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Differences in autonomic response and self-reported stress response between high and low intensity training in female world-class biathlon athletes

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SAMTYKKE TIL HØGSKOLENS BRUK AV MASTEROPPGAVE I KROPPSØVING

Forfatter: **Kari Eie**

Norsk tittel: **Forskjeller i autonom respons og selv- rapportert respons mellom trening på høy og lav intensitet hos kvinnelige topptrente skiskyttere**

Engelsk tittel: **Differences in autonomic response and self-reported stress response between high and low intensity training in female world-class biathlon athletes**

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Forskjeller i autonom respons og selv- rapportert respons mellom trening på høy og lav intensitet hos kvinnelige topptrente skiskyttere

Eie, Kari

Avdeling for lærerutdanning ved Høgskolen i Nord- Trøndelag, Levanger.

SAMMENDRAG

Målsetting: Dette studiet ønsket å se nærmere på autonomisk respons og selvrapportert stress respons i en periode med trening på høy intensitet etterfulgt av en periode med trening på lav intensitet hos kvinnelige topptrente skiskyttere. **Metode:** Syv kvinnelige topptrente skiskyttere gjennomførte målinger på hvilepuls (HR_{rest}), utfylling av et vurderingsskjema; Daily Analyses of Life Demands for Athletes (DALDA), registrering av en form skala og treningsimpuls (TRIMP) gjennom en høyintensitetsperiode (HIT) som inkluderte 2-3 konkurranser og en lavintensitetsperiode (MOD). Hver morgen gjennomførte utøverne en 5 min liggende måling på HR_{rest} ved hjelp av Polar RS800 hjertefrekvensmålere og hver kveld svarte de på DALDA. I tillegg ble form skalaen fylt ut hver kveld etter middag. Treningsbelastningen ble rapportert i treningsdagbøker basert på hjertefrekvensmålinger. **Resultat:** Hvilepulsen økte signifikant gjennom en HIT periode og sank signifikant gjennom en MOD periode, og det var en signifikant forskjell mellom treningsperiodene. Det ble ikke funnet noen signifikante forskjeller på DALDA og form skalaen verken gjennom eller mellom HIT og MOD periodene. Ingen korrelasjoner mellom HR_{rest}, DALDA eller form skalaen ble funnet. **Konklusjon:** De signifikante forskjellene i HR_{rest} gjennom to ulike treningsperioder indikerer økt sympatisk aktivitet i en utholdenhetstreningsperiode med høy intensitet, og økt parasympatisk aktivitet i en utholdenhetstreningsperiode med lav intensitet hos kvinnelige topptrente skiskyttere. Det var ingen respons på selv- rapportert stress gjennom en utholdenhetstreningsperiode med høy intensitet eller gjennom en utholdenhetstreningsperiode med lav intensitet.

Nøkkel ord: Hvilepuls, DALDA, form skala, kvinnelige topptrente skiskyttere, utholdenhetstrening

Differences in autonomic response and self-reported stress response between high and low intensity training in female world-class biathlon athletes

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ABSTRACT

Purpose: The current study aimed to examine autonomic response and self-reported stress response during a high intensity endurance training period followed by a low intensity endurance training period in female world-class biathlon athletes. **Methods:** Seven female world- class biathlon athletes were monitored for resting heart rate (HR_{rest}) , Daily Analyses of Life Demands for Athletes (DALDA), the form scale and training impulse (TRIMP) during a high intensity endurance training period including 2-3 competitions (HIT), and a low intensity endurance training period (MOD). The athletes performed 5 min supine HR_{rest} measurements every morning by use of Polar RS800 heart rate monitors and completed the DALDA assessment daily after dinner. Additionally form and feeling were noted by use of the form scale. Training was recorded in training diaries based on HR recordings. **Results:** Resting heart rate increased significantly during HIT and decreased significantly during MOD, and there was found significant differences between the two training periods. No significant differences were found in DALDA or the form scale. Correlations showed no significant relationship between HR_{rest}, DALDA and form scale. **Conclusion**: The significant differences in HR_{rest} during the two different training periods indicates increased sympathetic activation in a high intensity endurance training period, and increased parasympathetic activation in a low intensity endurance training period in female world-class biathlon athletes. There were no responses to the self-reported stress during a high intensity endurance training period and a low intensity endurance training period. No correlations between HR_{rest}, DALDA or the form scale were found.

Key Words: Resting heart rate, DALDA, form scale, world- class female biathletes, endurance training

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INTRODUCTION

Endurance athletes aim to improve their performance levels and corresponding physical capacity. The training effect for endurance athletes is determined by the relationship between physical stress loads and recovery (Åstrand et al., 2003: 313-368). Physical training exposes the body to stress which in turn leads to a process of rebuilding its homeostasis. High training loads followed by recovery can lead to overcompensation (Åstrand et al., 2003: 313- 368). This in turn may cause a performance enhancement due to an improved function of the overloaded parameter. Additionally, training loads needs to be adjusted relatively to every athlete's status of training level (Åstrand et al., 2003: 313- 368). Therefore, an individual composition of intensity, duration and frequency is necessary to find the optimal distribution of total training loads (Hickson et al., 1985; Laursen and Jenkins, 2002; Åstrand et al., 2003: 313-368). The world`s best cross-country skiers vary the composition of intensity, duration and frequency during a training year in order to reach a high VO_{2max} in the competitive season (Ingjer, 1991). However, in order to achieve higher performance levels, the right balance between training and recovery is needed. This balance between training and recovery is an individual matter and possible consequences of an imbalance are underperformance and overtraining (Gustavsson et al., 2008). Furthermore, it can be individual differences in athletes responses to the point where overreaching occurs (Urhausen and Kindermann, 2002).

