Mastergradsoppgave

Nocturnal cardiac autonomic recovery after high-intensity interval and long-slow duration treadmill running in young male, well-trained endurance athletes

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HiNT
HØGSKOLEN I NORD-TRØNDELAG

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SAMTYKKE TIL HØGSKOLENS BRUK AV MASTEROPPGAVE I KROPPSØVING

Forfatter: Saija Mikkilä

Norsk tittel: Restitusjon i det autonome nervesystemet under søvn etter hard intervalltrening og rolig langkjøring ved løping på tredemølle hos unge mannlige, godt trente utholdenhetsutøvere

Engelsk tittel: Nocturnal cardiac autonomic recovery after high-intensity interval and long-slow duration treadmill running in young male, well-trained endurance athletes

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Saija Mikkilä
underskrift

ABBREAVIATIONS

HF	high frequency power, estimate of the parasympathetic activity
HF n.u.	high frequency power in normalized units, HF/(total power-VLF)*100
HIIT	high-intensity interval training
HRV	heart rate variability
LSD	long-slow duration
LF	low frequency power, estimate of the sympathetic activity
LF n.u.	low frequency power in normalized units, LF/(total power-VLF)*100
LF/HF	ratio of low frequency to high frequency power, estimate of the sympathetic activity
RR interval	oscillation between two adjacent R waves
SDNN	standard deviation of RR intervals
SWS	slow wave sleep
TP	total frequency power, estimate of the global heart rate variability
TRIMP	training impulse
VLF	very low frequency component, physiological explanation is not widely defined

NORSK SAMMENDRAG

Formål: Målet med studiet var å undersøke restitusjon i det autonome nervesystemet under søvn etter to forskjellige treningsøkter, hard intervalltrening og rolig langkjøring, med omtrent tilsvarende treningsimpuls. *Metode*: Fire godt trente utholdenhetsutøvere deltok i denne studien. Idrettsutøveres hjertefrekvens variabilitet ble overvåket under søvn i 7-dagers protokollen: etter to dager uten trening, etter hard intervalltrening og rolig langkjøring. Idrettsutøveres livskvalitet ble undersøkt ved hjelp av Quality of Life Index spørreskjema. Spørreskjemaet ble returnert for hver kveld for å vurdere de ikke-treningsrelaterte stressfaktorer som kunne påvirke hjertefrekvens variabilitet. Daglig aktivitet ble loggført i utøvernes individuelle dagbok i løpet av studiet. *Resultater*: Ingen signifikant effekt på restitusjon i det autonome nervesystemet under søvn ble funnet mellom hvile og trening, eller mellom treningsøktene. Dessuten var det ingen signifikant endring i livskvalitet, og daglig aktivitet inkludert ikke mer fysisk trening enn tildelt. *Konklusjon*: En enkelt hard intervalltrenings økt, og en enkelt rolig langkjørings økt med omtrent tilsvarende treningsimpuls påvirker ikke restitusjon i det autonome nervesystemet i dette utvalget når livskvaliteten forblir uendret. Akkumulert fysisk stress grunnet trening bør tas hensyn til når hjertefrekvens variabilitet brukes som restitusjons mål, og det individuelle mønsteret i restitusjon i det autonome nervesystemet bør undersøkes for effektiv treningsplanlegging.

Nøkkelord: hjertefrekvens variabilitet, treningsimpuls, utholdenhetstrening

ABSTRACT

Purpose: This study aimed to investigate the nocturnal cardiac autonomic recovery after two different training sessions, high-intensity interval training session and long-slow duration training session, with approximately equivalent training impulse. *Methods*: Four well-trained male endurance athletes participated in this study. Athletes' nocturnal heart rate variability was monitored during 7-day protocol: after two non-training days, and for two nights after high-intensity interval trainings session and long-slow duration training session. Athletes' life satisfaction was investigated by using the Quality of Life Index questionnaire. The questionnaire was returned for every evening in order to consider the non-training stressors influencing the heart rate variability. Also, daily activity was noted on athletes' individual diary during the study. *Results*: No significant effect in the nocturnal cardiac autonomic recovery was found between rest and training sessions, or between the training sessions. Also, no significant change in life satisfaction was found, and daily activity did not include any additional physical training. *Conclusion*: A single high-intensity interval training session and a single long-slow duration session with the approximately equal training impulse do not affect the nocturnal cardiac autonomic recovery in this study when the non-training stressors remain unchanged. Accumulation of physical stress due to training should be considered when using the heart rate variability as recovery monitor, and individual pattern in the cardiac autonomic recovery should be investigated in order to achieve greater understanding when planning of training program.

Keywords: heart rate variability, training impulse, endurance training

i FULLMAKTSERKLÆRING
ii ABBREVIATIONS
iii NORSK SAMMENDRAG
iv ABSTRACT

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1 INTRODUCTION

Extensive training in elite athletes requires adequate recovery in order to increase performance or performance potential, and to avoid overtraining or other severe health problems (Lehmann, et al., 1991; Lehmann, et al., 1997; Kenttä & Hassmén, 1998). In order to increase the performance capacity, the principles for overload and recovery has to be concerned. Fatigue caused by physical stress in training has to be followed by recovery in purpose to adapt to the training stimuli. Hypothetically, the higher the training stimulus, the longer recovery is needed. In endurance training the recovery time can be up to 48 hours when a high-intensity interval training session is concerned (Rushall & Pyke, 1990 pp. 46, 217). The lowest recovery time can be achieved with a long-slow duration training session (ibid. p. 217). Further, athletes respond to training individually, i.e. the stress caused by training and the need for recovery varies among athletes. There is not a sufficient method to measure the individual athlete's optimal overload/recovery ratio (ibid. pp. 28, 31). Also, the non-training stressors, such as psychological and social issues, should be concerned if the recovery appears to be inadequate and the athlete is showing signs of overtraining. Decreased performance and disturbed sleep could for instance be indicators for overtraining. It should also be noted that overtrained athletes could appear to be very motivated and willing to train harder in order to compensate for the decreased performance (Kenttä & Hassmén, 1998). Also, in the overtrained state the autonomic nervous system is altered. Israel (1976) suggests two types of overtraining: sympathetic and parasympathetic. Sympathetic overtraining reflects overload in the sympathetic nervous system, and causes athlete to be tired, restless and have decreased heart rate in rest. In parasympathetic overtraining, the heart rate will not increase properly even in exercise, and the athlete can appear depressed and phlegmatic.

Heart rate variability (HRV) indicates health matters in various populations, and is affected by sleep, environment, psychological stress and exercise, just to name a few. It has also been said to reflect the state in the autonomic nervous system and to provide essential information of the parasympathetic regulation, which is significant for post-exercise recovery and maintaining homeostasis (Task Force, 1996; Aubert et al., 2003; Brandenberger et al., 2005; Carter et al., 2003; Al Haddad et al., 2009; Vanderlei et al., 2009). Heart rate variability has been widely investigated during and after exercise at the daytime (Carter et al., 2003; Seiler et al., 2007; Manzi et al., 2009), and after exercise at the nighttime (Pichot et al., 2000; Al Haddad et al., 2009; Hynynen et al., 2006; and Hynynen et al., 2010), with conflicting results. It should be noted that the HRV is not a direct measure for the autonomic modulation of the heart, although a well-established method in sports science, especially concerning the vagal-related activity, which is important for the recovery (Aubert et al. 2003). Further, no consistent method for HRV registration during the day or night is provided, and various populations are used in the investigations, making generalization of the results somewhat difficult. The main finding for the daytime recordings is that the total HRV registered in rest is increased by physical training, and the parasympathetic modulation of the heart is decreased during exercise. In highly trained athletes, the HRV is not affected by low intensity training, and the recovery to the resting HRV values is more rapid compared to recreational or less trained athletes (Carter et al., 2003; Seiler et al., 2007). Nevertheless, neither of these studies with daytime HRV registrations takes a single exercise session into consideration in a matter that would exclude accumulation from the previous sessions. Furthermore, Seiler et al. (2007) compared five different exercise sessions with unequal training impulses (TRIMP), and the equivalent TRIMP in different exercise sessions was not investigated. Manzi et al. (2009) took the individual TRIMP into consideration, which follows the training principle of individuality when the impulse is adjusted for one and each athlete individually (Rushall & Pyke, 1990 p.84), and concluded that dose-response relationship was significant in recreational athletes. However, the accumulation was not considered in the study, as well as the baseline was measured after a 4-week non-training period. Also in the Pichot et al. (2000) and Hynynen et al. (2010) nocturnal studies the accumulation was allowed, a single session was not investigated, and the TRIMP for the exercise sessions was not equal. Hynynen et al. (2006) found no significant difference in nocturnal HRV between overtrained and non-overtrained athletes, although the HRV in the morning, immediately after awakening, was lower in overtrained athletes compared to the non-overtrained control group.

