CHAPTER 2

A negative life event impairs psychosocial stress, recovery and running economy of runners

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ABSTRACT

The purpose was to investigate how a negative life event (NLE) affects perceived psychosocial stress, recovery and running economy (RE). Competitive runners were monitored in a prospective non-experimental cohort study over one full training season in which they experienced the same unplanned severe NLE. Sixteen runners recorded stress and recovery scores (RESTQ-Sport) every week. The average scores over 3 weeks before the NLE were used as a baseline and were compared to scores during the week of the NLE (week 0), week 1 and week 2. Seven runners completed a submaximal treadmill test before and after the NLE. Repeated measures ANOVA’s revealed that most scores on general stress scales were increased in week 0 and 1. Of the general recovery scales, “general well-being” was decreased in week 0 and 1, “social” and “physical recovery” were decreased in week 0. No changes in the sport-specific stress scales were found. However, two of the sport-specific recovery scales were decreased in week 0. An impaired RE was shown 3 weeks after the NLE. Therefore, it is important to know what is going on in an athlete’s life, because stressful life events alter RE after the stress and recovery already returned to normal levels.

Keywords: perceived stress, competitive athletes, athletic training, exercise test, major life event
INTRODUCTION

Negative life events (NLE’s) are a source of sudden changes in perceived psychosocial stress and recovery. In addition, NLE’s are assumed to have an impact on training and performance of athletes. However, scientific evidence for this assumption is not available, because it is unethical to expose athletes to a NLE. NLE’s are defined as major life changes that are negatively appraised [23,33]. A NLE was in this study more specifically defined according to the taxonomy of Elliot and Eisendorfer (1982) as “stressful event sequences”, meaning a major event that causes a series of related challenges [8,29].

In the holistic model described by Kenntä and Hassmén it has been proposed that the balance between physical and psychosocial stress and recovery is related to athletic performance [16]. It is expected that a NLE disturbs psychosocial stress and recovery. In addition, a NLE could also be related to an increased perception of training stress. These changes in physical and psychosocial stress and recovery may eventually lead to a performance drop.

One can imagine that a NLE (e.g. serious illness of a close family member, death of a family member/mate or being a victim of a crime) influences perceived psychosocial stress and recovery. To our best knowledge, there is no information available about this relationship in athletes. There is an abundance of literature about positive and negative emotions and mood, which are stress and recovery related measures, in caregivers of AIDS patients in the period before and after the patient passed away [9,20]. The caregivers showed an increase in negative affect and a decrease in positive affect two weeks after the death of the patients, within 1 month the outcomes were similar to the outcomes before [9]. It is important to keep in mind that this study involved caregivers who experienced long lasting stress before the death of the patient. In another study, it has been shown that NLE’s are related to more daily hassles and less uplifts [14]. Daily hassles are defined as annoyances that occur during daily life and uplifts are events that make you feel good. These hassles and uplifts are only one component (i.e. mood) of perceived psychosocial stress and recovery. Previous research was done in middle-aged adults who experienced long lasting stress before the NLE or the study was in middle-aged adults and did not include an analysis of weekly changes after the NLE. Therefore, questions remain about the
impact of a NLE’s on perception of psychosocial stress and recovery in well-trained athletes.

There is a wealth of literature indicating that stress can negatively influence cognition, emotion, behaviour and health of adults [11,18,29]. In addition, literature about overreaching/overtraining provides insights into performance decrements of athletes. Overreaching/overtraining of athletes is defined as an accumulation of training and/or non-training stress resulting in decrement in performance capacity, either short term or long term, respectively [19]. Although it has been recognized that psychosocial stress can be (part of) the cause of decreased performance, studies involving overreaching and overtraining generally investigated effects of intensified training on psychosocial parameters and performance instead of investigating the influence of increased psychosocial stress on training parameters and performance. Other studies have shown that worsened stress and recovery state is associated with reduced performance gains [3,25], performance drop [6,7] and impaired physical recovery [18,31]. However, to our best knowledge, there are no studies that investigated the influence of a NLE on disturbance in psychosocial stress and recovery and corresponding performance indicators of well-trained athletes.