In the autonomic nervous system the parasympathetic and sympathetic activity controls HR and this autonomic balance can be induced by both emotional and physical stress (Earnest et al., 2004). Endurance athletes measure heart rate by use of heart rate monitors to determine the exercise intensity and resting heart rate to monitor fatigue and recovery, because changes in the autonomic nervous system may be reflected in HR (Achten and Jeukendrup, 2003, Earnest et al., 2004). Heart rate monitors implements precision in training intensity in any time, and it is possible to adjust the intensity during exercise (Achten and Jeukendrup, 2003). According to Borresen and Lambert (2008), resting heart rate decreases after high intensity training. Seiler et al. (2007) compared highly trained athletes with untrained subjects and showed that resting heart rate decreases faster in highly trained athletes.

A total stress load for biathletes includes both physical and psychological influences. In addition to physical stress, an athlete is exposed to several other psychological stressors. Stressors like sickness, injuries, sleeping disorders, family situation, work/school situation, lifestyle, weather, climate and light can be defined as psychological and external stressful factors. In this article the sum of physical, psychological and external stressful influences will be reviewed as total stress. According to Rushall (1990) athletes have an individual capacity of coping with different sources and symptoms of stress. The above mentioned stressors will affect an athlete in the regular training and during competitions. World-class athletes experience high psychological and high physical stress during competitions (Rushall, 1992).

It is necessary to monitor athletes' total load of stress both inside and outside the sport in order to understand the individual responses that occur. Daily Analyses of Life Demands for Athletes (DALDA) developed by Rushall (1990) is an inventory which measure sources and symptoms of stress. Physiological and psychological capacity of world-class biathlon athletes are most likely very high, but differences in their perceived total stress in different training periods have not yet been examined. Coutts et al. (2007) examined triathletes in performance, fatigue and recovery and claimed that DALDA is an effective and practical method for monitoring fatigue and recovery in triathletes with 3 years of experience and a minimum of 8 h per week of training. The difficulty of knowing exactly how each athlete feels concerning form and feeling at the end of a day with high or low training loads can be challenging for researchers. The description of an athlete's subjective experience of the training will be useful information (Gustavsson et al., 2008).

The purpose of the current study was to investigate how resting heart rate (HR_{rest}) and self-reported load of total stress (DALDA and form scale) respond during a high intensive endurance training period followed by a low intensive endurance training period in female elite biathlon athletes. In this connection, seven female world-class biathlon athletes were daily monitored for HR_{rest}, a DALDA assessment and a form scale during 5 days of high intensity training, including 2-3 competitions (HIT), followed by 5 subsequent days with low intensity training and recovery (MOD). It was hypothesized that HR_{rest} and responses in the DALDA assessment will increase. Furthermore HR_{rest} and responses in the DALDA assessment is proposed to decrease during MOD compared to the HIT. The study also wanted to examine a possible relationship between HR_{rest}, DALDA and form scale.

METHODS

Overall design of the study

In order to investigate HR_{rest}, DALDA, form and feeling the athletes were monitored successively during a five-day high intensity endurance training period including competitions followed by a five-day low intensity endurance training period (Figure 1). Resting heart rate was recorded during 5 min in the supine position each morning by use of Polar RS800 heart rate monitors. Subjective reporting of psychological factors was recorded every evening by use of a stress analysis tool, Daily Analyses of Life Demands for Athletes (DALDA) developed by Rushall (1987). Form and feeling was recorded every evening by use of a form scale developed by Gustavsson et al. (2008). Training was recorded in training diaries based on HR recordings. A modified total training impulse model (TRIMP) was used to calculate total training loads (Sandbakk et al., 2011).

Athletes

Seven female world-class biathlon athletes, all members of the Norwegian biathlon team, including World Cup and World Championship medal winners, volunteered to participate in the study. All the athletes were fully acquainted with the nature of the study before they gave their written consent to participate. The study was approved by the Regional Committee for Medical Research Ethics (REK), Norway. The athletes' physical characteristics and their latest training history are presented in Table 1.

Table 1: Baseline characteristics, as well as training and number of shots the last six months, of seven female world- class biathlon athletes (mean ± SD).

Variables	**mean ± SD**
Age (years)	25 ± 3
Body height (cm)	172.6 ± 3.3
Body mass (kg)	62.4 ± 7.3
VO_{2max} (ml· kg^{-1}· min^{-1})	64.1 ± 3.2
VO_{2max} (l · min^{-1})	3.9 ± 0.2
Training last six months (hours)	480.3 ± 47.6
Shooting last six months (number of shots)	13378 ± 3246

Training (hours) and shooting (total number of shots) were recorded from May to October. Vo_{2max} = maximal oxygen uptake during roller ski skating.

Heart rate monitoring

To measure HR_{rest}, a heart rate monitor was used (Polar RS 800, Polar Electro OY, Kempele, Finland). Heart rate data (heart beats) was transmitted online from the belt to the watch and then to a computer program (Polar Pro Trainer 5, Polar Electro OY, Kempele, Finland) which labeled each heart beat. Each athlete performed 5 minutes measurement of heart rate in the supine position 2 min after they woke up.