Sleep is the most important period for the recovery and the slow-wave sleep (SWS) is commonly dominated by vagal activity, therefore it provides a beneficial opportunity to monitor cardiac autonomic recovery (Task Force, 1996; Aubert, et al., 2003; Brandenberger, et al., 2005; Al Haddad et al., 2009). The effects of training on the nocturnal HRV are somewhat unrevealed. Also, according to the author's best knowledge, the HRV has not been investigated in the matter that a single session is considered, or that the TRIMP is equal in the respective exercise sessions. The recent technology with commonly accessible heart rate monitors provides a noninvasive method for HRV investigations. Further, this technology is also suitable for athletes monitoring their own training without laboratory access. Therefore, an opportunity to monitor athletes in their own environment, and improve the measurement validity by excluding the disturbance caused by an unfamiliar environment and sleeping conditions, is available. Even though the autonomic modulation of the heart during exercise has to some degree been elucidated, the autonomic recovery is still not fully understood (Javorka et al., 2002), especially with respect to single exercise sessions excluding the accumulation effect of repeated training sessions. Therefore, the purpose of this study was to investigate nocturnal cardiac autonomic recovery in well-trained male endurance athletes after three different exercise conditions: 1) after two non-training days to define the baseline, 2) after a long-slow duration (LSD) session and 3) after a high-intensity interval training (HIIT) session. The training sessions were performed running on a treadmill. The TRIMP was calculated to be approximately equal for the LSD and HIIT sessions, and it was hypothesized that the HIIT session would decrease the global nocturnal post-exercise HRV compared to the non-training day and the LSD session. Further, it was also hypothesized that the parasympathetic and sympathetic related indices would be depressed after the HIIT session compared to the non-training day and the LSD session and, moreover, that return to baseline was more rapid after LSD than after HIIT.

2 METHODS

Overall design of the study

In order to investigate the nocturnal cardiac autonomic recovery, measured by registrations of the nocturnal HRV, four well-trained male endurance athletes performed the 7-day protocol (Table 1, p. 5). Maximal oxygen uptake ($VO_{2\ max}$) and lactate threshold were measured < 20 days before the subjects entered the study. The subjects were divided in to two exercise groups, and a randomized cross-over design including a HIIT and a LSD session with approximately equal TRIMP was performed by running on a treadmill. Athletes followed their regular training plan until the protocol began with two non-training days, followed by the 3rd day with a training session, and 4th day without training. On the 5th day the other training session was performed, and the 6th day was a non-training day. The protocol was enclosed in the morning of the 7th day. Athletes 1 and 3 performed the HIIT session before the LSD session, and athletes 2 and 4 performed the LSD session before the HIIT session. Further, the training sessions were separated by 48 hours, and as the exercise sessions had duration of 62 minutes (HIIT) and 120 minutes (LSD), the starting time was adjusted in that matter that the exercise would end either 10:30 a.m. or 1:00 pm in order to avoid changes in the circadian rhythm of an individual athlete. The athletes were prohibited from engaging in any physical training during the protocol. Daily activities such as walking or biking to school were allowed, and the activities were noted in the athletes' diary for the 7-day period. Heart rate variability was measured during all 6 nights in the 7-day period including two additional nights after the last training session. Athletes also returned a questionnaire for every evening during the study concerning athletes' life satisfaction (Quality of Life Index, see "Quality of Life Index and daily activity" below). All testing and training sessions were performed at the Meråker High School (Meråker videregående skole) in the North-Troendelag County, Norway.

Table 1. The 7-day protocol and cross-over design for the two exercise groups, both including two endurance athletes.

DAY	GROUP 1	GROUP 2
1	No training/ nocturnal HRV/QLI/diary	No training/nocturnal HRV/QLI/diary
2	No training/ nocturnal HRV/QLI/diary	No training/ nocturnal HRV/QLI/diary
3	HIIT/nocturnal HRV/QLI/diary	LSD/nocturnal HRV/QLI/diary
4	No training/ nocturnal HRV/QLI/diary	No training/ nocturnal HRV/QLI/diary
5	LSD/nocturnal HRV/QLI/diary	HIIT/nocturnal HRV/QLI/diary
6	No training/ nocturnal HRV/QLI/diary	No training/ nocturnal HRV/QLI/diary
7	End of registration in the morning	End of registration in the morning

HRV= heart rate variability; HIIT= high-intensity interval training; LSD= long-slow duration; QLI= Quality of Life Index questionnaire; diary= record for daily activities

Subjects

One male biathlon skier and three male cross-country skiers, with $VO_{2\,max} \geq 70$ ml/(kg·min) and the age span of 19-21 years, completed the study. The athletes were recruited from the Meråker High School. A total of ten athletes that met the inclusion criteria (male, age 18-25, $VO_{2\,max} > 60$ ml/(kg·min)) volunteered to participate in the study. However, one of the recruited athletes was excluded due to a chronic medical condition, as persons with current or prior condition of diabetes 1 or 2, neurological disorder, asthma, cancer or cardiac diseases, as well as users of nicotine products, initially were excluded from the study. Moreover, additionally five athletes had to withdraw from the study due to acute illness not related to their participation in this study. Thus, four athletes completed the data collection successfully. All the athletes gave their informed written consent, and the study was approved by the regional ethics committee (REK Midt, Regionale komiteer for medisinsk og helsefaglig forskningsetikk, Trondheim, Norway). Table 2 (p. 6) presents the physical characteristics and training status for the athletes before entering the study. All physical training other than assigned, as well as alcoholic beverages, were prohibited during the whole study.

Table 2. Physical characteristics and training status for four subjects before entering the study (mean and range).

Variables	**Mean (range)**
Age	19.5 (19-21) years
Body mass	76.5 (70.0-84.7) kg
BMI	24 (23-25) $kg \cdot m^{-2}$
HR_{max}	199 (189-212) bpm
HR_{rest}	38 (36-39) bpm
VO_{2max}	73 (70-78) $mL \cdot kg^{-1} \cdot min^{-1}$
Lactate threshold	90 (86-92) $\%HR_{max}$
Training last 12 months	431 (350-550) hours

BMI= body mass index; HR_{max}= the peak HR reached during the VO_{2max} test plus five beats; HR_{rest}= the lowest nocturnal HR during 7-day protocol; Lactate threshold= $\%HR_{max}$ when the lactate concentration in blood reaches 4 mM; Training last 12 months= self-reported total amount of training

Testing procedures

Heart rate variability

Athletes followed their natural circadian rhythm during the whole protocol. Nocturnal HRV was measured in three different exercise conditions: non-training, after high-intensity interval training and after long-slow duration training. During the 7-day protocol, the nocturnal HRV was registered via a heart rate monitor belt (Suunto Memory Belt, Suunto Vantaa, Finland) with a sampling rate of 1000 Hz. Suunto Memory Belt detects the beat-to-beat change in heart rate, i.e. the oscillation between two adjacent heartbeats. The beat-to-beat change is measured as time (milliseconds) between two R waves, and RR interval is further used to calculate HRV indices. The RR intervals can be also referred to as normal-to-normal intervals i.e. NN intervals (Vanderlei et al., 2009). Figure 1 (p. 7) illustrates electrocardiogram with two heartbeats, including the R wave, which forms the RR interval with the following R wave.

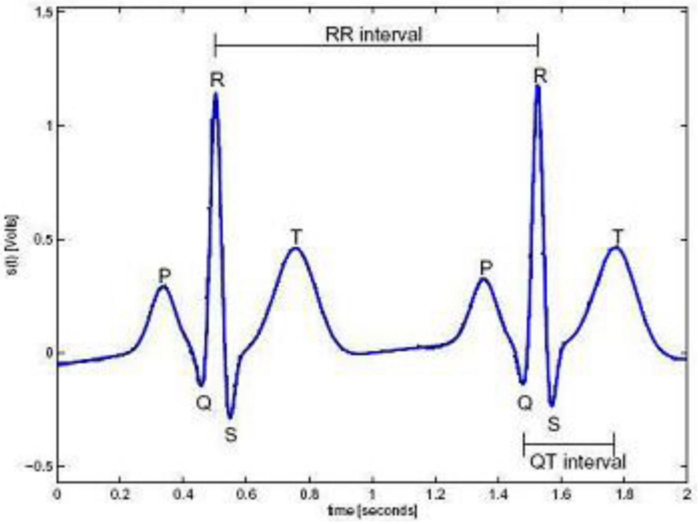


Figure 1. After the atrial depolarization (P wave), the impulse generated in the sinus node to begin the cardiac excitation is conducted and distributed further, resulting in depolarization of the ventricles (QRS complex). The sinus node is controlled by the autonomic nervous system. The T wave represents the ventricular repolarization (reproduced from Yarlagadda, 2010).

The baseline measurement was performed during the first 2-day non-training period. The first night was used as a familiarization period and the second night recording was used as a baseline. For the nocturnal HRV recording, the athletes wore the heart rate monitor belt during the night sleep. The belt was put on right before going to bed and to ensure flawless operation the electrodes on the belt was lightly wetted with tab water, and the strap was tightened and secured with sports tape. The HRV recording started automatically as the heart rate monitor belt detected a heartbeat. The belt was removed in the morning and the recording stopped automatically as the heart rate was no longer detectable.