Prospective research in which a NLE happens unintentionally is the only possibility for investigation of the impact of a NLE on perceived psychosocial stress and recovery and performance indicators of athletes. The current study is part of a larger study in which several parameters including perceived psychosocial stress and recovery and performance indicators of approximately 90 endurance athletes were monitored for two years (running, cycling, rowing, ice skating and triathlon). Results of this large monitoring study are separated because of differences in research topics, protocols and sports. In its broad outlines, the research topics of the separated results are psychosocial stress and recovery, training distribution, injuries and submaximal performance.

The competitive runners who participated in the study experienced a severe unplanned NLE during the monitoring period and were therefore included in the current study. The first goal of this study was to investigate how the NLE affects aspects of perceived psychosocial stress and recovery of competitive runners. It has been previously shown that a NLE influences physical parameters and that misbalanced stress and recovery can influence performance, therefore
the second goal was to assess the influence of a NLE on performance indicators of competitive runners.

METHODS

Participants and design
Twenty-four competitive middle- and long-distance runners were monitored in a prospective non-experimental cohort study over one full training season (46 weeks). Sixteen of these runners (11 male and 5 female) completed the required questionnaires for this study to monitor stress and recovery and were included. Three of these runners competed at international level, eleven at national level and two at regional level. The mean (± SD) age, height and weight were 23 ± 4 years, 1.80 ± 0.05 m and 64.6± 7.0 kg, respectively. The runners who were included in this study did not differ in age, height, weight, VO2max and demographics from the 5 runners who were not included (p > 0.05).

At the start of the study, a sport physician medically cleared all runners according to the Lausanne recommendations [4] and a written informed consent was obtained. During the monitoring period, the runners kept a daily training log in which they all reported the same severe NLE. Following ethical guidelines, we cannot report the exact nature of the NLE. However, examples of severe NLE’s are being a victim of crime, serious illness or injury of a family member or mate and death of a family member or mate [23,26]. It should be emphasized that all athletes experienced the same NLE and that the NLE was of a severe nature. The study was approved by the local ethics committee and meets the ethical standards of the journal [12].

Perceived psychosocial stress and recovery
At the end of each week, the athletes filled out a Dutch online version of the RESTQ-Sport, which has shown sufficient reliability and validity for the purpose of monitoring changes in perception of stress and recovery. The test-retest reliability that was reported by Nederhof et al. was sufficient for most of the subscales (Cronbach’s alpha ranging from 0.70 to 0.90 for the 17 subscales [21]. Nederhof et al. showed insufficient reliability for “conflict/pressure” (Cronbach’s alpha; 0.55) and for “success” (Cronbach’s alpha; 0.67). Therefore, care should be taken when interpreting the results of these two scales. These reliability values are similar
to the results of the original questionnaire that was developed by Kellmann and Kallus [15]. The RESTQ-Sport was used to assess perceived psychosocial stress and recovery activities over the past week. The RESTQ-Sport consists of 77 items (including one warm-up item) divided into 19 scales of 4 items. Each item was scored on a Likert-type scale with values ranging from 0 (never) to 6 (always). The answers indicated how often athletes took part in various activities over the week. The questionnaire included seven general stress scales, five general recovery scales, three sport-specific stress scales and four sport-specific recovery scales. High scores on stress scales reflected high perceived psychosocial stress and high scores on recovery scales reflected more recovery related activities [15]. The scores of all separate scales were averaged over 3 weeks before the NLE to obtain a baseline measurement to which the outcomes of the week of the NLE, 1 and 2 weeks thereafter were compared.

**Training log**

To monitor training load, all runners kept an online training log in which duration and perceived exertion of each training session was recorded. Duration was recorded in minutes and perceived exertion was measured by session Ratings of Perceived Exertion (sRPE) on a scale from 6 to 20, 30 minutes after completing a training session or race. Training load is calculated by multiplying the duration in minutes with sRPE scores. This method has been proved to be valid to determine global training load for training sessions [5,10]. Training frequency, duration and training load are calculated for each week by summing the scores. sRPE scores were averaged for each week.