Daily Analysis of Life Demands for Athletes (DALDA)

DALDA is a psychological evaluation procedure which is valid for competitive athletes over the age of eleven years. The DALDA assessment contains 9 sources (PART A) and 25 symptoms (PART B) of stress. There are 3 possible options for answering; worse than normal (a), normal (b) and better than normal (c). It can be used as a tool for coaches to make better coaching and also to make better reviews and evaluations about an athlete (Rushall, 1987). According to Rushall (1987) following features can be measured:

- Training responses which are either too stressed or under stressed
- The ideal amount of stress to promote the optimum level of training effort
- The influence of outside-of-sport stresses that interfere with the training response
- Preliminary features of overtraining
- Reactions to travel fatigue and jet-lag
- Peaking responses

This procedure was used to measure the total stress of each athlete. The current study used the number of a-answers (“worse than normal”) in part B of the assessment (symptoms of stress) with the intent to capture increased stress. Each athlete answered the assessment every evening after dinner during a period of 17 days including 7 days of baseline for the athletes to become familiar with the assessment.

The form scale

A form scale was used during 17 days of competitive training. The form scale follows the athletes' subjective degree of recovery and effect of training load. Additionally, the form scale gives both an overall estimation of form as well as the local feeling in the muscles (Gustavsson et al, 2008). The form scale was scored on a + 4 to -4 point scale (4 = ekstremely good form, -4 =extremely bad form) in both form and feeling every evening. The form scale was used as an extra measure of fatigue, in addition to HRrest and DALDA.

Maximal oxygen uptake

To measure the athletes endurance capacity, all the subjects performed a maximal oxygen uptake (VO_{2max}) tests on roller skis, using a G2 skating technique (Nilsson et al., 2004). The test was conducted on a motor-driven treadmill (Bonte Technology, Netherlands; belt dimensions of 6 x 3 m, type treadmill), specially designed for roller-ski tests. After a standardized warm-up lasting for 20 min, a VO_{2max} test was performed. The tests were performed at inclinations from 10 to 14 percent, and the speed was increased every minute by 1 km h^{-1} until a level that brought the athletes to exhaustion, which occurred after 4-8 min. Oxygen uptake was measured continuously, and VO_{2max} was taken as the average of the three highest 10-s consecutive measurements. The following criteria considered the test to be a maximal effort: 1) blood lactate concentration > 8 mmol L^{-1}, 2) RER > 1.10 3) a plateau in VO_2 with increasing intensity (Gore, 2000). The measurement of gas exchange values were done via open-circuit indirect calorimetry using Oxycon Pro apparatus (Jeager, Hoechberg, Germany). To calibrate the O_2 and CO_2 gas analyzers high-precision gases (16.00 ± 0.04% O_2 and 5.00 ± 0.1% CO_2) before measurement was used. The inspiratory flowmeter was calibrated with a 3L volume syringe (Hans Rudolph Inc, Kansas City, MO, USA). Blood lactate concentration was determined by blood samples (5 µl), taken from the fingertip (Lactate Pro LT-1710*t*, ArkRay Inc, Kyoto, Japan; validated by Medbo et al., 2000).

Training during the study

All training during the study was recorded and quantified by HR recordings during each training session. Training was recorded in training diaries based on HR recordings. Training was categorized into1) low intensity (LIT; 60 - 82% of HR_{max}), 2) moderate intensity (MIT; 83 - 88 % of HR_{max}), 3) high intensity (HIT; > 88 % of HR_{max}) and 4) strength- and speed training. To calculate the overall training loads in each training period based on intensity and duration a modified TRIMP model according to Sandbakk et al. (2010) was used in this study. Originally TRIMP was introduced, developed and validated by Banister and Calvert (1980). TRIMP was calculated by multiplying the accumulated duration spent in each intensity zone by 1, 2 and 3 for the LIT, MIT and HIT, respectively. Strength- and speed training was multiplied by 2 as for the moderate intensity. The design of the study is presented in figure 1.

