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# MOOD SCORES AS PREDICTOR OF RUN PERFORMANCE PROFILES IN ADOLESCENT ATHLETES

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## Abstract

**Introduction and aim of the study:** Knowledge of overexertion and stress adaptation based on the monitoring of seasonal performance changes is scarce in adolescent athletes. Therefore, we investigated the contribution (amount and experience) and impact of training-related stressors and stressors in other life domains on mood, sleep quality, and motivation in adolescent middle- to long distance runners, who differ in seasonal performance profiles. We hypothesized that: 1. The amount and a relatively high negative experience of life events and daily hassles are related to an unfavourable performance-profile. 2. Negative mood scores, a worsened sleep quality, and a decreased motivation are predictive for a stagnating performance profile.

**Materials and methods:** Out of a group of thirty-five runners (age: 12-19 yrs), who were followed during 7 months of training, dichotomization was applied retrospectively by dividing the total group into a group with stagnating performances (SP, n=8) and a group with increment in performances (IP, n=8). Group differences between responses of the various parameters and their prognostic value on the performances profile were analyzed. Run performances were measured by the Zoladz-test on four occasions with time intervals of 8 weeks (T1-T4).

**Results:** The Profile of Mood States (POMS) showed statistically significant higher mean scores in SP than IP on tension (T1, T2, T3), anger (T1, T2, T3), depression (T2, T3) and vigor (T2). No significant group differences were observed for daily hassles, life events, sleep quality, and physical enjoyment. SP showed a very stable profile for all parameters, except for tension, whereas IP showed incidentally slight variations in time course.

**Conclusions:** The differences in mood between SP and IP, but not in the amount or experienced intensity of the stressors, may indicate a predisposition in stress-adaptation in SP, leading to a stagnating performance profile. Therefore, to obtain timely information about unwanted performance stagnations, we recommend seasonal monitoring of emotional functioning at least once a month and preferably every week, to be able to timely intervene maladaptation to sports-specific or general stressors.

***Keywords:*** *POMS, stressors, cortisol, growth hormone, Zoladz-test*

## Introduction

In adolescent athletes knowledge of overexertion based on the monitoring of seasonal performance changes is scarce, in spite of the fact that unwanted performance changes are the hallmark of overexertion (1,2). Overexertion is a significant problem in adolescent athletes; a follow-up study over a period of three years reported that 50% of a group of young skiers showed signs of overtraining, and 35% of adolescent swimmers (3,4). A general problem concerning overexertion is the fact that overexertion is not always an unwanted phenomenon, i.e., training-related supercompensation requires a heavy training program, so overexertion may be evoked on purpose. However, this must be followed by enough recovery to reach a better performance than before. In practice, an arbitrary period of two weeks has been appointed to assess a desired effect of such a training program (5,6). In cases of an unwanted phenomenon, Coutts et al. (2) and Nederhof et al. (7) recently showed that the balance between *stress (general and sport-specific) and recovery* plays a role in the development of an unwanted overexertion. Examples of general stressors in the adolescent life domains are daily hassles and life events, such as school performances, domestic situation, and relationships. Sport-specific stressors are for instance the daily training load, competitions, inadequate preparations, external distractions, expectations, and the behaviour of coaches (8-10). Adolescent elite athletes have to deal with these stressors at the same time. In cases of an imbalance between stress and recovery, distress might develop, leading to overexertion and even an unwanted decline in sport performances. Individual trait- and state-influences also play their role in stress reactivity. For example, mood changes may be associated with an inadequate stress adaptation (11) that modulates seasonal performance-changes. Therefore, predictive parameters that warn athletes and coaches against an unwanted overexertion, need to be used. However, while several combinations of physiological and psycho-emotional parameters are found to be markers in adult athletes (12,13), a limited number of psychometric parameters, such as increased effort, were confirmed in the few studies with adolescent athletes (14). Furthermore, up to now there is very little scientific evidence available concerning the effects of monitoring of (non)training stress in adolescent elite athletes (14,15).