Validity of the heart rate monitor

Suunto Memory Belt is easy to use by athletes themselves, causes no or minor disturbance compared to the most ECG systems, and is commonly available. However, less information is available regarding its validity and, therefore, the Suunto heart rate monitor was tested in a pilot study before data collection to the main study. Validation study compared the Suunto Memory Belt to a portable ECG system (Myomonitor IV, Delsys, Boston, US, sampling rate 250 Hz). In this validation study the HRV data was collected simultaneously with Suunto Memory Belt and Myomonitor IV in two subjects in supine position for 10 minutes in a quiet room. The memory belt data was transferred into the Suunto Training manager software (Suunto, Vantaa, Finland), and the

ECG data was transferred to EMGworks® software (Delsys, Boston, US). The RR interval data was transferred further to a statistical analyze package (Microsoft Office Excel 2007, Microsoft Corporation). RR interval data was then inspected for artifact and ectopic beats as the EMGworks® software is able to identify these incidences. Automatic interpolation of the memory belt data was allowed in this phase as it is automatically conducted in the downloading phase, but the correction procedure was modified for the main study (see Data handling and calculations below). Time domain parameters; mean RR and SDNN, and frequency domain parameters; low frequency (LF) and high frequency (HF) power were calculated with HRV software (Kubios HRV, version 2.0, Department of Physics, University of Kuopio, Finland). SPSS Statistics 19.0.0 (IBM Corporation, Somers, NY) was used for the remaining statistical analyses: intraclass correlation and cross-correlation.

Table 3 presents the number of observations, and results for the HRV: mean RR in ms^2, SDNN in ms^2, LF and HF in ms^2 and percentage. Also, the statistical correlation analyses are presented for the both recording methods. The results show significant intraclass correlation in both subjects. Figures 2 and 3 (p. 9) present the cross-correlation, which does not show any delay in the recordings.

Table 3. Heart rate variability indices and correlation parameters for the Suunto Memory Belt and Myomonitor IV in the Suunto Memory Belt validation study.

Subject	**N**	**Mean E (ms)**	**Mean S (ms)**	**SDNN E (ms)**	**SDNN S (ms)**	**LF E (ms^2/%)**	**LF S (ms^2/%)**	**HF E (ms^2/%)**	**HF S (ms^2/%)**	**ICC (*r*)**	**ICC (*p*)**	**CC (*r*)**
1	725	841.1	840.8	45.1	44.9	693/34.3	690/34.4	614/30.4	603/30.1	1.00	< .001	1.00
2	490	1230.6	1230.3	93.7	93.7	1975/24.8	1964/24.7	3627/45.5	3628/45.6	1.00	< .001	1.00

N= number of observations; E= ECG Myomonitor IV; S= Suunto Memory Belt; SDNN= standard deviation of RR intervals; LF= low frequency power; HF= high frequency power; ICC= Intraclass correlation of all observations for the ECG and Suunto Memory Belt; CC= Cross-correlation of all observations for the ECG and Suunto Memory Belt

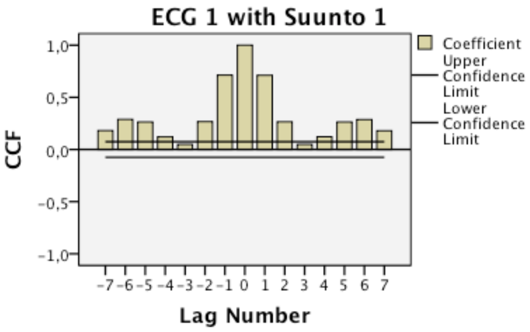


Figure 2. ECG and Suunto Memory Belt cross-correlation for the subject 1. The highest correlation is evident on the lag 0, which in interpreted as the best match to its pair.

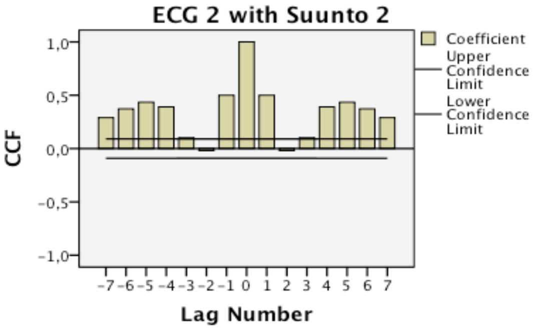


Figure 3. ECG and Suunto Memory Belt cross-correlation for the subject 2. The figure shows that the highest correlation is evident on the lag 0, and is the best match to its pair.

Based on this study, the Suunto memory Belt has high validity compared to Myomonitor IV. Although the method have only been investigated during daytime supine rest, it seemed probable that Suunto Memory Belt would be a valid tool to register nocturnal heart rate validity during a quiet period of sleep in the main study aiming to investigate nocturnal autonomic regulation of the heart.

Lactate threshold

Testing was performed on a treadmill during uphill running. The treadmill was tested prior to the study to insure its accuracy regarding velocity and incline. Six different velocities between 2.5 and 17 km/h, and six different inclines between 1.7° and 11.5° were measured in order to define real velocity and incline on the treadmill compared to the values on the treadmill display.

For the testing, the athletes met up at the test facility wearing appropriate running shoes, t-shirt and shorts/running pants for testing. They were instructed not to consume meals later than 2 hours before testing. Only light endurance training prior to the test day was advisable, strength training was prohibited.

Lactate threshold was tested on a treadmill with 3° inclination. 10-minute warm-up was performed at 8 km/h. Velocity was then increased with 1 km/h every 4 minutes. 30 seconds between every increase in velocity was allowed for blood collection by skin puncture of the finger to determine blood lactate concentration (Lactate Pro™, KDK Corporation, Kyoto, Japan) and to note the Borg RPE Scale (RPE= rate of perceived exertion; Borg, 1998 pp. 29-38). The Borg RPE Scale is a 15-grade scale from 6 to 20, whereas the 6 presents "no exertion at all", and 20 presents "maximal exertion" (ibid. p. 31). For the finger stick the puncture site on the 3rd or 4th finger was cleaned with a wet wipe (H_2O) and dried off with a dry pad in order to remove perspiration and other impurities. The puncture site was the outer and upper region of the fingertip, halfway between the center of the finger pad and the edge of the fingernail. The finger stick was provided with an adjustable lancing devise (Ascensia Microlet, Bayer HealthCare, Bauer, Switzerland) with compatible 0.5 mm/28g lancets (Microlet, Bayer HealthCare, Bauer, Switzerland). The first drop of blood was wiped off with gauze, and the second drop (approximately 5 µL) was drawn into the lactate strip (Lactate Pro™ Test Strip, ARKRAY Factory, Inc., Shiga, Japan) by touching the drop with the tip of the strip. The measurement started then automatically. Heart rate was measured via telemetry every 10 sec (heart rate monitor, Suunto Td6, Suunto Vantaa, Finland) during the entire test, and the highest stable heart rate during the last minute of every velocity was noted. The test was ended when the blood lactate concentration exceeded 4 mM.

Maximal oxygen uptake and maximum heart rate

Maximal oxygen uptake was measured with a gas analyzing system with a dynamic mixing chamber (Metamax II, CORTEX Biophysik GmbH Leipzig, Germany). The test was performed by running on the treadmill, with 6° inclination, 5 minutes after finishing the lactate profile test. During the break between the tests, the participants engaged low-intensity physical activity, and were allowed to consume their beverage of choice. O_2 and CO_2 levels were calibrated before each test day with known calibrating gas and room ambient air. Also, O_2 and CO_2 levels were calibrated with room ambient air $\leq$ 5 min prior to each test. Start velocity on the VO_{2max} test was 2 km/h less than the final velocity of the lactate profile test. Velocity was accelerated each minute by 1 km/h allowing 1 minute of exercise at each velocity. The test was continued until the VO_2 plateau (primary criteria) was evident, and respiratory exchange ratio was >1.15 and blood lactate concentration was >8.0 mmol/l (secondary criteria). If the VO_2 plateau was not achieved, the secondary criteria was used for evaluating the $VO_{2\,max}$ attainment (Bassett & Howley, 2000). Further, the $VO_{2\,max}$ was determined from the median of the 3 consecutively highest VO_2 values. Peak lactate and the Borg RPE Scale (6-20) was measured right after the test had been finished. Heart rate was measured during the entire test and 5 heartbeats were added to the peak heart rate achieved during the test to determine maximal heart rate (Ingjer, 1991).

Quality of Life Index and daily activity

The athletes answered the Quality of Life Index questionnaire (Ferrens & Powers, 1985) every evening before going to bed in order to point out the effects on HRV due to the chances in daily stress level. The questionnaire has two sections. The first section (Appendix I) measures importance of various domain in participants' life, and was answered only once at the beginning of the 7-day protocol. The second section (Appendix II) measured satisfaction with the same domain than concerned in the first section, and was answered every evening before nocturnal HRV registration. Changes in life satisfaction level were further analyzed in relation to importance of domain. Five scores were calculated 1) Total Quality of Life Score, 2) Health and functioning subscale score, 3) Social and economic subscale score, 4) Psychological/spiritual subscale score, and (5) Family subscale score. Generic version III was recommended by the creator Carol Estwing Ferrans in e-mail correspondence (Mars 19th, 2011), although, this version was not already translated to participants' native language, Norwegian. Generic version II, which was previously validated in Norwegian language (Rannestad et al, 2008; Rustøen et al., 1999), was therefore revised. The revision was done by deducting two questions from the Norwegian version II; the questions 20 and 26. Further, a one new question was added; the question 14 from the English version III. The added question was back-translated from the English Generic version III. Also, athletes noted their sleeping schedules and daily activities in to the individual diary consisting of at least 7 double-sided pages, one for each day.