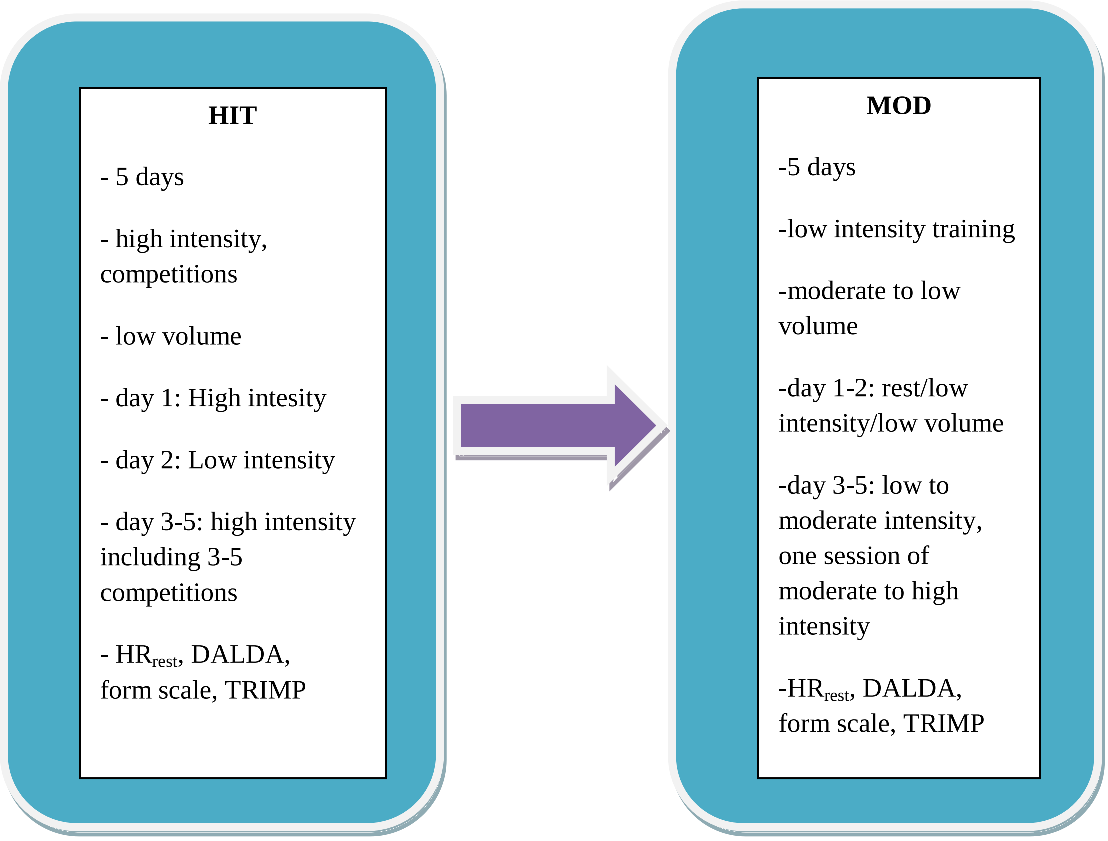

Figure 1: The design of two periods of different endurance training. HIT = high intensity endurance training period including competitions. MOD = moderate to low volume and low intensity endurance training period. (Ref: Emanuelsen, master thesis, 2009)

HIT started with one high intensity training session, followed by one day of low intensity training and rest. The last three days during the HIT- period, all the subjects participated in 2-3 succeeding competitions (2 x 1.4 km sprint, 7.5 km individual start and 12.5 km mass start). MOD included five days of rest or recovery training including one session of moderate to high intensity.

Data handling and calculations

In order to analyze differences between HR_{rest}, Dalda, the form scale and training loads in the two different training periods, a mean score was established at each variable for each person in the two training periods. For the form scale median was used as mean value because the variables were measured at an ordinal level. To analyze the development within each period one mean score was given to each person at each variable and represented the person`s score of the day.

Statistical analyses

All data were checked for normality by use of the Shapiro-Wilk`s test and are presented as mean and standard deviation (SD) unless otherwise stated. To compare means in HR_{rest}, training intensities and TRIMP between the two training periods, the paired-samples *t*-test was used. A one- factor within subjects ANOVA with the repeated measure of the time factor was used to analyze development of HR_{rest} over the entire 10-days training period. Possible follow up testing was carried out by the LSD paired *t*-test procedure. For non-parametric data (DALDA and form scale) the Wilcoxon matched pairs test was used to compare the two training periods. Friedman`s non-parametric test for several related samples was used to analyze the development of DALDA a-answers and the form scale during the entire 10-days training period. Possible follow up tests for finding differences were done by Wilcoxons test. Correlations between variables were tested using Spearman correlation coefficient test (HR_{rest}, DALDA a-answers and the form scale). Cross-correlations were used to detect time-lags between HR_{rest} and DALDA. Statistical significance was set at $p < 0.05$. All statistical tests were analyzed using SPSS 17.0 Software for Windows (SPSS Inc., Chicago, IL).

RESULTS

Training during the study

Table 2 shows the training during the study. High intensity training was significantly higher in HIT compared to MOD. Strength training was significantly higher in MOD compared to HIT ($p < 0.05$). There were no differences in low intensity training, moderate intensity training and speed training.

Table 2: Accomplished training during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean ± SD).

Variable	HIT (5 days)	MOD (5 days)
LIT (min)	419 ± 94	423 ± 117
MIT (min)	19 ± 22	30 ± 19
HIT (min)	83 ± 9*	9 ± 12
Strength (min)	-	27 ± 29 †
Speed (min)	1 ± 4	4 ± 6
Tot. training (min)	522 ± 93	492 ± 132
Tot. TRIMP	709 ± 104*	567 ± 90

LIT = low intensity endurance training (60 – 82 % of HR_{max}); MIT = moderate intensity endurance training (83 - 88 % of HR_{max}); HIT = high intensity endurance training (> 88 % of HR_{max}); Strength = strength training; Speed = speed training; Tot. training = total training including LIT, MIT, HIT as well as strength and speed; Tot. TRIMP = total TRIMP score in each period; HIT PERIOD = high intensity endurance training period including competitions; MOD = low intensity endurance training period. * = significantly different from the MOD period, $p < 0.05$.† = significantly different from the HIT period, $p < 0.05$.

Resting heart rate

Table 3 shows mean and range of HR_{rest} during the two training periods, while figure 2 gives the day to day variations for each athlete (Fig. 2 A-G) as well as for all athletes pooled (Fig 2 H). For all athletes pooled the HR_{rest} in the MOD period was significantly lower than the HIT period ($p < 0.05$). Additionally there were significant differences between day 1 and day 5, day 2 and 5, day 6 and day 8, day 6 and day 10, day 7 and day 10 ($p < 0.05$).