It is well known that dealing with stressors and the experience of distress is reflected in mood, anxiety, and many other psychometric parameters. For example, negative mood, as the affective outcome of a total coping process, is a sensitive parameter of problematic situations in elite sports (7). Moderate sport activity three times a week is found to increase emotional health, as assessed by the so-called iceberg profile of the Profile of Mood States (POMS) score (16,17). Flattening of this profile is often used as a signal of increased stress (15). In sport activities, a flattened iceberg profile has been found when the training load was increased during training camps or as a preparation to an important competition (18-20). These findings are mirrored when a taper is used (21).

Regarding the relationship between negative mood and performances, only depression has been found to be associated consistently with poor performances (22). The other negative moods, such as tension, anger, fatigue and confusion, do not necessarily differentiate between levels of achievement, but have predictive value for a performance outcome (23). O'Connor (24) found depression and anger to discriminate between good and bad performances in adult track athletes. In spite of these findings, the underlying mechanisms contributing to an adequate or inadequate adaptation to stressors, as well as to seasonal performance changes, are not completely known.

As a chronic unwanted underperformance is the gold standard of a maladaptive process in coping with sports-specific and general stressors (24), we focused on differences in seasonal performance profiles. Therefore, the aim of the present study is first of all to gain more insight into the contribution (amount and experience) and impact of training-related stressors and stressors in other life domains on mood, sleep quality, and motivation in adolescent middle- to long distance runners, who differ in seasonal performance profiles. Out of a group of 35 runners (age: 12-19 yrs), who were followed during 7 months, 16 runners were retrospectively dichotomized into a group with an increment in performances (IP, n=8, upper quartile), and a group that showed a stagnating performance (SP, n=8, lowest quartile). Run performances were assessed by a Zoladz-test (25). Secondly, we want to recognize inadequate seasonal stress responses of *still-training* athletes on time, based on responses of psycho-emotional parameters that are performance-related, and can be used in a field setting. We hypothesize that: 1. the amount and experience of stressors are related to a stagnating performance-profile, 2. negative mood scores, a worsened sleep quality, and a decreased motivation are predictive for a stagnating performance profile.

Based on the results, recommendations can be given about parameters that could be assessed in a field setting and used as a practical 'toolkit' to register inadequate adaptation to stressors and/or upcoming overexertion in the field.

## Materials and methods

### *Subjects*

Thirty-five healthy, elite adolescent middle- to long distance runners participated in the study (m/f: 24/11; age: mean 15.7 yrs, range 12-18; height: mean 175.8 cm, range 158-191; body weight: mean 61.8 kg, range 50-74; BMI: mean 19.9 kg/m$^2$, range 17.6-22.9). The athletes were recruited by trainers of the Royal Dutch Athletics Association (KNAU) and all subjects competed successfully in international and national competitions. None of the subjects reported using medication. Prior to the final admission the subjects were informed about the purpose and procedures of this study. Written informed consent was obtained from all subjects before participation in the study. When underage (<18 yr), parental consent was also obtained. This study was approved by the local ethics committee. Subjects were asked to abstain from strenuous physical activity the day before data collection (see Methods). The 35 subjects were followed during seven months in which four tests were carried out (T1-T4). T1 measurements were at the start of the season after two weeks of initial training in October. T2, T3 and T4 were carried out with time intervals of approximately eight weeks.

As already stated, based on performance-differences between the start of the season (T1) and the start of the season-ending competition period (T4), 16 out of 35 runners were retrospectively dichotomized into a group (n=8), who showed a stagnating performance (SP) or an increment in performance (IP). These groups were selected irrespective of the absolute performance-level at the start. Anthropometric data of both groups are shown in table 1.