**Laboratory tests**

At the beginning of the season, all runners performed a maximal incremental treadmill test. Running speed during the warm-up phase was determined individually, depending on the runner’s maximal speed that was predicted by their coach, to finish the test in 8 to 12 minutes [17]. After five minutes, the speed continuously increased by 0.8 km/h per minute. The runners were instructed to run until exhaustion, and they were verbally encouraged to do their best during the test. During the entire test, the slope of the treadmill was set at 2%. \( \dot{VO}_{2\max} \) was defined as the highest 30 second rolling average of \( \dot{VO}_2 \) observed during the test.
Peak speed (Vpeak) was defined as the highest speed achieved by the runner during the test. Maximal heart rate (HR\textsubscript{max}) was determined as the highest HR during the test.

Submaximal tests were performed every 6-7 weeks and all runners were familiar to the test. The total duration of the submaximal test was 15 minutes. Running speed was set for 6 minutes at 55% (00:00 – 06:00 min:s), 6 minutes at 70% Vpeak (6:00-12:00 min:s), followed by 3 minutes at 85% Vpeak (12:00-15:00 min:s). Runners were asked for their Ratings of Perceived Exertion (RPE) 30 seconds before the end of each stage (after 5:30, 11:30 and 14:30 min:s, respectively).

Heart rate (HR) and running economy (RE) were calculated as submaximal performance indicators. The first stage of the submaximal test was used as warm up. HR during stage 2 (HR\textsubscript{2}) was calculated as an average of HR over the last 3 minutes of the stage (9:00-12:00 min:s). Due to the slow half-life of HR [1], the first minute of stage 3 was excluded from the analysis, which means that heart rate in stage 3 (HR\textsubscript{3}) was calculated over the last 2 minutes (13:00 - 15:00 min:s). RE is defined as steady state \(\dot{V}O_2\) during submaximal running [27]. To reach steady state \(\dot{V}O_2\), 3 minutes of \(\dot{V}O_2\) stabilization after an intensity change is required [13]. Therefore, \(\dot{V}O_2\) is only calculated for stage 2 of the submaximal test. \(\dot{V}O_2\) during stage 2 (\(\dot{V}O_2\)-2, respectively) was averaged over the same interval as HR\textsubscript{2}. \(\dot{V}O_2\)-2 is expressed as ml∙min\(^{-1}\).

A preliminary study in our laboratory showed that the day-to-day variation of HR and \(\dot{V}O_2\) during the submaximal treadmill test is 1-2% and 3%, respectively. These day-to-day variations are in line with previously measured variations [1,28]. All tests were performed in similar environmental conditions (temperature: 18.8 ± 0.9; relative humidity: 39.7 ± 11.6) on the same treadmill (Lode Valiant, Groningen, the Netherlands). During all tests, the slope of the treadmill was set at 2%. Gas exchange data were measured using an automated breath-by-breath analyser (Cortex Metalyzer 3b, Leipzig, Germany) and heart rate was recorded every second (Polar, Kempele, Finland). Runners were asked to refrain from strenuous exercise and drinking alcohol the day before each test and consuming caffeine in the last three hours before each test.
Data analyses

Descriptive statistics were determined for all parameters and represented as mean ± SD. All outcome variables showed to be normally distributed by a Shapiro-Wilk’s test (p<0.05) [24,30], visual inspection of histograms, normal Q-Q plots and box plots.

The period of data inclusion (RESTQ-Sport and training log) for this study was three weeks before the NLE, the week of the NLE and two weeks thereafter. In total, 96 RESTQ-sport questionnaires and 672 training log days were analysed. The average RESTQ-Sport scores, training frequency, duration, sRPE and training load over 3 weeks before the NLE were used as a baseline and compared to scores of week 0, 1 and 2 by repeated measures ANOVA’s with Bonferroni pairwise comparisons. Mauchly’s test of sphericity was used to determine whether the variances of the data were equal and the Greenhouse-Geisser correction was applied when necessary. To calculate the magnitude of the difference between pre-test and post-test, partial Eta squared (partial η²) was calculated (where 0.1 is a small, 0.25 is a medium, and 0.4 is a large effect size). In the fourth week before and in the third week after the NLE, seven athletes (5 male and 2 female) completed the submaximal test. These tests were analysed with paired t-tests to detect changes in submaximal performance indicators (HR2, HR3 and O2-2). Independent t-tests showed that there were no differences in age, height, weight, VO2max. RESTQ-Sport and training load between the entire group of 16 athletes and the subgroup of 7 athletes who completed the tests. The previously described analyses of the RESTQ and training load were done for both groups. Significance was set at 0.05. All statistical analyses were performed with SPSS 20 software (SPSS Inc., Chicago, IL, USA).