Table 3: Resting heart rate (beat per minute) during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean and range for individual values; mean and SD for all subjects pooled).

Athletes	**HIT (5 days)**	**MOD (5 days)**
1	45 (43-46)	41 (39-44)
2	55 (51-59)	53 (51-55)
3	59 (56-65)	56 (49-58)
4	47 (45-48)	45 (44-46)
5	55 (51-58)	55 (51-60)
6	63 (60-67)	63 (59-65)
7	59 (50-66)	50 (45-55)
Mean	**55 ± 7**	**52 ± 7***

*= Significantly lower HR_{rest} in MOD compared with HIT, $p < 0.05$.

Daily Analyses of Life Demands for Athletes

Table 4 shows mean and range of DALDA- answers ("worse than normal") during two training periods, while figure 2 gives the day to day variations for each athlete (Fig. 2 A-G) as well as for all athletes pooled (Fig. H). There were no significant differences between or within these two periods.

Table 4: DALDA (number of a-answers, "worse than normal") during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean and range for individual values; mean and SD for all subjects pooled).

Athlete	A-answers HIT (5 days)	A-answers MOD (5 days)
1	*0.0 (-)*	0.8 (0-4)
2	0.2 (0-1)	1.0 (0-3)
3	0.0 (-)	0.4 (0-1)
4	0.6 (0-2)	1.0 (1-1)
5	2.0 (0-3)	2.4 (0-5)
6	1.4 (0-3)	0.4 (0-1)
7	*0.4 (0-1)*	0.4 (0-1)
Mean ± SD	**0.7 ± 0.8**	**0.9 ± 0.7**

The form scale

Table 5 shows mean and range of form and feeling during two training periods. There were no significant differences between or within the two training periods.

Table 5: The form scale (scale values: +4 - ÷4) during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven female world-class biathlon athletes (data are given in median values and. Median and range for individual values; median for all subjects pooled).

Athlets	Form		Feeling	
	HIT (5days)	MOD (5days)	HIT (5days)	MOD (5days)
1	4 (3-4)	3 (3-4)	4 (3-4)	3 (3-4)
2	2 (1-3)	1 (0-1)	2 (0-3)	0 (-1-1)
3	0 (-1-1)	2 (1-2)	0 (-1-1)	2 (1-3)
4	0 (-1-0)	0 (-1-0)	0 (-1-0)	0 (-1-0)
5	1 (0-2)	0 (0-1)	1 (0-2)	0 (0-1)
6	0 (0-1)	0 (0-1)	0 (-1-(2))	0 (0-1)
7	0 (-1-1)	0 (0-1)	0 (-2-(-1))	0 (0-1)
Median	**0**	**0**	**0**	**0**

Figure 2 is showing mean of HR_{rest} and DALDA a-answers ("worse than normal") as day to day variation throughout the current study in each athlete (A-G), as well as for the athletes pooled (H). For all athletes there were significant increases in HR_{rest} in during the HIT period as well as a decrease in MOD. There were no significant differences in DALDA a-answers.

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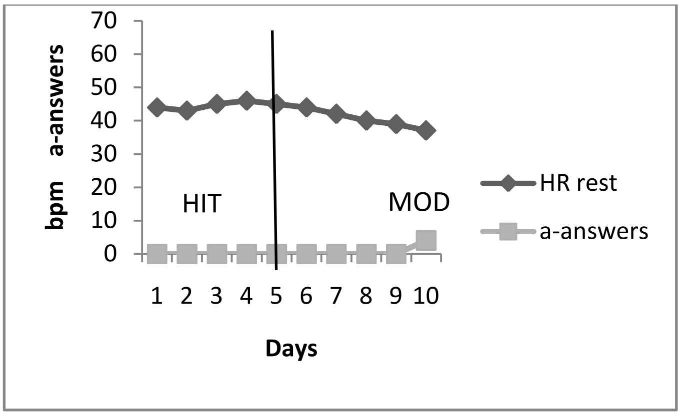

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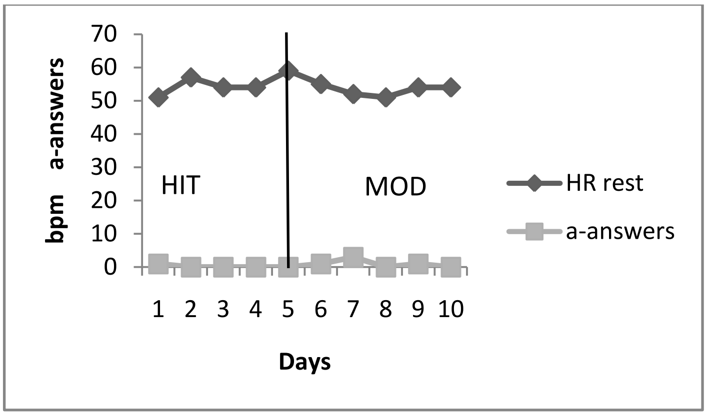