Training procedures

Calculation of the training impulse and training load

Duration for the LSD session was calculated with Foster TRIMP with five HR zones (Foster, et al., 2001) based on the estimated training impulse for the HIIT session. This calculation gave duration of 1 hour 45 minutes for the LSD session, and due to practical considerations the duration was rounded up to the nearest full hour. TRIMP was also calculated after the sessions according to the actual $\%HR_{max}$ during both training sessions. In addition, the training load was noted after the training session based on the session rate of perceived exertion (sRPE; Foster, 1998) calculated from the Borg's CR10 Scale (Borg, 1998 p. 39-43) and exercise duration. The Borg CR10 Scale operates from 0 to 10, whereas 0 presents "nothing at all", and 10 "extremely strong (almost maximal)" (ibid. p. 41). Training impulse in Foster TRIMP is divided in to five zones, zone 1: 50-60% of HR_{max}, zone 2: 60-70% of HR_{max}, zone 3: 70-80% of HR_{max}, zone 4: 80-90% of HR_{max} and zone 5: 90-100% of HR_{max}. HR was monitored every 10 seconds via telemetry during all exercise sessions (Suunto Td6, Suunto Vantaa, Finland).

High-intensity interval training session

Total duration on HIIT session was 62 minutes. Heart rate was measured via telemetry every 10 seconds during the entire session. The HIIT session included 10-minute warm-up at 60-64% of HR_{max} and 5 minutes at 70-74% of HR_{max} follow by 5x4 minute intervals at 90-94% of HR_{max} with 3-minute active rest at 60-64% of the HR_{max}. The session was completed with 10-minute cool down at 70-74% of HR_{max} and 5 minutes at 60-64% of HR_{max}. The HIIT session was performed on a treadmill with 3° incline in two athletes, whereas the two other athletes varied the incline between 2° and 6° due to not reaching or not maintaining the wanted $\%HR_{max}$ at desired velocity. Athletes received instructions according the HR range they should maintain at each time of the session, although, they controlled the treadmill velocity self based on their perceived exertion in order to provide suitable acceleration for each athlete individually. Oxygen uptake was measured during the 1st, 3rd and the 5th interval, and during the last 4 minutes of the cool down. Blood lactate concentration and Borg RPE Scale (6-20) was measured after the 1st, 3rd and the 5th interval, as well as right after the training session was completed. Borg's CR10 scale and session duration was used to determine the sRPE for the entire session. Table 4 (p. 11) shows the CR10 scale, sRPE and TRIMP for the HIIT session. Also, %HR$_{max}$, %VO$_{2max}$, blood lactate concentration and RPE values are presented after 19, 33, 47 and 62 minutes of running.

Table 4. Training load and training impulse in four well-trained athletes for the high-intensity interval training session (mean and range).

Time (min)	%HR$_{max}$	%VO$_{2max}$	La$^-$	RPE (6-20)	CR10 (0-10)	sRPE	TRIMP
19	89 (86-92)	85 (79-96)	6.9 (3.9-14-3)	15 (11-19)	-----	-----	-----
33	92 (91-94)	82 (77-88)	7.6 (4.1-14.3)	16 (14-19)	-----	-----	-----
47	94 (93-94)	82 (79-86)	8.0 (4.2-14.3)	18 (16-19)	-----	-----	-----
62	60 (59-61)	30 (26-33)	2.3 (1.0-4.9)	9 (6-11)	7 (5-9)	434 (310-558)	188 (178-203)

%HR$_{max}$ = percentage of the maximum heart rate; %VO$_{2max}$ = percentage of the maximal oxygen uptake; La$^-$= blood lactate concentration; RPE (6-20)= The Borg RPE Scale; CR10 (0-10)= The Borg CR10 Scale; sRPE= session rate of perceived exertion; TRIMP= training impulse; 19 min= at the end of the 1st sprint; 33 min= at the end of the 3rd sprint; 47 min= at the end of the 5th sprint; 62 min= at the end of cool down

Long slow duration training session

Total duration of the LSD session was 120 minutes at 65-69 %HR$_{max}$. Heart rate was measured via telemetry every 10 seconds during the entire training session. Velocity and incline on the treadmill was allowed to be regulated by the athletes for variation during the session as long as the HR zone was maintained. VO$_2$ was measured every half an hour for 4 minutes starting 4 minutes before reaching a half hour mark. Also, blood lactate concentration and Borg Scale (6-20) was measured every half an hour just immediately after finishing the VO$_2$ measurement. Borg's CR10 scale and session duration was used to determine the sRPE for the entire session. The CR10 scale, sRPE and TRIMP for the LSD session are presented in table 5 (p. 14). Also, %HR$_{max}$, %VO$_{2max}$, blood lactate concentration and RPE values are presented after 30, 60, 90 and 120 minutes of running.

Table 5. Training load and training impulse in four well-trained for the long slow duration training session (mean and range).

Time (min)	$\%HR_{max}$	$\%VO_{2max}$	La^-	RPE (6-20)	CR10 (0-10)	sRPE	TRIMP
30	67[a] (65-70)	52 (46-57)	1.2 (0.9-1.4)	9 (7-11)	-----	-----	-----
60	66[a] (66-67)	51 (47-57)	1.1 (0.8- 1.2	10 (8-13)	-----	-----	-----
90	67 (67-68)	53 (46-60)	0.9 (0.7-1.1)	11 (9-13)	-----	-----	-----
120	67 (66-67)	50 (43-54)	0.9 (0.7-1.1)	12 (10-14)	2.5 (2-3)	300 (240-360)	239[a] (233-243)

$\%HR_{max}$ = percentage of the maximum heart rate; $\%VO_{2max}$ = percentage of the maximal oxygen uptake; La^-= blood lactate concentration; RPE (6-20)= The Borg RPE Scale; CR10 (0-10)= The Borg CR10 Scale; sRPE= session rate of perceived exertion; TRIMP= training impulse; [a]= missing one observation due to technical failure

Data handling and calculations

As only four athletes completed the training sessions successfully, the second night of HRV data after the LSD session was not recorded in one athlete. The missing data was imputed according to Snedecor & Cochran (1971 pp. 317-318).

Recommendations of Brandenberger et al. (2005) were followed in order to isolate a 5-minute sequence during the first slow wave sleep for the further HRV analysis. The first SWS period was recognized after two criteria: 1) the first or the second 5-minute period of the first low and regular HR episode lasting at least 15 min, and 2) a round Pointcaré plot. Also, the lowest SD of the heart rate in the period of interest was applied (Al Haddad et al., 2009), if further criterion was needed. This period was also manually inspected for artifacts and ectopic beats by using heart rate recorder compatible software (Firstbeat Athlete, Firstbeat Technologies Oy, Jyväskylä, Finland). Automatic interpolation was allowed, and the degree of correction was noted as the software calculated the error automatically. HRV data for frequency analyzes was processed by Kubios HRV software. The following parameters were analyzed: heart rate (bpm), mean RR (ms), SDNN (ms), total power in ms^2, low-frequency power and high-frequency power (HF) in ms^2, percentage and normalized units, and LF/HF ratio in ms^2. Frequency domain analysis studies the spectral components of the tachogram. The power is calculated from the RR interval periods in various lengths that represent the parasympathetic and sympathetic modulation of the heart. The Fourier Transform provides mathematical algorithms and is a commonly used method for estimating the power spectral density.

Total power (TP) is variance of all NN intervals (≤ 0.4 Hz). The variability during 2.5-7 second period (0.15-0.4 Hz) is the high frequency component reflecting the respiratory and vagal modulation, and the 7-20 second period (0.04-0.15 Hz) is the low frequency component reflecting the parasympathetic and sympathetic function of the heart with sympathetic predomination (Aubert et al., 2003; Task Force, 1996; Vanderlei et al., 2009).

Heart rate registrations were downloaded from the Suunto Td6 heart rate monitor to the compatible software program (Training Manager, Suunto, Vantaa, Finland), and exported to Microsoft® Excel® for Mac 2011 statistical package for further calculations. Heart rate was used to calculate TRIMP after the exercise sessions. Also, the total score of the Quality of Life Index questionnaire was calculated on Excel Scoring Program available on the internet (http://www.uic.edu/orgs/qli/questionaires/questionnairehome.htm).

Statistical analysis

Data is presented as mean ± SD unless otherwise stated. Statistical analysis was performed by means of the SPSS (PASW) 18.0 for Mac OS X (IBM Corporation, Somers, NY) statistical package. Comparison between HRV baseline night and training sessions was performed with the Friedman non-parametric test for several related samples. The level of significance was set at $P < 0.05$. Further, in case of significant result in the Friedman test, the Wilcoxon paired samples test was performed. Also, the comparison between the daily QLI scores was performed with the Friedman non-parametric test for several related samples. The level of significance was set at $P < 0.05$ and in case of significant result in the Friedman test, the Wilcoxon paired samples test was performed.

