Presleep Heart-Rate Variability Biofeedback Improves Mood and Sleep Quality in Chinese Winter Olympic Bobsleigh Athletes

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Original citation & hyperlink:
QinLong, L, Steward, C, Cullen, T, Kaixuan, C & Yue, Z 2022, 'Presleep Heart-Rate Variability Biofeedback Improves Mood and Sleep Quality in Chinese Winter Olympic Bobsleigh Athletes', International Journal of Sports Physiology and Performance, vol. (In-Press), pp. (In-Press). https://doi.org/10.1123/ijspp.2022-0037

DOI 10.1123/ijspp.2022-0037
ISSN 1555-0265

Publisher: Human Kinetics

Running Title: Pre-sleep heart rate variability biofeedback improves mood and sleep quality in Chinese Winter Olympic bobsleigh athletes

Submission type: Original investigation

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Abstract word count: 211
Text word count: 3492
Number of figures: 6
Number of tables: 5

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Running head: Pre-sleep heart rate variability biofeedback

Abstract

Purpose: To evaluate the effectiveness of heart rate variability (HRV) biofeedback on improving autonomic function, mood and sleep in elite bobsleigh athletes.

Methods: Eight Chinese Winter Olympic bobsleigh athletes (age: 24±2 years; body mass 89±15kg and height 184±5cm) completed a randomised crossover study with and without HRV-biofeedback before a single night's sleep. HRV-biofeedback was provided 35 minutes prior to bedtime in the experimental condition. The assessment of HRV took place 45 and 10 minutes before bedtime. The Profile of Mood States (POMS) questionnaire was completed 50 and 15 minutes prior to bedtime. Sleep duration and quality were measured through an air-mattress sleep monitoring system.

Results: Sleep efficiency ($P=0.020$, $F=7.831$, CI=0.008 to 0.072) and the percentage of deep sleep duration increased ($P=0.013$, $F=10.875$, CI= 0.006 to 0.035) whilst the percentage of light sleep decreased ($P=0.034$, $F=6.893$, CI=-0.038 to -0.002). Pre-sleep HRV-biofeedback increased parasympathetic and decreased sympathetic activity. Mood states of anger ($P=0.006$, $F=7.573$), panic ($P=0.031$, $F=4.288$), tension ($P=0.011$, $F=6.284$), depression ($P=0.010$, $F=6.016$), fatigue ($P=0.000$, $F=16.901$) and total mood disturbance ($P=0.001$, $F=11.225$) were reduced before sleep.

Conclusion: Pre-sleep HRV-biofeedback improved some measures of autonomic function, mood, and sleep quality in Chinese Olympic bobsleigh athletes. Pre-sleep HRV-biofeedback provides a practical strategy that may help reduce sleep disturbances during periods of training and competition.

Keywords: Bobsleigh athletes; Heart rate variability biofeedback; Sleep quality; Profile of mood states.

1 Introduction

Bobsleigh is a winter sport that requires good acceleration and high peak speeds during the initial push-phase, as well as excellent kinaesthetic awareness and decision-making capabilities to navigate the track at speeds of up to 160km/h.[1] Marginal time differences between success and failure mean that even subtle declines in physical and cognitive ability could be detrimental for performance. During the Winter Olympics, athletes are often required to compete late in the evening. In the Beijing Winter Olympics, all four heats for the two-man and two-woman bobsleigh teams took place after 20:00 local time,[2] in addition to light training in the evenings on non-competition days. Evening competitions have been shown to increase sleep onset latency and reduce sleep quality.[3] Although this is not a universal finding[4], an increase in sympathetic activity and a state of arousal may negatively impact sleep.[5] For example, high intensity evening exercise elicits sympathetic mediated physiological responses, including an increase in nocturnal heart rate[3,4] and a reduction in HRV.[3] Moreover, the stress of competition can manifest as negative mood states that prolong sympathetic activity and disrupt sleep.[6] It is well established that impaired or shortened sleep can impact sporting performance in aspects crucial to bobsleigh performance, such as lower body power and cognitive performance.[7,8] Hence, strategies to overcome impaired sleep are a high priority for this group of athletes.

HRV-biofeedback is a therapeutic tool that uses breathing manoeuvres to match breathing with heart rate patterns,[9] in order to help restore autonomic nervous system balance through increasing parasympathetic nervous system activity.[10] The use of HRV-biofeedback has been shown to help treat anxiety, depression and sleep related issues in diseased and healthy populations.[9] Reiner et al[11] found that it supported feelings of relaxation over and above other common relaxtion techniques such as meditation, yoga and unassisted breathing techniques. The pychophysiological benefits of HRV-biofeedback may in turn reduce sleep onset latency[11] and scores of sleep disturbance.[12] To date there is very limited research using this intervention in athletes in these scenarios.