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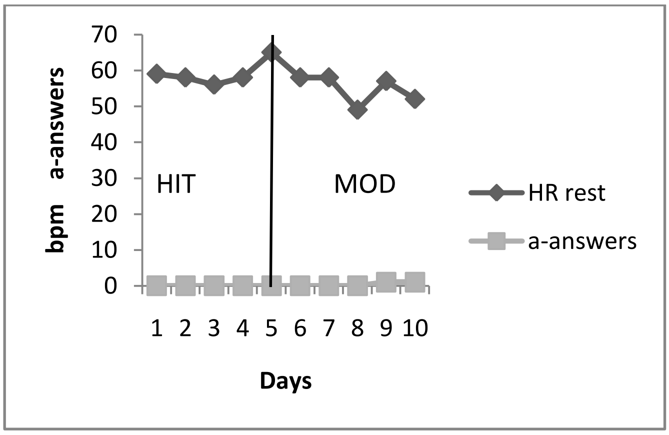

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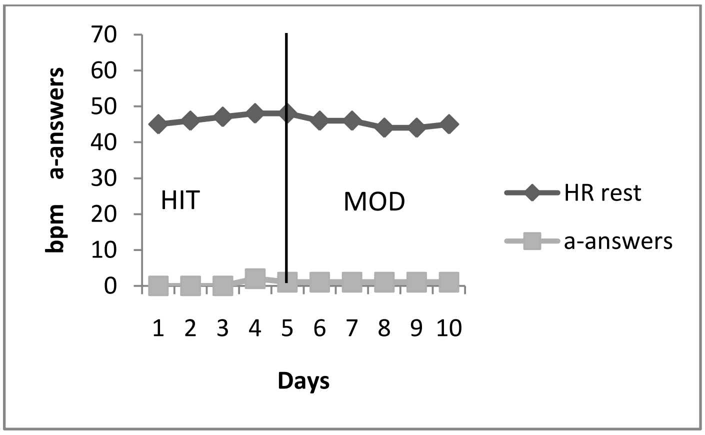

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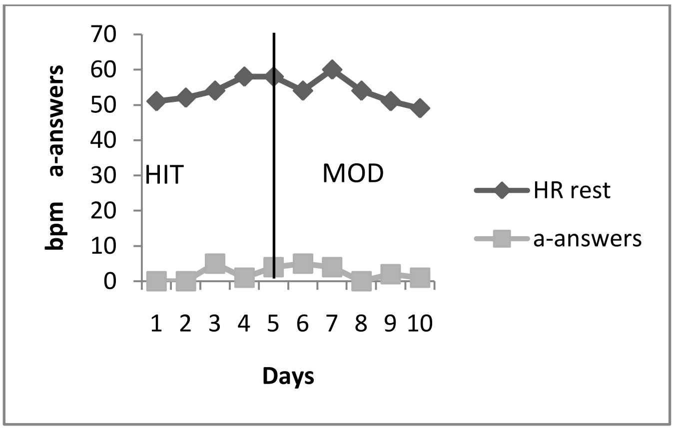

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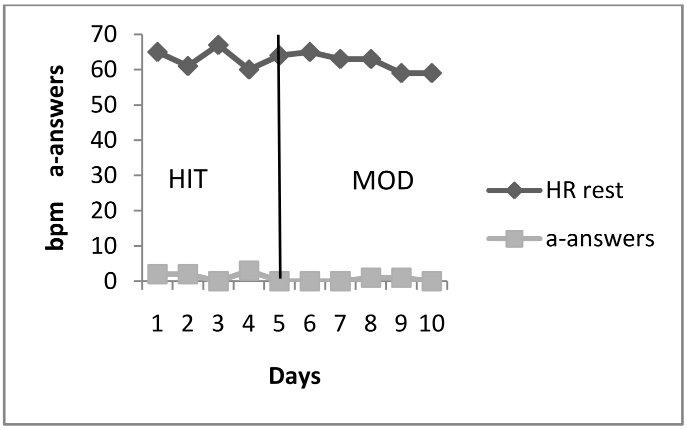

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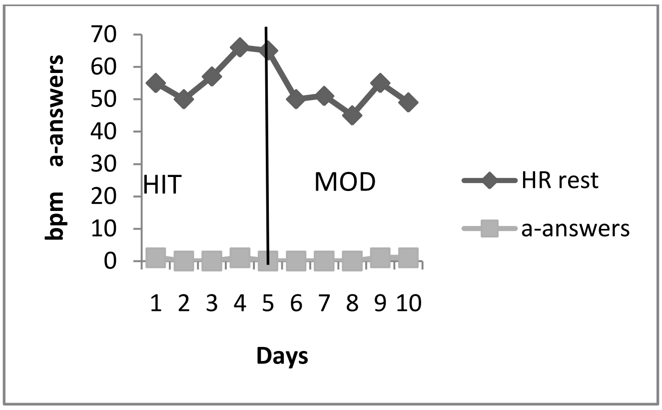

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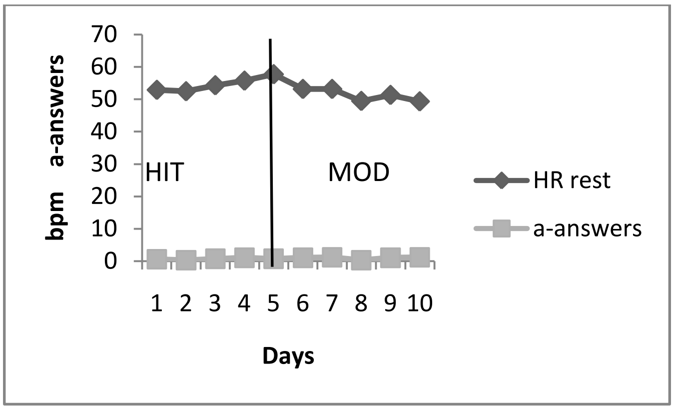

Figure 2A-H: Day to day variations in HR_{rest} and DALDA a-answers in each athlete throughout a high intensity endurance training period and a low intensity endurance training period. Figure H: Day to day variations in mean values of HR_{rest} (SD ± 7.3) and DALDA a-answers (SD ± 1.2) in all athletes pooled. The Y-axis shows score for HR_{rest} and number of a-answers in part B of the DALDA assessment. The x-axis shows the different days during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD).