Table 1: *Anthropometric data of the SP- and IP-groups*

| | | N | Mean | SEM | P-value |
|---|---|---|---|---|---|
| Age (yrs) | SP<br>IP | 8<br>8 | 16.1<br>15.5 | 0.4<br>0.8 | 0.52 |
| Height (cm) | SP<br>IP | 8<br>8 | 175.6<br>176.0 | 2.4<br>4.2 | 0.94 |
| Weight (kg) | SP<br>IP | 8<br>8 | 61.4<br>62.1 | 1.2<br>3.2 | 0.83 |
| BMI (kg/m$^2$) | SP<br>IP | 8<br>8 | 19.9<br>20.0 | 0.6<br>0.1 | 0.99 |

SP = runners with stagnating performance; IP = runners with increasing performance

***Methods***

All tests were carried out in the subject's natural environment. Performance-tests were carried out at their own training track, and questionnaires were filled in at home, two or three days before or after the performance tests.

***Performance-test***

Run performances were assessed by the Zoladz-test after a day of rest during which the subjects also had to abstain from other strenuous physical activity (25). Although the Zoladz-test has originally been developed for marathon runners, its use has been validated for middle- to long distance runners (26). Once settled for each subject, this testing day was not changed during the study. The Zoladz test consists of five runs in a specific heart rate (HR) zone for 6 min, with 2 min of rest between each run. The five HR zones are established by a countdown from the individual maximum HR (HRmax), by steps of 10 heart beats. Zone 5 is the most intensive zone, related to a performance capacity with a heart rate of (HRmax – 10), and zone 1 is a zone with the least intensive performance and a heart rate of (HRmax – 50) (25). Supervised by their trainers, HRmax of each subject was monitored by a Polar tester before this test, using two all-out sprint tests of 300 m. Based on experience the researchers were confident that such a distance gave enough time for participants to reach HRmax.

The mean HR value of the two all-out sprint tests was used, and in general differences were less than 2 bpm. Performance capacity per zone was registered as the running distance in meters. Given the duration (40 min), the Zoladz-test gives insight into the aerobic performance-capacity (zone 1, 2 and 3) and the combined anaerobic/aerobic performance-capacity (zone 4 and 5). As indicator of performance capacity in further analysis the mean distance over all five HR zones was calculated. Additional insight into competition performances could not be obtained, because competition trials were often tactical races, during which actual performance capacity was not shown, providing unreliable data.

***Training load***

The trainers registered the daily training distances and hours, as well as the training intensity. Seasonal periodization of the training was as follows: training started with a low volume and low intensity at baseline. Then, during the period T1-T2 the training volume increased first, followed by an increasing intensity (T2-T3). During the last period (period T3-T4) training volume was slightly decreased and the intensity was further increased. The overall average training load was 7.2 ± 0.44 hr/wk (mean ± SD), with 7.8 ± 0.6 hr/wk for SP and 7.1 ± 1.0 hr/wk for IP. The mean training frequency per week (4-5 sessions/wk) did not vary much during the season, except for periods of injuries/illnesses or competition programs. During T1-T2, training volume amounted up to ± 70 km/wk, whereas training volume during T2-T3 increased to peaks of 126 km/wk when training intensity also increased. During T3-T4, the mean period of training in HR zone 3-5 (HR ≥160 b/m) increased from 15 to 23 min, while training volume decreased to levels of 50-70 km/wk.

**Materials**

***Measurement of stressors***

- *Daily Hassles:* registered by the Everyday Problem Checklist (EPCL) with 114 items, representing different life areas: school or work, domestic life, social relationships etc. The EPCL is a validated version of the Daily Hassles scale. Frequency and experience of daily hassles were scored on a 4-point Likert-scale (0-3), slightly modified for the population of this study (27). A higher score indicated that the subjects experienced more and more frequently daily hassles. The internal consistency (Cronbach's alpha) for the items on the frequency of daily hassles is .87, and for experienced intensity .76 (27).
- *Life Events:* registered by the Questionnaire of Life Events (QLE) with 37 items, and 2 optional events to be entered by the subjects. It is a checklist especially for youngsters, in which their experiences were labelled 'positive' or 'negative' (28). A higher score indicated that the subject experienced more life events. The questionnaire has been validated across different youth populations in various health settings (28). The internal consistency for all items is .75, and for the sum score .80 (28).