3 RESULTS

Nocturnal heart rate variability

Table 6 presents the results for the nocturnal HR and HRV on the 2nd night (rest) during the 2-day non-training period, as well as for the 1st and 2nd night after the LSD and the HIIT sessions. No significant effects in nocturnal HR and HRV were found.

Table 6. Nocturnal heart rate and heart rate variability in four well-trained male endurance athletes after long-slow duration and high-intensity interval training sessions (mean ± SD).

	Rest	**LSD1**	**LSD2**	**HIIT1**	**HIIT2[b]**	***P***
HR (bpm)	40 ± 4	39 ± 2	40 ± 3	39 ± 1	38 ± 1	ns
RR (ms)	1227 ± 45	1321 ± 233	1192 ± 143	1086 ± 242	1292 ± 168	ns
SDNN (ms)	139.5 ± 79.3	97.0 ± 36.5	101.8 ± 29.2	99.4 ± 17.2	106.8 ± 14.4	ns
LF (ms^2)	2242 ± 1328	1370 ± 1253	1682 ± 714	2186 ± 480	2043 ± 1554	ns
HF (ms^2)	5922 ± 3953	3998 ± 4417	5669 ± 3910	2462 ± 1030	4949 ± 2926	ns
TP (ms^2)	10481 ± 6176	6163 ± 3754	8475 ± 4102	6861 ± 2776	8823 ± 5428	ns
LF/HF (ms^2)	0.416 ± 0.110	0.642 ± 0.649	1.954 ± 2.143	1.025 ± 0.448	0.529 ± 0.239	ns
LF (%)	24.0 ± 6.3	23.8 ± 14.2	28.6 ± 19.7	34.1 ± 9.9	22.9 ± 6.2	ns
HF (%)	59.1 ± 11.5	52.0 ± 21.7	40.2 ± 27.5	37.7 ± 16.8	49.5 ± 18.2	ns
LF (n.u.)	29.0 ± 5.9	32.9 ± 21.6	45.4 ± 31.2	48.5 ± 13.0	33.2 ± 12.0	ns
HF (n.u.)	71.0 ± 5.9	67.1 ± 21.6	79.5 ± 56.5	51.5 ± 13.0	66.8 ± 12. 0	ns

HR= heart rate; RR= RR interval; SDNN= standard deviation of RR intervals; LF= low frequency power; HF= high frequency power; TP= total frequency power; LF/HF= ratio of low frequency to high frequency power; n.u.= normalized units; Rest= baseline, second night after two non-training days; LSD1= first night after long-slow duration session; LSD2= second night after long-slow duration session; HIIT1= first night after high-intensity interval session; HIIT2= second night after high-intensity interval session; ns= no significance; [b]= includes imputed data for one athlete.

Figures 4A, 5A and 6A present the difference in the mean TP (Fig. 4A), the HF (Fig. 5 A) and LF (Fig. 6 A) between rest and training for all subjects pooled. Figures 4B, 5B and 6B present the same indices for each athlete individually. There were no significant differences in any of these indices.

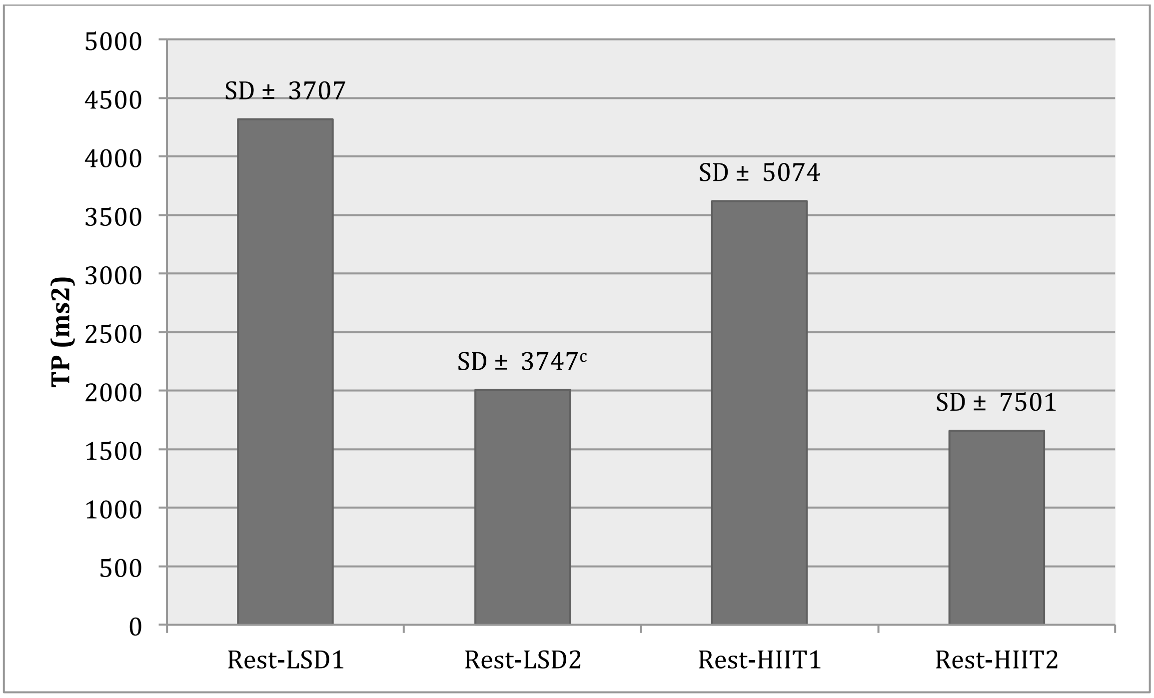
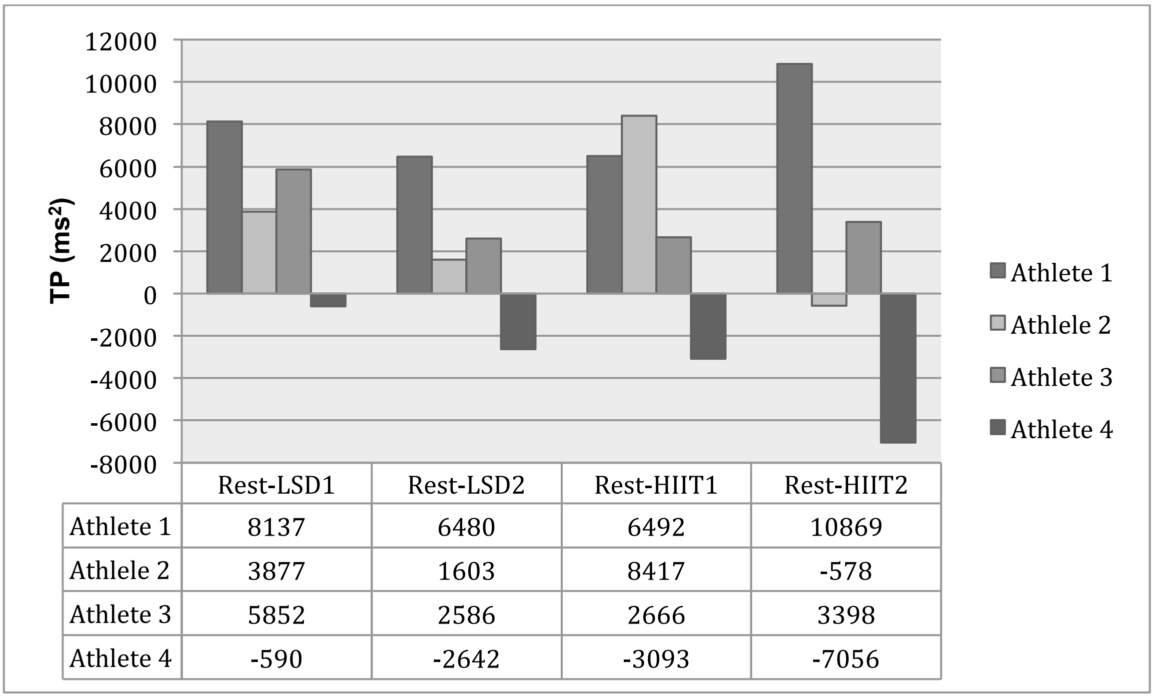


Figure 4A. Change in the mean total frequency power (ms^2) for four athletes. ^{c}= includes imputed data for one athlete.



	Rest-LSD1	Rest-LSD2	Rest-HIIT1	Rest-HIIT2
Athlete 1	8137	6480	6492	10869
Athlele 2	3877	1603	8417	-578
Athlete 3	5852	2586	2666	3398
Athlete 4	-590	-2642	-3093	-7056

Figure 4B. Individual change in the total frequency power (ms^2) for four athletes. Imputed data: athlete 3, LSD2.

