbed stress and recovery balance may have a delayed or prolonged influence on performance.

In the third chapter we have investigated the influence of physical stress on submaximal performance of runners. Physical stress was determined by training duration in three training zones, i.e. perceived low, middle and high intensity. One of the main findings was that more training at low intensity was related to improved submaximal performance. Another key finding was that more training at high intensity was related to a decrease in submaximal performance. This finding may sound counterintuitive as it is known that training at a high intensity can improve submaximal performance [2]. To put these results into perspective, we speculate that there are two likely explanations: 1) the runners

were experiencing a total training load that was too high and they could not cope with high training intensities, resulting in accumulated fatigue which can lead to higher session ratings of perceived exertion [8]; 2) the runners experienced a substantial amount of psychosocial stress in addition to their already demanding training schedule, resulting in higher ratings of perceived exertion. This is implied because previous research showed that mental fatigue leads to increased session ratings of perceived exertion [9,16]. Also the findings of our first chapter provide support to the second explanation. In chapter 1 it was shown that increased psychosocial stress and decreased psychosocial recovery can lead to a decrease in performance. However, we do not know if psychosocial stress and recovery is directly related to performance or if it influences the training load, which subsequently influences the performance. Both situations that are described in explanation 1 and 2 could lead to non-functional overreaching and coinciding stagnation or decrease of performance [6,11].

Conceptual models suggest that changes in training load may not only have an influence on performance of runners but that these changes can also lead to an increased injury risk. As a result of being injured, runners cannot train and compete at their best. Chapter 4 shows the relation between physical stress (training parameters) and injuries of runners. The results have led to the following insights: A high training load, relative to the individual's average, increases the risk of sustaining an injury three weeks thereafter. This finding supports two ideas: 1) it is important to investigate training load on an individualized basis (also see Chapter 3); 2) there is a delay between high training load and the risk of sustaining an injury [12]. Other findings were that prolonged high cumulated relative training load/volume and high absolute and relative training intensity increases the risk of sustaining an injury. In addition, a high training intensity does not only decrease performance (Chapter 3), but it also increases the risk of becoming injured.

In chapter 5, a new submaximal rowing test was introduced. Rowing is one of the endurance sports that is known for its tough training approach which is characterized by highly demanding training schedules [7,18]. In addition, performance of rowers is tested in a very exhaustive way, by means of maximal rowing ergometer tests [7]. Highly demanding training and testing schedules can cause rowers to be susceptible to non-functional overreaching which is

characterized by impaired performance [11]. Therefore, it is important for future studies to use a valid and reliable submaximal test to monitor rowing performance so that the relationship with stress and recovery can be investigated. The new submaximal rowing test has shown good reliability and validity. It has the potential to monitor performance parameters of rowers that can help coaches and sport scientists to gain insight into the development of their rowers and the role of stress and recovery.

To recapitulate briefly, in the current thesis more insight is given into the interactions between physical and psychosocial stress, recovery and performance parameters. In addition, a new submaximal performance indicator for monitoring rowing performance has proven to be reliable and valid which implies the potential to be a useful monitoring tool.

Strengths, limitations & recommendations

In the present thesis, we have chosen to prospectively monitor stress, recovery, performance parameters and injuries of 115 endurance athletes. An advantage of this prospective multidisciplinary approach is that coaches were interested in participating with their athletes. Therefore, we were able to work closely together with the coaches who made it possible to monitor the athletes in their natural training environment. The main advantage was that changes in physical and psychosocial stress and recovery could be captured prior to changes in performance parameters and the occurrence of injuries. This gives unique insights into the actual variations in physical and psychosocial stress and recovery of athletes and the impact on performance parameters and injuries. An example of this uniqueness is that we were able to capture stress, recovery and performance data of runners before and after an unforeseen negative life event (chapter 3).

Besides the advantages of the chosen design, there are limitations. Two years of monitoring physical stress and recovery on a daily basis, psychosocial stress and recovery on a weekly or three-weekly basis and performance parameters on a 6 to 7 weekly basis is a large investment for athletes. This investment resulted in an extensive database, which led to a larger body of knowledge than has been described in this thesis. However, it also resulted in non-compliance of some athletes. This, among other reasons (such as injuries, illnesses and personal situations) has caused that some athletes dropped out of the study

and/or did not show up at tests or did not fill out the training logs or recovery and stress questionnaires. For example, in chapter 3 only a very small percentage of training log data was missing. However, 73 out of the potential 126 tests were performed because athletes were ill, injured or engaged in other activities at school or at home. Because of the missing tests we were not able to investigate the combined influence of training in the three intensity zones on performance. This problem also occurred in our first study. In chapter 1 there was so many data missing in the training logs, that we could not include this information to assess the interaction between physical and psychosocial stress and recovery. Overall, at the start we had the intention of using multilevel models, including physical and psychosocial stress and recovery to investigate the ongoing influences on performance and injury. However, we did not manage to include all parameters in one model but we were able to obtain new insights on separate parts of the holistic model.