RESULTS

RESTQ-Sport

Figure 1 shows the average scores of all RESTQ-Sport scales. All scores on general stress scales are significantly increased in the week of the NLE (week 0) (Table 1). These scores were still increased compared to baseline in the week thereafter (week 1), except for “social stress”. Of the general recovery scales, “general well-being” was decreased in week 0 and 1; “social recovery" and “physical
recovery” were decreased in week 0. In week 2 there were no significant differences with the baseline. No significant changes in the sport-specific stress scales were found in the week during and the weeks after the NLE. However, “being in shape” and “self-efficacy” of the sport-specific recovery scales were decreased in the week of the NLE, but not the 2 weeks thereafter.

Training log
No change in training frequency was shown. Training duration decreased significantly with 102 minutes in the week of the NLE and 114 minutes in week 1, compared to baseline. In week 2 there were no significant difference between training load and training duration compared to baseline. There were no differences between baseline sRPE and sRPE in week 0, 1 and 2. However, weekly averaged sRPE scores in week 2 were 0.7 higher than sRPE in week 0. Weekly training load decreased significantly compared to baseline by 1611 AU in the week of the NLE and 1740 AU in week 1. These changes are shown by the solid line in Figure 2.

Submaximal performance indicators
Age, height, weight and \( \text{VO}_{2\text{max}} \) of the 7 runners who completed the submaximal test before and after the NLE is 24 ± 4.5 years, 181 ± 8.7 cm, 67 ± 10.0 kg and 60.9 ± 5.90 ml·kg\(^{-1}\)·min\(^{-1}\). These characteristics are not significantly different from the entire group. Changes in RESTQ-Sport scales after the NLE of these 7 runners are the same as the changes of the entire group. However, these 7 runners do not show significant changes in training load, although the pattern of changes is similar (see Figure 2).
<table>
<thead>
<tr>
<th>General</th>
<th>Baseline</th>
<th>Week 0</th>
<th>Week 1</th>
<th>Week 2</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>General stress</td>
<td>0.88 (0.57)</td>
<td>2.11** (0.85)</td>
<td>1.47* (0.89)</td>
<td>1.07 (0.76)</td>
<td>1.64, 24.54</td>
<td>18.82</td>
<td>0.000</td>
<td>0.556</td>
</tr>
<tr>
<td>Emotional stress</td>
<td>1.24 (0.53)</td>
<td>2.00** (0.68)</td>
<td>1.67** (0.67)</td>
<td>1.26 (0.69)</td>
<td>-</td>
<td>14.27</td>
<td>0.000</td>
<td>0.487</td>
</tr>
<tr>
<td>Social stress</td>
<td>1.04 (0.57)</td>
<td>1.72** (0.69)</td>
<td>1.36 (0.75)</td>
<td>1.09 (0.61)</td>
<td>1.92, 28.86</td>
<td>10.30</td>
<td>0.000</td>
<td>0.407</td>
</tr>
<tr>
<td>Conflicts/pressure</td>
<td>1.53 (0.71)</td>
<td>2.34** (0.75)</td>
<td>1.89* (0.65)</td>
<td>1.92 (0.78)</td>
<td>-</td>
<td>12.12</td>
<td>0.000</td>
<td>0.447</td>
</tr>
<tr>
<td>Fatigue</td>
<td>1.30 (0.64)</td>
<td>2.03* (1.06)</td>
<td>1.79* (0.99)</td>
<td>1.38 (0.66)</td>
<td>2.11, 31.65</td>
<td>8.60</td>
<td>0.001</td>
<td>0.364</td>
</tr>
<tr>
<td>Lack of energy</td>
<td>1.47 (0.64)</td>
<td>2.92** (1.15)</td>
<td>2.03** (0.91)</td>
<td>1.75 (0.81)</td>
<td>1.44, 21.54</td>
<td>18.40</td>
<td>0.000</td>
<td>0.551</td>
</tr>
<tr>
<td>Physical complaints</td>
<td>1.25 (0.49)</td>