***Measurement of the impact of the stressors***

- *Sleep Quality:* registered by the 14 items Groningen Sleep Quality Scale (GSQS), using a 4-point Likert-scale (1-4) (29). A higher score indicated that the subject experienced lower sleep quality. The scale was originally constructed to assess sleeping problems in depressed patients. The internal consistency for the items is .88 (29).
- *Profile of Mood States:* the shortened version of the Profile of Mood States (POMS) with 5 subscales (tension, anger, depression, vigor, and fatigue) was used, represented by 32 items with a 5-point Likert-scale from 0 (not at all) to 4 (extremely) (30). The internal consistency for all subscales is higher than .87 (30). The commonly used total mood disturbance score has been found to be invalid (31), and is therefore not used in this study.
- *Physical Enjoyment:* registered by the 18 items Physical Activity Enjoyment Scale (PACES) with a 7-point Likert-scale (1-7) (32). This questionnaire

measures a motivational component: enjoyment. The items were translated in Dutch. A higher score indicated that subjects experienced more enjoyment in sport activities. The internal consistency of the items is .93 (32). Social desirability bias was tested and found to be absent (32).

***Statistical Analysis***

Data were analyzed using the Statistical Package for Social Sciences (SPSS) software version 13.0. In order to predict the group-classification (IP and SP), a variance analysis UNIANOVA (SStype 3) was performed. Psycho-emotional parameters were used as dependent variables. Because mean performance at baseline was dependent on age, and both factors correlated highly (r=0.71. *P*=0.00), these factors were included as covariates. Time course differences of parameters between SP and IP have been analyzed with paired t-tests. For all statistical analyses significance was accepted at *P* ≤0.05. Values are expressed as mean ± SEM.

**Results**

***Anthropometric data***

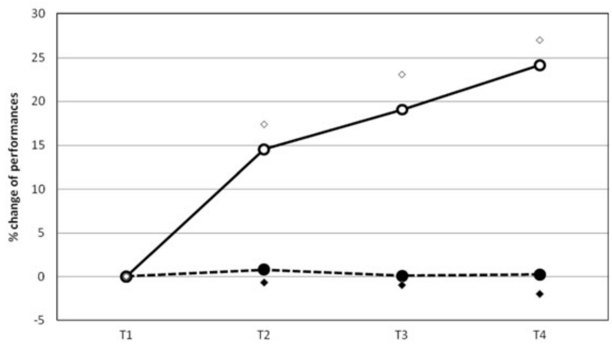
The anthropometric data showed no significant differences between both groups (see Table 1).

***Performance change***

A stagnating performance over time (between T1 and T4) indicated a mean change of + 2 m (range: -9 to +88 m), while an increasing performance indicated a mean change of + 230 m (range: +161 to +319 m). These differences were highly significant (P =0.00).

Fig.1 depicts the changes in seasonal performances (cumulative in %) for SP and IP, with baseline performance normalized at 100%.

Figure 1. *Temporal response profiles of run performances (± SEM) during the season for SP (broken line) and IP (solid line)*




For reasons of clarity the lower boundary of SEM from SP (◆) and the upper boundary of SEM from IP (◇) are depicted. Baseline performances (T1) for both groups are set at 100%. See text for further details.

Table 2. *Time course of psycho-emotional parameters over T1-T4 for both groups, and the differences in parameter scores at each test moment between SP (n=8) and IP (n=8)*