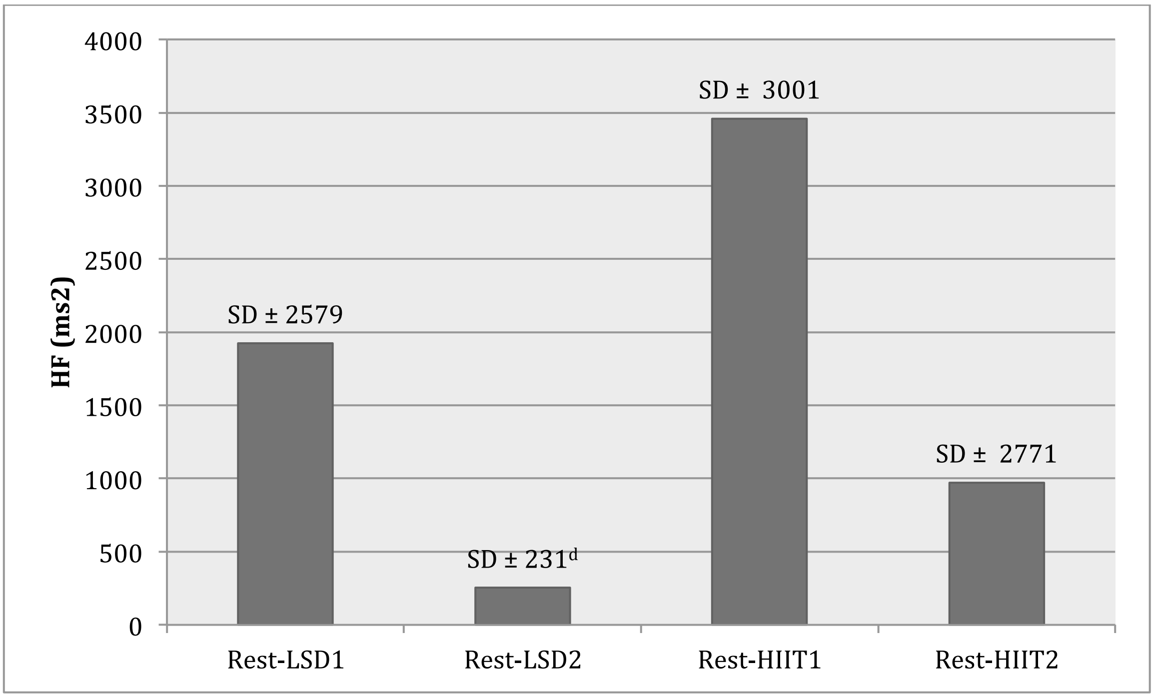
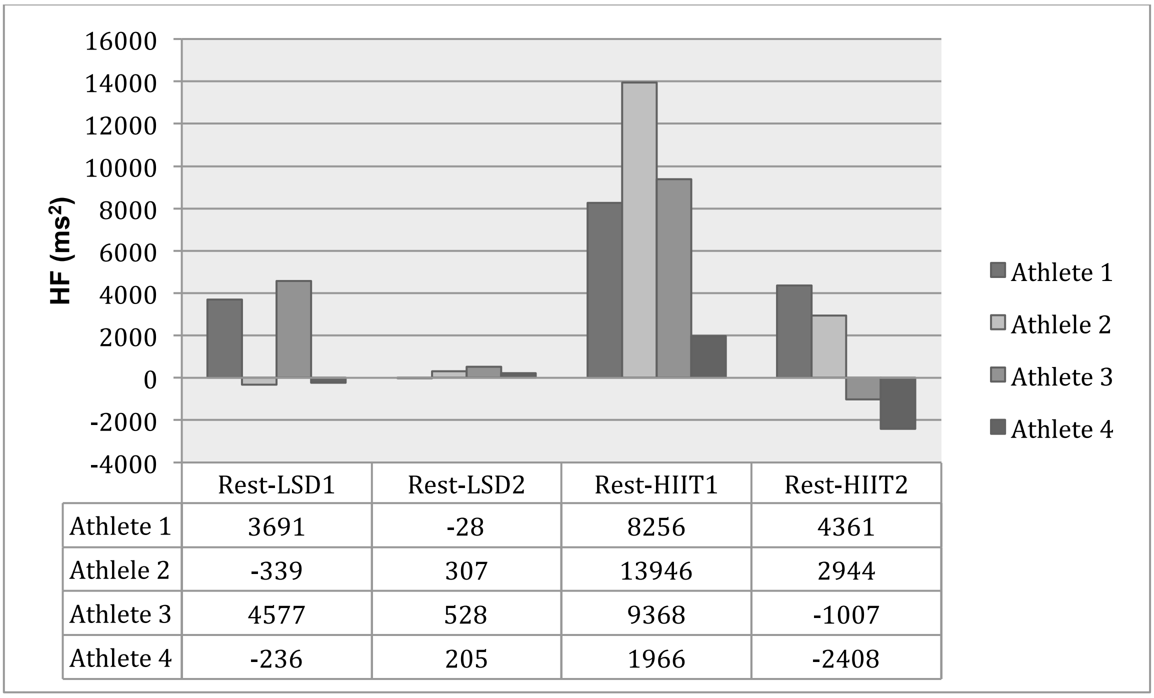


Figure 5A. Change in the mean high frequency power (ms^2) for four athletes. ^{d}= includes imputed data for one athlete.



	Rest-LSD1	Rest-LSD2	Rest-HIIT1	Rest-HIIT2
Athlete 1	3691	-28	8256	4361
Athlele 2	-339	307	13946	2944
Athlete 3	4577	528	9368	-1007
Athlete 4	-236	205	1966	-2408

Figure 5B. Individual change in the high frequency power (ms^2) for four athletes. Imputed data: athlete 3, LSD2.

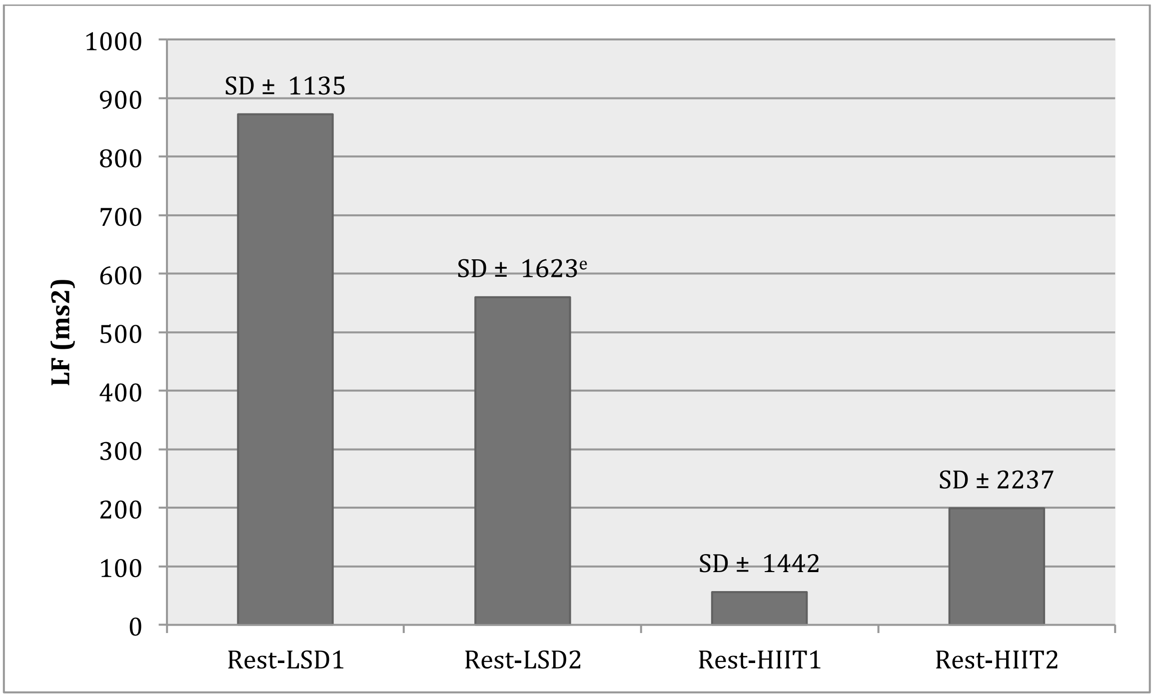
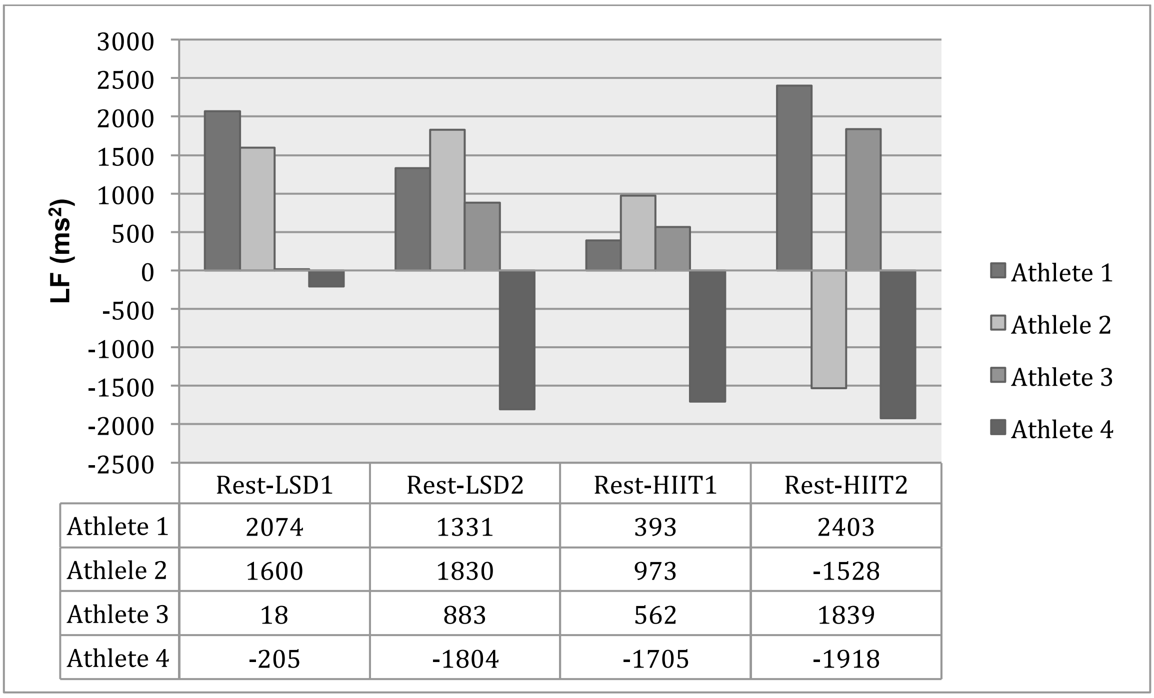