<td>2.17** (0.84)</td>
<td>1.86** (0.61)</td>
<td>1.31 (0.54)</td>
<td>1.77, 26.52</td>
<td>12.17</td>
<td>0.000</td>
<td>0.448</td>
</tr>
<tr>
<td>General success</td>
<td>2.35 (0.54)</td>
<td>1.89 (0.79)</td>
<td>2.17 (0.55)</td>
<td>2.19 (0.51)</td>
<td>1.88, 28.26</td>
<td>2.67</td>
<td>0.090</td>
<td>0.151</td>
</tr>
<tr>
<td>Social recovery</td>
<td>3.22 (0.61)</td>
<td>2.47** (0.55)</td>
<td>3.02 (0.71)</td>
<td>3.11 (0.60)</td>
<td>-</td>
<td>6.20</td>
<td>0.001</td>
<td>0.293</td>
</tr>
<tr>
<td>Physical recovery</td>
<td>2.98 (0.56)</td>
<td>2.14** (0.58)</td>
<td>2.70 (0.70)</td>
<td>2.88 (0.60)</td>
<td>-</td>
<td>10.87</td>
<td>0.000</td>
<td>0.420</td>
</tr>
<tr>
<td>General well-being</td>
<td>3.34 (0.69)</td>
<td>2.00** (0.67)</td>
<td>2.59** (0.67)</td>
<td>3.13 (0.67)</td>
<td>1.93, 28.93</td>
<td>20.70</td>
<td>0.000</td>
<td>0.580</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>2.33 (0.44)</td>
<td>2.34 (0.60)</td>
<td>2.41 (0.51)</td>
<td>2.33 (0.47)</td>
<td>-</td>
<td>0.23</td>
<td>0.878</td>
<td>0.015</td>
</tr>
<tr>
<td>n = 16</td>
<td>Baseline</td>
<td>Week 0</td>
<td>Week 1</td>
<td>Week 2</td>
<td>df</td>
<td>F</td>
<td>p</td>
<td>Partial ( \eta^2 )</td>
</tr>
<tr>
<td>--------</td>
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<td>-------------------</td>
</tr>
<tr>
<td>Sport- specific</td>
<td>Disturbed breaks</td>
<td>1.03 (0.66)</td>
<td>1.09 (0.72)</td>
<td>1.02 (0.59)</td>
<td>0.92 (0.67)</td>
<td>2.03, 30.41</td>
<td>0.59</td>
<td>0.593</td>
</tr>
<tr>
<td></td>
<td>Emotional exhaustion</td>
<td>0.87 (0.68)</td>
<td>1.09 (0.81)</td>
<td>0.89 (0.82)</td>
<td>0.88 (0.55)</td>
<td>-</td>
<td>0.88</td>
<td>0.458</td>
</tr>
<tr>
<td>stress</td>
<td>Injury</td>
<td>2.19 (0.63)</td>
<td>1.84 (0.58)</td>
<td>1.95 (0.70)</td>
<td>2.08 (0.73)</td>
<td>-</td>
<td>1.45</td>
<td>0.241</td>
</tr>
<tr>
<td>Sport- specific</td>
<td>Being in shape</td>
<td>2.71 (0.66)</td>
<td>2.17* (0.49)</td>
<td>2.64 (0.75)</td>
<td>2.72 (0.71)</td>
<td>-</td>
<td>4.34</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>Pers. accomplishment</td>
<td>2.78 (0.62)</td>
<td>2.80 (0.58)</td>
<td>2.92 (0.64)</td>
<td>2.91 (0.78)</td>
<td>-</td>
<td>0.49</td>
<td>0.693</td>
</tr>
<tr>
<td>recovery</td>
<td>Self-efficacy</td>
<td>2.69 (0.63)</td>
<td>2.08* (0.65)</td>
<td>2.61 (0.78)</td>
<td>2.63 (0.82)</td>
<td>-</td>
<td>3.52</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>Self-regulation</td>
<td>1.78 (0.63)</td>
<td>1.52 (0.87)</td>
<td>1.91 (0.73)</td>
<td>1.88 (0.95)</td>
<td>1.75, 26.27</td>
<td>1.42</td>
<td>0.250</td>
</tr>
<tr>
<td>Training</td>
<td>Training frequency</td>
<td>6.5 (1.4)</td>
<td>6.0 (1.9)</td>
<td>5.7 (1.5)</td>
<td>6.4 (1.7)</td>
<td>2.00, 30.12</td>
<td>1.73</td>
<td>0.174</td>
</tr>
<tr>
<td>log</td>
<td>Training duration</td>
<td>539 (204)</td>
<td>437* (180)</td>
<td>425* (194)</td>
<td>473 (143)</td>
<td>-</td>
<td>3.21</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>sRPE</td>
<td>14.8 (2.3)</td>
<td>14.3 (2.5)</td>
<td>15.0 (2.3)</td>
<td>15.0* (2.3)</td>
<td>-</td>
<td>3.40</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>Training load</td>
<td>7271 (2875)</td>
<td>5660* (2469)</td>
<td>5531* (2782)</td>
<td>6335 (2173)</td>
<td>-</td>
<td>3.78</td>
<td>0.017</td>
</tr>
</tbody>
</table>