| PARAMETER | | T1 | *P*-value | T2 | *P*-value | T3 | *P*-value | T4 | *P*-value |
|---|---|---|---|---|---|---|---|---|---|
| daily hassles | SP | 28 ±6 | 0.06 | 17 ±4 | 0.78 | 17 ±4 | 0.21 | 19 ±5 | 0.12 |
| | IP | 13 ±3 | | 15 ±4 | | 10 ±3 | | 9 ±3 | |
| daily hassles experience | SP | 35 ±10 | 0.08 | 23 ±6 | 0.58 | 22 ±7 | 0.23 | 26 ±8 | 0.12 |
| | IP | 13 ±3 | | 19 ±5 | | 12 ±4 | | 10 ±4 | |
| life events | SP | 3.0 ±0.7 | 0.87 | 2.5 ±0.8 | 0.78 | 2.9 ±0.9 | 0.55 | 2.6 ±0.4 | 0.16 |
| | IP | 2.9 ±0.5 | | 2.3 ±0.5 | | 2.1 ±0.7 | | ***1.7 ±0.5***[3] | |
| positive life events | SP | 1.9 ±0.4 | 0.30 | 1.8 ±0.5 | 0.81 | 1.9 ±0.5 | 0.85 | 1.6 ±0.3 | 0.89 |
| | IP | 2.4 ±0.4 | | 2.0 ±0.4 | | 1.7 ±0.5 | | 1.5 ±0.4 | |
| negative life events | SP | 1.0 ±0.3 | 0.18 | 0.7 ±0.5 | 0.25 | 1.0 ±0.6 | 0.37 | 1.0 ±0.4 | 0.12 |
| | IP | 0.4 ±0.3 | | 0.1 ±0.1 | | 0.4 ±0.2 | | 0.2 ±0.2 | |
| depression | SP | 0.5 ±0.3 | 0.14 | 1.0 ±0.3 | **0.02*** | 1.1 ±0.4 | **0.00*** | 0.7 ±0.3 | 0.19 |
| | IP | 0.1 ±0.1 | | 0.2 ±0.1 | | ***0.1 ±0.1***[2] | | 0.2 ±0.1 | |
| anger | SP | 1.5 ±0.3 | **0.03*** | 1.4 ±0.2 | **0.03*** | 1.5 ±0.3 | **0.04*** | 0.9 ±0.3 | 0.18 |
| | IP | 0.7 ±0.2 | | 0.6 ±0.2 | | 0.5 ±0.2 | | 0.4 ±0.1 | |
| fatigue | SP | 1.0 ±0.3 | 0.33 | 1.0 ±0.3 | 0.26 | 1.0 ±0.4 | 0.26 | 1.0 ±0.4 | 0.26 |
| | IP | 0.7 ±0.2 | | 0.5 ±0.2 | | 0.4 ±0.2 | | 0.4 ±0.1 | |
| tension | SP | 1.0 ±0.2 | **0.05*** | 0.9 ±0.1 | **0.05*** | 1.2 ±0.3 | **0.02*** | ***0.6 ±0.2***[1] | 0.33 |
| | IP | 0.4 ±0.1 | | 0.5 ±0.1 | | ***0.4 ±0.1***[2] | | 0.4 ±0.1 | |
| vigor | SP | 2.9 ±0.2 | 0.06 | 2.8 ±0.2 | **0.05*** | 2.6 ±0.4 | 0.38 | 2.4 ±0.3 | 0.48 |
| | IP | 2.2 ±0.6 | | 2.2 ±0.6 | | 2.2 ±0.9 | | 2.1 ±0.8 | |
| sleep quality | SP | 1.0 ±0.2 | 0.70 | 1.1 ±0.3 | 0.25 | 0.8 ±0.4 | 0.38 | 1.0 ±0.2 | 0.31 |
| | IP | 1.0 ±0.1 | | 1.5 ±0.1 | | 1.2 ±0.2 | | 1.2 ±0.1 | |
| physical enjoyment | SP | 3.6 ±0.7 | 0.67 | 4.0 ±0.8 | 0.77 | 4.5 ±0.4 | 0.33 | 3.9 ±0.8 | 0.54 |
| | IP | 3.2 ±0.8 | | 3.7 ±0.6 | | 3.8 ±0.5 | | 3.3 ±0.6 | |

SP = runners with stagnating performance; IP = runners with increasing performance; bold* = statistically significant differences between SP and IP (*P*≤0.05); bold italic = differences in time course of the parameters within SP or IP: [1]significantly different from the score at T1, [2]significantly different from the score at T2 and [3]significantly different from the score at T3 (*P*≤0.05).