Correlations between variables

There were no general or no individual day to day correlations between HR_{rest}, DALDA a-answers or the form scale. Nor were there any inter-individual cross correlations between HR_{rest} and DALDA a-answers.

DISCUSSION

The current study examined development of resting heart rate, symptoms of total stress and self-reported form and feeling during a high intensity endurance training period and a low intensity endurance training period in world-class biathlon athletes. The a-answers in the DALDA assessments refer to answers which is “worse than normal”. The major findings were as follows: 1) Resting heart rate increased significantly during HIT and was significantly higher than MOD. 2) Resting heart rate decreased during MOD and was significantly lower compared with HIT. 3) There were no significant differences in DALDA a-answers, form, feeling and fatigue between HIT and MOD.

Autonomic balance

The current study shows that HR_{rest} is induced by high intensity endurance training. The HIT period contained 3-4 bouts of high intensity training during 5 days. There was a significant increase in HR_{rest} from day 1 to 5 in the HIT period which indicates increased strain throughout the HIT period. The autonomic nervous system induces the heart rate and an increase in HR_{rest} during HIT is supported by other studies which show that a variation in HR_{rest} can be the result of total training loads (Borresen and Lambert, 2008; Seiler et al., 2007; Hautala, et al., 2000 and Kaikkonen et al., 2007). A decrease in heart rate recovery after physical training loads is justified as a coordinated interaction of parasympathetic re-activation and sympathetic withdrawal (Borresen and Lambert, 2008). This interaction process of parasympathetic re-activation and sympathetic withdrawal is, however, slower after maximal exercise compared to submaximal exercise because of a significantly higher stimulation of the sympathetic nervous system during maximal physical exercise (Borresen and Lambert, 2008). An increase in HR_{rest} in world-class biathlon athletes in the current study during several days of maximal physical exercise can possibly be explained by an above mentioned slower autonomic interaction process.

Additionally the current study found a significant decrease in HR_{rest} during MOD. This indicates a high degree of recovery during low intensity training for world-class athletes. A high ability of recovery for athletes in high level is in line with studies by Borresen and Lambert (2008) and Seiler et al. (2007) who claims that highly trained endurance athletes’ responses rapid and have accelerated heart rate recovery compared to untrained individuals in cessation of exercise. Too heavy training load over time might, however, lead to a parasympathetic dominance, bad recovery and finally no overcompensation but rather stagnation in performance. Because of a decrease in HR_{rest} during the MOD period the current study may indicate precision in low intensity training among the athletes. The current study also indicate a dynamic process of sympathetic and parasympathetic activity because of the appropriate variation of increase and decrease in HR_{rest} in relation to training intensity during a HIT period followed by a MOD period.

Total stress

Analyzes of a- answers ("worse than normal") in DALDA in the current study did not show any significant differences in DALDA during two training periods. However, Coutts et al (2007) showed DALDA to be an effective and practical method for monitoring fatigue and recovery and found a significant increase in a-answers part B. Since the subjects in Coutts analyze had 3 years of experience and a training volume of 8 h per week, there are some differences in the experience and training level compared to world-class biathletes. In the current study most of the biathletes had international experience of biathlon competitions in World Cup. In addition there were achieved World Championships medals and World Cup victories among the athletes. The current study does not suggest DALDA not being valid as a measurement, but high level of performance and assumed high tolerance for stress may indicate that female world class biathletes are strong both physically and psychologically; therefore, a marginal difference in DALDA is the outcome of this study. World-class biathlon athletes are used to withstand the stress that comes with high and intensive training loads and also competitions. The athletes are in balance both physically and psychologically and manage recovery between every exercise bout.

A more extreme overload training regime would probably lead to a greater impact in this level of endurance trained representatives. The current study refined the investigated athletes to be the ones with high performance level, strong health and no symptoms of sickness and overtraining before the high intensive training period started with the intent to have the highest possible level in the participants. By including imbalanced athletes in the current study, there would probably be a higher respond in the total stress.

Interestingly, the results of the current study are in contrast with Nicholls et al (2009) which showed a delayed increase in DALDA symptoms after competitions. Additionally Nicholls (2009) found differences in DALDA symptoms on training days compared with resting days. The current study did not find any delayed increase in DALDA symptoms or on training days compared with resting days. This could indicate that highly trained athletes are less sensitive but rather focused and concentrated to finish hard training and competition days with high quality, and further accept a tired state as "normal" in the subsequent days. HR_{rest} may be a more accurate measurement for fast responds during high and low intensive training for athletes in the current study.

For a biathlete in world class level HR_{rest} increased and decreased significantly during these two periods, but on the other hand symptoms of total stress showed no obvious variations during the study.