During the 2022 Beijing Winter Olympics many athletes will be under high levels of physiological and psychological pressure to succeed. This will likely further increase pre-competition anxiety and lead to an increased risk of impaired sleep throughout the competition and subsequently impair performance. Countermeasures for poor sleep may be a potent tool to reduce the impact of pre-competition anxiety on performance but are not commonly used by athletes and coaches.[13] Indeed, the majority of studies on sleep in elite athletes have focussed on better understanding the problem while relatively few have assessed potential solutions. The aims of this study were to determine whether pre-sleep HRV-biofeedback could improve parameters of autonomic function, mood and sleep. It was hypothesised that pre-sleep HRV biofeedback would enhance autonomic function and mood which would in turn improve sleep duration and quality in Chinese Olympic bobsleigh athletes.

2 Methods

2.1 Participants

Eight Chinese Winter Olympic bobsleigh athletes (Tier 5: World class),[14] consisting of five males (4 pilots and 1 brakeman) and three females (3 pilots) (age: 24±2 years; body mass 89±15kg and height 184±5cm) participated in this cross-over study. During the testing period, all athletes were undergoing a 4-day training cycle, which consisted of 3 days training and 1 day of rest. On training days, athletes had two sessions and followed the same training routine. Sessions took place at the National sliding Centre from 9:00 - 11:00 in the morning and 19:00 - 21:00 in the evening. The athletes were in bed by ~22:30. The bedtime and wake times for each athlete can be found in Table 2. All participants volunteered to take part in the study and completed informed consent forms and health questionnaires prior to participation. Ethical approval was provided by the Beijing Sport University Ethics Committee (2020132H) and all procedures conformed to the Declaration of Helsinki.

2.2 Study design

Athletes completed a randomised, counterbalanced, cross-over design study. The study consisted of two phases; the first phase included control testing and the second phase intervention testing. Each phase was separated by 4-days. There were no differences between training loads for each individual training cycle (Table 1). Total distance was calculated based on the distance of the bobsleigh track, multiplied by the 5 slides per training session. During the testing period the brakeman participated in the same training regimen as the pilots as this athlete had recently changed position from pilot to brakeman. Pilot testing of HRV-biofeedback training and the POMS questionnaire took place the day before testing. Moreover, the air-mattress sleep monitoring system (Sleeptek 300, Beijing Tonghe Technology Co., Ltd.) was installed in the home of the athletes to help minimise artificial sleep disruption on the test day.

During the experimental trial HRV was assessed 45 minutes before bedtime in the HRV-biofeedback condition and 10 minutes before bedtime in the HRV-biofeedback and control condition. We decided to measure HRV at these time points as HRV is typically higher in the late evening[15] and modifying HRV prior to bedtime may play a subsequent role in mediating changes in sleep, especially following evening exercise.[3] HRV-biofeedback was provided to the intervention group 35 minutes prior to bedtime. POMS were assessed 15 and 50 minutes before bedtime in the HRV-biofeedback condition and 15 minutes before bed in the control condition. Sleep was continuously monitored throughout the night through the use of an air-mattress sleep monitoring system which is described in more detail below.[16] A schematic representation of the experimental protocol can be found in Figure 1.

Insert Figure 1

2.2 Experimental protocol

In the week prior to testing the diet of athletes were controlled in accordance with the team's dietary plan. On the day of testing, athletes were asked to avoid napping throughout the day. Six of the athletes reported not napping during training periods prior to the study and two reported taking the occasional nap but not on a daily basis. The athletes arrived at the laboratory for testing at the same time of day to control for the influence of circadian rhythm on autonomic activity and mood.[17,18] Athletes had no recent physical or psychological traumas and had no previous exposure to any form of psychological therapy. The laboratory was maintained at an ambient temperature of 24-26℃ and a relative humidity of 52-55% (Aneroid barometer, THB9392, China).

Following an explanation of the study protocol, the mood states of athletes were assessed 50 minutes prior to bedtime through the revised POMS questionnaire[19], which has previously been translated and validated.[20] The questionnaire included 40 items and consisted of five negative mood subscales (Anger, Panic, Tension, Depression and Fatigue) and two positive mood subscales (Vigour and Self-esteem). Each was an individual 5-point Likert scale that athletes ranked from 0 (Not at all) to 5 (Extremely). Total mood disturbance was then calculated (5 total negative emotional values - 2 total positive emotional values + 100).