***Predictive psycho-emotional parameters***

Table 2 depicts the time course of psycho-emotional parameters over T1-T4 for both groups and the differences in parameter scores between both groups at each test moment. The number and experience of daily hassles were registered per time period of 8 weeks. At T1 this period was the period of the previous 8 weeks. Additionally, over the same period the number of life events was registered, and distinguished in positive and negative events. The scores of hassles and life events in table 2 are the mean sum scores over this period.

Concerning the time course, SP showed a stable pattern for all parameters with only a significant decrease for the tension score between T1 and T4 ($P$= 0.03). IP showed a slightly less stable pattern over time, with incidentally significant decreases for the depression score between T2-T3 ($P$=0.05), tension between T2-T3 ($P$=0.02), and the number of life events between T3 and T4 ($P$=0.04).

Regarding differences between SP and IP at each test moment, the stressors daily hassles and life events, as well as sleep quality and physical enjoyment showed no differences between both groups (see Table 2). Differences in scores of anger, tension, and depression were mostly significant, whereas vigor and fatigue scores showed mostly no differences between both groups.

**Discussion**

This study indicated that a more negative mood profile in adolescent athletes, but not the amount or experience of stressors, differentiates between improved and stagnating performers. Specifically, higher levels of tension, anger, and depression were associated with a stagnating performance profile. In order to distinguish between stable and unstable differences in psycho-emotional parameters between groups (indicating more 'state' – or 'trait'-related influences), the effects of baseline differences were taken into account. In cases where stable differences between the groups were observed, we postulate the existence of 'trait'-related or pre-set level-related differences (predisposition) in stress-adaptation (33).

***Baseline differences***

Overall, the SP-group had higher mood scores on *every* subscale of the POMS than the IP-group with statistically significant differences in anger and tension scores (see Table 2). Relatively high negative mood scores are often associated with being stressed and being inadequately adapted to the performance that is needed (34). In this study, a stressful training- or competition event at baseline was absent, probably indicating that the observed scores of our runners in the SP group represented a reaction to general stressors. This is in line with a study of Raglin et al. (35), who also observed higher global mood scores at the start of the season in unsuccessful compared with successful rowers.

There was no indication that significant differences in daily hassles and life events were involved, although the IP group scored systematically lower on daily hassles and negative life events. Our results seem to indicate that the runners in the SP group have a general modus of being stressed with a significant impact on performance. An effect of hassles and life events on well-being has been found in a study of Serido et al. (36), who argued that daily hassles and life events have an unique influence on distress. Based on the results of this study, we postulate that in the SP group a certain trait-influence may exist with higher negative mood scores at the start of the season.

Hooper and McKinnon (33) already suggested in adult athletes that differences in mood scores could indicate a predisposition, leading to an impaired performance.

***Seasonal differences***

Concerning the time-course of the psycho-emotional parameters over the total season, we found stable patterns for both groups, with IP showing incidentally slightly more significant differences in various parameters over time. The continuously stable pattern of higher scores in SP seems to reflect a constant situation of heightened stress (see later) with a stable coping strategy.

The overall stability of the mood scores in both groups is different from the results of studies, in which dose-response relationships between training load and mood state were analyzed (18-20,37). Varying mood states over time have been observed as part of an adaptation process to an increasing training load during the season (37). In our study, the training load increased also during the season with peak loads during periodization (see section Training load). However, a focus on such a dose-response relationship was not our primary goal, as we wanted to get a more general picture during the season by measuring parameters with intervals of 8 weeks. Such a general picture refers to the responses of our runners to sport-specific stressors as well as general stressors (i.e. related to school, work, friends, domestic problems etc.) over a total season. Furthermore, we could not obtain data during a peak period in the periodization, because this interfered too much with the training program. Therefore, we did not monitor performances nor stressors or impact of stressors as a function of increasing training loads during periodization. This might explain the relative stable scores of the psycho-emotional parameters during the season for both groups, in line with the results of other studies (15,38).