Figure 6A. Change in the mean low frequency power (ms^2) for four athletes. ^{e}= includes imputed data for one athlete.



	Rest-LSD1	Rest-LSD2	Rest-HIIT1	Rest-HIIT2
Athlete 1	2074	1331	393	2403
Athlele 2	1600	1830	973	-1528
Athlete 3	18	883	562	1839
Athlete 4	-205	-1804	-1705	-1918

Figure 6B. Individual change in the low frequency power (ms^2) for four athletes. Imputed data: athlete 3, LSD2.

Quality of Life Index and daily activity

No significant effect of training, i.e. rest, LSD and HIIT, was found upon scores on the Quality of Life Index questionnaire. Daily activities consisted mainly about school activity, and no activity considered as physical training was reported.

4 DISCUSSION

The aim of this present study was to investigate whether the nocturnal HRV would be affected differently after LSD and HIIT sessions with equivalent TRIMP among young well-trained male endurance athletes. It was hypothesized that the HIIT session would depress the nocturnal HRV compared to rest and LSD session, and that the cardiac autonomic recovery would be delayed in HIIT compared to LSD session. The main finding of the study was that 1) there was no significant effect to the nocturnal cardiac autonomic recovery after LDS and HIIT sessions compared to the non-training day measurements or between the training sessions, 2) individual response in nocturnal cardiac autonomic recovery is noticeable, and 3) the training order did not seem to influence the nocturnal cardiac autonomic recovery.

Cardiac autonomic recovery

LSD and HIIT sessions with approximately equivalent TRIMP did not introduce significant effects on cardiac autonomic recovery in well-trained male endurance athletes. Therefore, the results do not support the hypothesis that HIIT session would cause greater changes in HRV compared to LSD session. Also, the hypothesis regarding more rapid recovery after LSD session is not supported. These results are in partial conflict with the previous studies (see below), although they did not investigate a single session of exercise.

Pichot et al. (2000), Al Haddad et al. (2009) and Hynynen et al. (2010) studied the nocturnal HRV in healthy athletes. Pichot et al. (2000) studied a 4-week training program with seven young male middle-distance runners ranked at the national level as participants. The training program included 3-week exhaustive training sessions and 1-week light training whereas the recovery was allowed. Training load was relatively stable during the first three weeks followed by significant decrease during the last week with light training and recovery. It was further shown that a 3-week heavy training decreased, and a 1-week relative rest increased, the parasympathetic activity significantly.

Hynynen et al. (2010) studied 10 physically active men during the last two weeks of the 33-week marathon project. The training load was average of 5±1 sessions and 7±2 hours per week. The project included measurement after moderate endurance exercise and marathon, in addition to baseline measurement after rest day. The conclusion was that the nocturnal HRV has prolonged dose-response effects on autonomic modulation. In these studies the training accumulation was allowed, a single session was not investigated and the training loads were variable. This might indicate that the cardiac autonomic regulation is not affected by a single session in statistically significant matter, and the accumulation should be included when monitoring training stimulus in well-trained athletes. Although, the day- and nighttime recordings should not be compared (Task Force, 1996) when the absolute indices values are concerned, however similar conclusions are drawn from the day- and nighttime measurements. Manzi et al. (2009) studied trained long distance runners, with minimum training distance minimum 50 km/week, during a 6-month training period before marathon. The individual TRIMP was taken into consideration in training and it was adjusted for one and each athlete individually. Results showed decrease in sympathetic activity as the TRIMP was increased. Further conclusion was that the dose-response relationship was significant in recreational athletes. However, the accumulation was not considered in the study, as well as the baseline was measured after 4-week non-training period, and the HRV was measured on the afternoon. When the baseline is concerned, the substantial effects in the cardiac autonomic modulation could in author's opinion explain by a long non-training period before the baseline measurement. Also, the TRIMP calculation was different from this study, which as well might explain different findings. All in one, results show that the parasympathetic domination tends to rise with the training load in recreational and highly trained athletes, and sympathetic domination can be detected after hard rather than moderate training period. Also, the global variation in HRV tends to rise in both athletes, recreational and highly trained athletes, during and after training period. This can be also seen among individual athletes in the present study, and might be indicating differences in the training- and competition period prior to the study.

Al Haddad et al. (2009) investigated nocturnal HRV after supramaximal exercise. Eleven physically active (2-5 hours physical exercise per week) males participated in the study. Participants performed two intermittent runs separated by 10-minute passive recovery in the sitting position. Runs included 15-second exercise on supramaximal intensity (95% of the velocity reached at the intermittent fitness test) followed by 15-second active recovery on a lower intensity (45% of the velocity reached at the intermittent fitness test) until exhaustion. Total duration of the runs was 10 min 48 s ± 1 min 30 s. Nocturnal HRV was measured the night before exercise for the baseline, and for two nights after exercise. Results showed decreased parasympathetic modulation during the first night. On the second night, almost all HRV indices had returned to the baseline. Al Haddad et al. (2009) concluded that a single supramaximal exercise lasting more than 12 minutes could influence the autonomic nervous system for approximately 36 hours. Therefore, the findings in this present study might be explained with the training status, as the participants in Al Haddad et al. (2009) study were physically active, but not highly trained athletes. Also, Seiler et al. (2007) reported more rapid autonomic recovery in highly trained endurance runners after high-intensity exercise than in regularly training athletes, although only the daytime post- exercise recovery up to 240 min was investigated. Further, the HRV remained unaffected after low intensity exercise in highly trained athletes. This supports the findings in this study, and further confirms that in well-trained athletes the cardiac autonomic recovery might not be affected as easily as in recreational athletes. However, Hynynen et al. (2006) found no significant difference in nocturnal HRV between overtrained and non-overtrained athletes, but the after awakening HRV was lower in overtrained athletes compared to non-overtrained control group. Total of 12 overtrained athletes were studied with a control group of 11 trained athletes. Both groups consisted mostly of endurance athletes, but both male and female participated the study. Never the less, this might point out the fact that the nocturnal autonomic modulation has high individual variation as it also can be seen in this present study, and longer registering periods are required in order to draw conclusions and monitor training in an individual athlete.

Quality of Life Index and daily activity

As Kenttä & Hassmén (1998) point out, the non-training stressors should be considered when recovery or the athletic performance appears unsatisfactory. The Quality of Life Index had no significant change, and no additional physical training was reported during the protocol in this study. This supports the findings in the nocturnal HRV.

Methodological considerations

The main strength of this study is the nocturnal HRV measurement from the estimated SWS period recommendated by Branderberger et al. (2005). The SWS period is naturally dominated by parasympathetic modulation, and can be estimated from heart rate registration without using electroencephalographic (EEG) registration. Also, the SWS period provide a sleeping episode free of movement, which rarely contains artifact from e.g. movement. SWS is also dominated by regular breathing pattern and excludes the possible external disturbance as noise. The calculation method used for obtaining HRV indices was mainly the frequency domain analysis, which is recommended for the 2-5 minute recordings by Task Force (1996). Time domain analysis; mean RR and SDNN are also appropriate indices for the period of interest in the study. Further, the heart rate monitor was validated for this present study with significant intraclass correlation, and no delay was presented at the cross-correlation statistics.