The baseline is the average of RESTQ-sport scales and training log over three weeks before the NLE. Adjusted degrees of freedom, F and p-values are shown if the assumption of equal variances was violated (df). * = significantly different from baseline with \( p \leq 0.05 \). ** = significantly different from baseline with \( p \leq 0.01 \). # = significantly different with \( p \leq 0.05 \) from week 0. sRPE = session Ratings of Perceived Exertion. Training duration is expressed in minutes and training load is expressed in arbitrary units.
Figure 1 Average RESTQ-Sport scores. Baseline scores are averaged over 3 weeks before the NLE. The week of the NLE is week 0. * represents the scales that are in week 0 significantly different from the baseline. ** represents the scales that are in week 0 and in week 1 significantly different from the baseline.
Figure 2 Average training load (AU). The week of the NLE is week 0. The open squares are the averaged training load over 3 weeks before the NLE (baseline). The straight line represents the entire group (16 runners) and the dotted line represents the 7 runners who completed the submaximal performance tests. * represents the weeks of which the training load of the entire group was significantly different from the baseline.

Table 2 shows paired t-test results of submaximal test results of 4 weeks before and three weeks after the NLE. No significant differences were found between submaximal HR before and after the NLE. However, VO$_2$-2 significantly increased by 130 ml·min$^{-1}$, which is 3.5%.

| Table 2. Paired t-test results of submaximal test |
|-----------------|-----------------|-------|-------|
|                 | Before NLE (SD) | After NLE (SD) | t     | p     |
| HR2 (bpm)       | 160 (9.7)       | 158 (10.3)     | 1.964 | 0.097 |
| HR3 (bpm)       | 174 (8.0)       | 172 (8.0)      | 1.370 | 0.220 |
| VO$_2$-2 (ml·min$^{-1}$) | 3689 (666.4) | 3820 (659.6) | -5.666* | 0.001 |

HR2 and HR3 are heart rate during the second and third stage of the submaximal test. VO$_2$-2 is oxygen uptake during the second stage of the submaximal test (running economy).
DISCUSSION

The goals of this study were to investigate how aspects of perceived psychosocial stress and recovery are affected by a NLE and to assess the influence of a NLE on performance indicators. The first finding of this study was that a NLE impairs aspects of general stress, general recovery and sport-specific recovery of athletes. These changes were shown during the week of the NLE and one week thereafter. In the second week after the NLE, all perceived psychosocial stress and recovery scores returned back to baseline. The second finding was that RE decreased after the NLE. The decrease in RE was shown three weeks after the NLE, compared to four weeks before the NLE. A change in training load was shown in the week of the NLE and one week thereafter.