Form Scale

Analyses of the form scale did not show any significant variations during HIT and MOD. This indicates either a stable pattern in their report of both form and feeling in the muscles, or the form scale to be too wide to capture symptoms of tiredness and bad recovery. In the current study there were no differences in either DALDA or the form scale which indicates the world-class biathlon athletes to be affected by a stable and capable load of total stress. An issue of underreporting symptoms of total stress can, however, be related to the competition days. To increase the feeling of self-confidence and physical shape, an "over positive respond" to total stress these days may have occurred. From another perspective, good results in the competitions in the HIT period indicate no under-reporting.

Limitations of this study

The present study used the assessment Daily Analyses of Life Demands for Athletes to measure total stress in athletes. According to Rushall (1990) the DALDA assessment procedure should contain a baseline period of from two to four weeks. In this study we had one week baseline and this period was also used as an indicator of a normal training period for these biathletes. The whole study lasted for 16 days. Another aspect of the non significant DALDA results is the biathletes ability of describing their own situation concerning factors like home life, sleeping disorders, sickness and friends. Not knowing exactly what normal is could induce the results and their describing as normal may vary from one day to another.

Despite the standardized conditions, psychological factors might have been affecting the subjects differently, leading to different HR_{rest} response. The measurements of HR_{rest} were performed in hotel rooms or at home, and may not be considered as highly standardized as in laboratory conditions. However, this together with the short baseline period in DALDA were necessary trade-offs, acquired for achieving HR_{rest} and DALDA data from female world-class athletes during 16 days of competitive training. Additionally, there may be other factors apart from the variables measured during this study that might affect HR_{rest}, such as, insufficient sleep, psychological and physical stress, as well as breathing rhythm, light, noise and temperature (Task Force of the European Society of Cardioligy and the North American Society of Pacing and Electrophysiology, 1996: Achten & Jeukendrup, 2003; Song & Lehrer, 2003).

Conclusion

The current study showed variations in HR_{rest} in female world-class biathlon athletes during ten days of high intensity and low intensity endurance training. An increase in HR_{rest} during a HIT period including competitions indicates activation of the sympathetic nervous system. A decrease during a MOD period indicates activation of the parasympathetic nervous system. In contrast there were no responses in DALDA or the form scale during the HIT period or the MOD period. This indicates no remarkable influences of total stress in world-class biathlon athletes during ten days of high intensity and low intensity endurance training.

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TABLES AND FIGURES

Tables:

Table 1: Baseline characteristics, as well as training and number of shots the last six months, of seven female world- class biathlon athletes (mean ± SD).

Table 2: Accomplished training during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean ± SD).

Table 3: Resting heart rate (beat per minute) during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean and range for individual values; mean and SD for all subjects pooled).

Table 4: DALDA (number of a-answers, “worse than normal”) during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven world-class biathlon athletes (mean and range for individual values; mean and SD for all subjects pooled).

Table 5: The form scale (scale values: +4 - ÷4) during two a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD) in seven female world-class biathlon athletes (data are given in median values and mean and range for individual values; mean and SD for all subjects pooled).

Figures:

Figure 1: The design of two periods of different endurance training. HIT = high intensity endurance training period including competitions. MOD = moderate to low volume and low intensity endurance training period.

Figure 2A-G: Figure 2A-G: Day to day variations in HR_{rest} and DALDA a-answers in each athlete throughout a high intensity endurance training period and a low intensity endurance training period. Figure H: Day to day variations in mean values of HR_{rest} (SD ± 7.3) and DALDA a-answers (SD ± 1.2) in all athletes pooled. The Y-axis shows score for HR_{rest} and number of a-answers in part B of the DALDA assessment. The x-axis shows the different days during a high intensity endurance training period (HIT) and a low intensity endurance training period (MOD).

APPENDIX

Table 1, Appendix: Table 1 is showing the form scale (Gustavsson, 2008).

The form scale.

	Form		**Følelse**
4	Ekstremely good form	**4**	Ekstremely light feeling
3	Very, very good form	**3**	Very, very light feeling
2	Very good form	**2**	Very light feeling
1	Good form	**1**	Light feeling
0	Normal form	**0**	OK feeling
-1	Not so good form	**-1**	Somewhat heavy feeling
-2	Very bad form	**-2**	Very heavy feeling
-3	Very, very bad form	**-3**	Very, very heavy feeling
-4	Ekstremely bad form	**-4**	Ekstremely heavy feeling

Table 2, Appendix: Table 2 is showing the DALDA assessment (Rushall, 1990), part A = sources and part B = symptoms of stress.

DALDA PART A

	Alternative	**Sources**
1	a b c	Diet
2	a b c	Home-life
3	a b c	School/Work
4	a b c	Friends
5	a b c	Sport Training
6	a b c	Climate
7	a b c	Sleep
8	a b c	Recreation
9	a b c	Health

DALDA PART B

	Alternative	Symptoms
1	a b c	Muscle pains
2	a b c	Techniques
3	a b c	Tiredness
4	a b c	Need for a rest
5	a b c	Supplementary work
6	a b c	Boredom
7	a b c	Recovery time
8	a b c	Irritability
9	a b c	Weight
10	a b c	Throat
11	a b c	Internal
12	a b c	Unexplained aches
13	a b c	Technique strength
14	a b c	Enough sleep
15	a b c	Tiredness
16	a b c	General weakness
17	a b c	Interest
18	a b c	Arguments
19	a b c	Skin rashes
20	a b c	Congestion
21	a b c	Training effort
22	a b c	Temper
23	a b c	Swellings
24	a b c	Likability
25	a b c	Running nose