It should be noted that this study ended up with four subjects that completed the study protocol, and the results should be treated with caution. Recruiting was challenging due to the non-training days during the study, which is an understandably matter of consideration for young ambiguous athletes. Further, one nocturnal HRV measurement after LSD session was not available, and was replaced by using imputation in order to have four complete datasets. Heart rate data for one athlete during the LSD session was not collected for one hour due to technical failure. This, in my opinion did, not affect the session as the athlete could run on the desired $\%HR_{max}$ based on subjective feeling of the HR. Blood lactate concentrations and $\%VO_{2max}$ supported athletes subjective feeling of the HR, the treadmill velocity and incline remained unchanged, and the $\%HR_{max}$ was in desired range when the HR registration was regained. Also, according to my best knowledge, no directly comparable studies have been presented. Therefore, the findings in this study have to be compared with previous studies allowing accumulation.

Another challenge in this present study was calculating the training impulse and training load. Just to name few, Banister & Calvert (1980) proposed a TRIMP model based on HR average calculated from the resting -, maximal- and exercise heart rate multiplied with the exercise duration. Further, more complex TRIMP model has been presented by Hayes & Quinn (2009). This scoring system proposes to calculate TRIMP based on whole body bioenergetics, and will allow better comparison between continuous and interval sessions by removing limitations from scoring methods based on exponential weighting factors. However, the Banister & Calvert (1980) do not allow TRIMP calculations prior to exercise, and Hayes & Quinn (2009) scoring system still need further investigation and is rather complicated to use. Foster (1998) has introduced the sRPE scale, which is calculated from the Borg CR10 Scale and exercise duration. As this method is user friendly, it is only possible to estimate the training impulse after the training session. Foster et al. (2001) TRIMP model involves the time and HR on five HR zones for calculation, which can be proceeded on some level prior to the exercise. Therefore, two calculating methods were used in this study. The estimated Foster TRIMP score for the HIIT session was used to calculate duration for the LSD session, as well as after the session based on the true HR values registered during the session. Also, the exercise sessions were designed based on athletes' HR_{max}, and the sRPE score was calculated after the training sessions in order to support the Foster TRIMP score as there is many scoring systems with flaws and benefits. Hence, one can realistically assume that none of the scoring systems will provide the true individual TRIMP, which seems to be very challenging to be measured accurately. Interestingly, these presented TRIMP and sRPE calculations clearly provided wider approach to the training sessions than only one scoring system had have done.

QLI questionnaire was included in the study in order to evaluate the changes in quality of life. Although, QLI is not a direct measure of mental stress, but still provides valuable information of matters affecting possible mental stress and further can be to used explain changes in autonomic modulation due to it.

The Friedman test for one-way repeated measures analysis of variance by ranks was used for the statistical analysis. By using this non-parametric method based on rank, some data is missed when the actual score is translated to rank. However, due to the small sample size a non-parametric test was the more adequate choice for statistic analysis than a parametric test.

Conclusion

Athletes showed no significant change in HRV after single training sessions compared to rest or the other training session. Neither, was return to baseline more rapid after the LSD session compared to the HIIT session. Therefore, the nocturnal recovery in autonomic nervous system was not affected by LSD and HIIT sessions in this study. Further, a greater sample size should be included when investigating long-term cardiac autonomic recovery in well-trained athletes, and the individual cardiac autonomic modulation should be taken in to consideration, if HRV monitoring is used to support the TRIMP and training load calculations in training development.

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Please note: This is a translation of the Generic III version

Ferrans og Powers
LIVSKVALITETSINDEKS

Del I. Her skal du velge det svaret som best beskriver hvor tilfreds du er med ulike sider ved livet ditt. Angi svaret ditt ved å sette en ring rundt det tallet du velger. Det finnes verken "riktige" eller "gale" svar i denne teksten. Sett bare ring rundt ett tall ved hvert spørsmål.

HVOR TILFREDS ER DU MED:	Svært utilfreds	Ganske utilfreds	Litt utilfreds	Litt tilfreds	Ganske tilfreds	Svært tilfreds
1. Din helsetilstand ?	1	2	3	4	5	6
2. Helsetilbudet du får ?	1	2	3	4	5	6
3. Mengden av smerte du har?	1	2	3	4	5	6
4. Overskuddet du hart il daglige gjøremål ?	1	2	3	4	5	6
5. Din fysiske uavhengighet?	1	2	3	4	5	6
6. Den grad av kontroll du har med ditt eget liv?	1	2	3	4	5	6
7. Dine utsikter til å få leve lenge?	1	2	3	4	5	6
8. Din families helsetilstand?	1	2	3	4	5	6
9. Dine barn?	1	2	3	4	5	6
10. Din families trivsel?	1	2	3	4	5	6
11. Ditt seksualliv?	1	2	3	4	5	6
12. Ditt forhold til ektefelle/nærmeste pårørende?	1	2	3	4	5	6
13. Dine venner?	1	2	3	4	5	6
14. Den følelsesmessige støtten familien gir deg?	1	2	3	4	5	6
15. Den følelsesmessige støtten andre gir deg?	1	2	3	4	5	6
16. Dine muligheter til å oppfylle familieforpliktelser ?	1	2	3	4	5	6

(Vennligst gå til neste side)

HVOR TILFREDS ER DU MED:	Svært utilfreds	Ganske utilfreds	Litt utilfreds	Litt tilfreds	Ganske tilfreds	Svært tilfreds
17. Den gagn andre har av deg?	1	2	3	4	5	6
18. Den mengde stress og bekymringer du har?	1	2	3	4	5	6
19. Nabolaget ditt?	1	2	3	4	5	6
20. Hjemmet ditt?	1	2	3	4	5	6
21. Jobben din?	1	2	3	4	5	6
22. Ikke å ha noen jobb?	1	2	3	4	5	6
23. Utdannelsen din?	1	2	3	4	5	6
24. Din økonomiske uavhengighet?	1	2	3	4	5	6
25. Fritidsaktivitetene dine?	1	2	3	4	5	6
26. Dine utsikter til en lykkelig alderdom/ pensjonisttilværelse?	1	2	3	4	5	6
27. Din sjelefred?	1	2	3	4	5	6
28. Ditt forhold til Gud?	1	2	3	4	5	6
29. De mål du har satt deg i livet?	1	2	3	4	5	6
30. Din generelle trivsel?	1	2	3	4	5	6
31. Ditt liv i sin helhet?	1	2	3	4	5	6
32. Ditt utseende?	1	2	3	4	5	6
33. Deg selv totalt sett?	1	2	3	4	5	6

(Vennligst gå til neste side)

Del 2. Her skal du velge det svaret som best beskriver hvor viktig denne siden ved livet er for deg. Angi svaret ditt ved å sette en ring rundt det tallet du velger. Det finnes verken "riktige" eller "gale" svar i denne teksten. Sett bare en ring ved hvert spørsmål.

HVOR VIKTIG ER DETTE FOR DEG:	Svært utilfreds	Ganske utilfreds	Litt utilfreds	Litt tilfreds	Ganske tilfreds	Svært tilfreds
1. Din helsetilstand ?	1	2	3	4	5	6
2. Helsetilbudet du får ?	1	2	3	4	5	6
3. Mengden av smerte du har?	1	2	3	4	5	6
4. Overskuddet du hart il daglige gjøremål ?	1	2	3	4	5	6
5. Din fysiske uavhengighet?	1	2	3	4	5	6
6. Den grad av kontroll du har med ditt eget liv?	1	2	3	4	5	6
7. Dine utsikter til å få leve lenge?	1	2	3	4	5	6
8. Din families helsetilstand?	1	2	3	4	5	6
9. Dine barn?	1	2	3	4	5	6
10. Din families trivsel?	1	2	3	4	5	6
11. Ditt seksualliv?	1	2	3	4	5	6
12. Ditt forhold til ektefelle/nærmeste pårørende?	1	2	3	4	5	6
13. Dine venner?	1	2	3	4	5	6
14. Den følelsesmessige støtten familien gir deg?	1	2	3	4	5	6
15. Den følelsesmessige støtten andre gir deg?	1	2	3	4	5	6
16. Dine muligheter til å oppfylle familieforpliktelser ?	1	2	3	4	5	6

(Vennligst gå til neste side)

HVOR VIKTIG ER DETTE FOR DEG:	Svært utilfreds	Ganske utilfreds	Litt utilfreds	Litt tilfreds	Ganske tilfreds	Svært tilfreds
17. Den gagn andre har av deg?	1	2	3	4	5	6
18. Den mengde stress og bekymringer du har?	1	2	3	4	5	6
19. Nabolaget ditt?	1	2	3	4	5	6
20. Hjemmet ditt?	1	2	3	4	5	6
21. Jobben din?	1	2	3	4	5	6
22. Ikke å ha noen jobb?	1	2	3	4	5	6
23. Utdannelsen din?	1	2	3	4	5	6
24. Din økonomiske uavhengighet?	1	2	3	4	5	6
25. Fritidsaktivitetene dine?	1	2	3	4	5	6
26. Dine utsikter til en lykkelig alderdom/ pensjonisttilværelse?	1	2	3	4	5	6
27. Din sjelefred?	1	2	3	4	5	6
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29. De mål du har satt deg i livet?	1	2	3	4	5	6
30. Din generelle trivsel?	1	2	3	4	5	6
31. Ditt liv i sin helhet?	1	2	3	4	5	6
32. Ditt utseende?	1	2	3	4	5	6
33. Deg selv totalt sett?	1	2	3	4	5	6