The missing data may result in a form of response bias because the athlete who did comply must have been motivated to do so. Therefore, it should be taken in consideration that the results of the current thesis are probably influenced by a selection bias of motivated athletes. We have tried to motivate athletes to participate by giving feedback twice a year about the results. The timing and frequency of the feedback may have been critical in the response rates of the athletes. Some athletes stated that they had to wait too long for the information. Due to the observational nature of the study we did not want to intervene in the training routine of athletes. Therefore, it was not possible to provide athletes with instant and frequent feedback, because it may change training habits of the athletes. However, if these tools are used in practice, it is of great importance for the cooperation of athletes to give feedback on a regular basis (e.g. monthly).

In our study the collaboration with the coaches was essential to obtain complete training information. If coaches understand the importance of monitoring stress and recovery of their athletes it will contribute to the willingness to cooperate in scientific research and so he/she can motivate their athletes. Giving feedback to the coaches and athletes about the results and about their development over time can help them to understand the importance and increase compliance. Moreover, if feedback is given at an appropriate time it

may help the coaches to choose an individual training approach for their athletes.

One can argue that submaximal test results do not represent actual race performance of athletes. However, race performance is, among other influences, dependent on environmental conditions [5,17], anxiety of the athlete [15], pacing strategy [3] and neurophysiological factors [13]. Therefore, we cannot imply that we studied the influence of physical and psychosocial stress and recovery on athletic performance, but we have provided insights into the influence of physical and psychosocial stress and recovery on physiological performance parameters. These insights can help coaches to choose measurement tools to track performance parameters in a non-exhaustive way.

In chapter 1 and 3 we have assumed linearity in our multilevel analyses, similarly to linearity which is assumed in correlation and regression analyses. We are aware that the relationship between stress, recovery and performance may not be linear in all situations, for all athletes [11]. For example, high training loads can improve performance parameters if athletes recover well. High training loads can also cause a decrement in performance if the capacity of the athlete is not sufficient. These relationships may well be different for each individual athlete. Therefore, a non-linear approach is needed to model these relationships for each individual athlete to give the best advice. Complete datasets of athletes are crucial for the analysis and interpretation with a non-linear approach. Outcomes would help to search for the optimal balance of physical and psychosocial stress.

Our recommendation for future research would be to perform the tests regularly at the club before the beginning of training sessions. We have done pilots with this approach in rowing and the compliance in test participation turned out to be good. With this approach it is less demanding for the athletes to perform tests on a regular basis. Although performing tests on location may be good for the compliance of athletes, it will be a challenge to standardize the environmental conditions. Another recommendation for future research is to use our findings to give direction to studies that investigate the physiological mechanisms behind the relationships between stress, recovery, performance and injuries.

Conclusions

Based on the findings of the studies in this thesis, it can be concluded that changes in physical and psychosocial stress and recovery affect performance parameters and injury prevalence of endurance athletes. Combining these measures shows the potential to better predict changes in performance parameters. A negative life event has an impact on psychosocial stress, recovery and performance parameters of athletes. This impact is evident in measures of psychosocial stress and recovery for a few weeks, while it affects performance parameters on a longer term after the event. The risk of injuries increases after a prolonged increase in physical stress and also several weeks after one week of high physical stress (both relative to the athlete's individual average). Overall, coaches and athletes should be aware of these influences and training programs should be monitored and adapted to the individual athlete's balance in stress and recovery.

Practical implications

These practical implications are based on our results and on the process of monitoring athletes in our study. Monitoring training load on a daily basis is important to gain insight into the actual training load of athletes. Session ratings of perceived exertion and training duration are easy to collect and give information about the individual training load. It is important to scale training parameters to the individual's training program, because relative changes in training load show associations with changes in performance and the risk of injury.

The RESTQ-sport can be used for measuring psychosocial stress and recovery. In our study, athletes have filled out the long version of the RESTQ-sport on a weekly or 3-weekly basis. Athletes indicated that filling out the RESTQ-sport on a weekly basis was too much of an investment, so 3-weekly would be a better option. However, our results of chapter 2 showed that a negative life event was pronounced during only 2 weeks, which means that valuable information can be missed out on if the RESTQ-sport is filled out on a 3-weekly basis. Therefore, it is recommended to measure psychosocial stress and recovery on a regular basis (e.g. weekly).

The submaximal rowing ergometer test is suitable for measuring performance. Including a sport specific test into the regular warm up on a weekly basis would not disturb training habits and would help to better understand the adaptations to training and psychosocial stress and recovery of athletes. All in all, it is important to monitor individual physical and psychosocial stress and recovery of endurance athletes and relate it to changes in performance of the athletes.

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