A NLE influenced perceived psychosocial stress as well as recovery. Changes after the NLE were mainly shown by the increase of all general stress scales (e.g. “emotional stress” and “physical complaints”). Increased general stress was expected because NLE’s can affect the psychological wellbeing of a person [14]. Items of the RESTQ-Sport such as “I felt down” and “everything was too much for me” were scored higher, which means that these feelings were perceived more often. This is in line with the findings of a previous study in which positive states of mind and positive affect decreases and negative affect increases after a NLE [9]. Our results also showed that the scale of “physical complaints”, including items such as: “I felt physically bad” was scored higher up to one week after the NLE. Increased physical strain was also reflected in recovery scales of which “physical recovery” and “being in shape” were scored lower in the week of the NLE. These scales included items such as: “I felt physically relaxed” and “I recovered well physically”. These results are in line with a previous review showing that life stress can cause increased physical strain, for example decreased recovery and increased physical complaints [18].

The current findings showed increases in perceived psychosocial stress during the week of the NLE and one week thereafter. It is remarkable that the perception of stress returned to normal levels within two weeks. Social support and coping skills are important factors in effectively handling life stress [11] and may influence the perception of psychosocial stress. Therefore, an explanation for the relatively short period of disturbed psychosocial stress may be that all of the runners in our study trained in the same group and experienced the same NLE.
This might help the runners and coach to cope with the situation because they could support each other.

Previous research showed that a decrease in training load after a training camp coincides with decreased perceived psychosocial stress (i.e. combined general and sport-specific stress) [7]. Because of the decreased training load after the NLE in the current study, one may expect a decrease in sport specific stress. However, current results did not show a decrease in sport specific stress which indicates that sport specific stress is not only influenced by training stress, but also by a NLE. This may confirm an interaction between physical and psychosocial stress and recovery [16]. It may also indicate that the sport specific stress scale of the RESTQ-Sport is not able to detect rather small changes in training load. However, future research should determine to what extent changes in training load reflect changes in the RESTQ-Sport scales.

A reduced RE was shown after the NLE. The decrease in training load in the week of the NLE and the week thereafter are not likely to explain the reduction in RE, because it takes more than two weeks of altered training to induce changes in RE [2]. Decreased RE (i.e. increased submaximal VO\textsubscript{2}) that was shown after the NLE could be explained by the induction of a stress hormone response by the brain in a stressful situation [18]. It was shown in previous research that elite athletes with high life event stress had a higher cortisol concentration after an exhaustive exercise test, compared with athletes with low life stress [22]. Increased stress [3,25] and impaired recovery [31] coinciding with an elevated cortisol concentration could explain the finding of decreased RE. However, future research should investigate the relationship between changes in hormones caused by a stressful situation and the effect on RE.

It is noteworthy that no changes in submaximal HR were shown in the current study. HR is modulated through the autonomic nervous system as a reaction to stress [32]. During exercise, activity of the parasympathetic nervous system decreases and activity of the sympathetic nervous system increases [34]. It may be that the parasympathetic nervous system is differently affected by psychosocial stress than the sympathetic nervous system [32], which could explain that HR was not altered during exercise after the NLE. However, further research should investigate the underlying mechanisms of this hypothesis.
We were able to include weekly RESTQ-Sport questionnaires and daily training logs of 16 competitive runners of 6 weeks. However, not all athletes completed the submaximal tests. The current study showed that the characteristics (age, height, weight and \( \text{VO}_{2\text{max}} \)) and changes in perceived psychosocial stress, recovery and training load of 7 runners who completed the submaximal performance tests were similar to the changes that were shown by the entire group. This indicates that there was probably no selection bias.

This unique prospective study among competitive runners who all experienced a NLE showed disturbed perception of psychosocial stress and recovery in the week of and the week after the NLE. Furthermore, three weeks after the NLE, a decrease in performance was shown, indicated by a reduced RE. These results imply that an NLE impairs perceived psychosocial stress, recovery and submaximal performance. Therefore, it is very important to know what is going on in an athlete’s life, because stressful life events may alter performance of athletes after the stress and recovery returns to normal levels.

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REFERENCES
7] Coutts AJ, Wallace LK, Slattery KM. Monitoring changes in performance, physiology, biochemistry, and