Concerning the differences in parameters between SP and IP, we observed constantly higher scores in the POMS-subscales tension, anger, depression, vigor, and fatigue over a 7-months period in the SP-group (see Table 2). It is well known that negative mood scores are associated with a maladaptive response to (non) training-related stressors. For example, Tenenbaum et al. (39) observed elevated depression, anger and fatigue scores in a cyclist with a failure adaptation during the season, and Filaire et al. (13) observed higher tension scores in a professional soccer team, when the team performance dropped during the season. Elevated depression scores have been systematically associated with decreased performances and a failure in the efficacy to pursue goals (35,40). Such a link might explain why we could not find differences in depression scores at baseline between both groups, because the efficacy of goals will manifest itself during and not at the start of the season.

Vigor and fatigue scores were consistently higher in SP, although the differences were mostly not statistically significant. The fact that IP showed lower vigor scores was not expected. However, we have the experience that being less vigorous, combined with feelings of tiredness are common during a training season and, therefore, relative high vigor scores should not be considered as a marker of adequate adaptation per se. The silver medalist of the 1980 Olympic marathon stated during the peak moment of his career: "Always being tired was a part of my life" (personal communication). In addition, differences in training load-related fatigue and vigor scores may indicate differences in the capacity to endure training-related stress (15,38,41). As we did not measure the latter capacity, we cannot confirm whether higher scores in fatigue and vigor result in a stagnating performance by limitations in the capacity to endure training-related stress.

Negative mood scores were predictive for stagnating performances, whereas worsened sleep quality and decreased enjoyment were not predictive, although these parameters are often suggested to play a role in the overtraining syndrome or burnout (42). Therefore, only the emotional impact of the sports-specific and general stressors was found to be related to performance stagnation. This might be explained by the fact that these adolescent runners were still-training and were not experiencing a burnout of any kind. Morgan et al. (20) already showed that sleep disruptions are not reported as discriminative between good and bad performers, or even as a parameter of increased training stress. Additionally, motivational factors are complex and not just explained by experienced pleasure in sports, as assessed with our PACES questionnaire. Decisive may be the primary drive to demonstrate competence and self-validation, which has a tendency to restrict an athlete's ability to adapt when challenges in progress have to be overcome. However, such a motivational orientation is not restrictive when these barriers are not present, and hence, enjoyment in sport will be experienced (43).

***Limitations***

There are some limitations of this study. Firstly, the anthropometric data of the groups could not include Tanner's sexual maturating rating (SMR) (44), because we were unable to do this registration. Consequently, we do not know the matching of maturation over both groups, nor whether late maturers improved more than early maturers during the study period. Therefore, it cannot be ruled out that a late maturation is also a cause of a limited possibility to improve performances.

Secondly, due to the limited number of participants, it was not possible to investigate gender differences in the groups. Therefore, studies with a large number of participants are needed to establish the contribution of gender differences to the final outcome of this study.

***Conclusion and recommendations***

Outlining the major results of our study, the first hypothesis that an increased amount and intensity of stressors influenced performance profiles in adolescent middle- to long distance runners could not be verified. The second hypothesis that parameters linked to a failure in stress-adaptation are predictive for a stagnating performance profile, was partly verified. A consistent mood profile, as observed in SP, may indicate a predisposition to stress-adaptation and could be a self-selecting factor in seasonal performance-changes. Stagnating performers obviously regulate emotions in a different way than increasing performers. This study stresses mood as a discriminative factor for seasonal performance profiles. Especially elevated scores of tension, anger, depression and vigor were associated with runners showing a stagnating performance. Practically, we recommend the use of the shortened version of the POMS (at least once a month and preferably every week) by athletes and coaches, because relevant information can be obtained about emotional functioning and the ability to adapt to sports-specific or general stressors. Adolescent elite athletes train and compete at a high level and one should prevent that they slide slowly towards an unwanted performance stagnation.

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