Athletes were then instructed to sit and rest for 10 minutes before HRV (Ignite and H10, Polar Electro, Finland) was recorded 45 minutes before bedtime for 10 minutes. The validity of Polar H10 at rest is comparable to that of an Holter ECG for assessing RR intervals.[21] The use of HRV is an effective tool to assess autonomic nervous activity and is often used as an indicator of sympathetic and parasympathetic activity.[22] The indicators that reflect parasympathetic activity through HRV are as follows: parasympathetic nerve index (PNS Index), root mean square of continuous difference between RR intervals (RMSSD), mean RR interval (MRR) and high frequency power (HF). The indicators that reflect sympathetic activity include: sympathetic nerve index (SNS Index), mean heart rate (MHR), stress index (SI), and low frequency power (LF). LF/HF stands for sympathetic and parasympathetic balance. The RR interval data were then exported, and the Kubios HRV-standard (ver.3.4.3) software was used to calculate the autonomic nervous system data as described elsewhere.[23]

HRV-biofeedback was then implemented 35 minutes before bedtime, over a 20-minute period. Athletes were provided with real time HRV data and an image of Bodhi tree through a self-generated physiological coherence system (American Heart Math Association and Beijing Haofeng Digital Technology Co.). The athletes simultaneously listened to music and watched the

Bodhi tree, whilst matching their breathing rhythm (0.1Hz) in accordance with the system. The image of the Bodhi tree would grow depending on the mental coordination and respiratory control of the athlete (low, medium or high) (Figure 2). Based on the computer screen image, athletes were able to modify breathing manoeuvres in an attempt to improve autonomic nervous system control.[24] The biofeedback training process during pilot tests and testing sessions are described elsewhere.[24]

Insert Figure 2

The mood states of athletes were assessed 15 minutes prior to bedtime through the revised POMS questionnaire[24] and HRV was then reassessed 10 minutes before bedtime. After the final measurement, athletes were instructed to lay down on the air-mattress (Figure 3), which was placed between the back of the athlete and the bed. The air-mattress contained supporting air cells, piezoelectric sensors, a signal transmission line, and a host computer. Through the microphone and piezoelectric sensors, the system was able to continuously monitor heart rate, body movements and respiration. The Sleeptek air-mattress has been successfully validated against Polysomnography and as a result is registered as a medical device (20182071457) for monitoring sleep within hospitals across the People's Republic of China. The correlation coefficients of the air-mattress for beat to beat heart rate ($r=0.98$, $P<0.01$) and breath by breath respiration ($r=0.96$, $P<0.01$) are comparable to electrocardiograms and piezoelectric belts, respectively.[16]

Insert Figure 3

Sleep efficiency was calculated as the ratio of total sleep time to time in bed and sleep onset latency (SOL) as the time between bedtime and falling asleep. Total sleep was made up of 4-6 cycles, with each cycle separated into Time awake, Rapid Eye Movement (REM) and Non-Rapid Eye Movement (NREM). The combination of stage 1 and 2 of NREM represented the duration of light sleep, and the combination of stage 3 and 4, deep sleep duration. This allowed each sleep cycle to be divided into four stages, time awake, light sleep, deep sleep and REM.[25]

2.3 Statistical analysis

A Shapiro-Wilk test was used to confirm data normality. A within-subjects linear mixed model analysis were performed to examine the differences in sleep, HRV, POMS and workloads. The test times were used as a fixed effect, whilst athlete identity was the random effect within the models. Selection of variance-covariance structures were based on the smallest Akaike Information Criterion. Upon observing a main effect, post hoc pairwise comparison with Bonferroni correction was used for the mean values. Statistical significance was accepted at $P<0.05$.

Upon the occurrence of significant differences, within-subjects correlations were calculated between sleep, HRV, POMS and workloads variables.[26] This provided a correlation and 95% confidence interval between the covariates and outcome measures. If the 95% confidence intervals overlapped positive and negative values, the effect was considered as unclear. The magnitudes of correlations were classified as trivial ($r \leq 0.1$), small ($r = 0.1–0.3$), moderate ($r=0.3-0.5$), large ($r=0.5-0.7$), very large ($r=0.7-0.9$), and almost perfect ($r \geq 0.9$).[27] All statistical analysis was carried out in SPSS (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.) and figures generated in GraphPad Prism 5.0 (GraphPad Software Inc. San Diego, CA).

3 Results

3.1 Workload metrics

There were no significant differences in workload metrics between conditions for session duration, rest time, rating of perceived exertion and total slide time between the HRV-biofeedback and control conditions for day and evening training ($P>0.05$). Correlation analysis revealed no relationships between workload metrics with measures of sleep, HRV and POMS.

Insert Table 1

3.2 Sleep quality and duration

HRV-biofeedback increased sleep efficiency (P=0.020, F=7.831, CI=0.008 to 0.072), percentage of deep sleep (P=0.013, F=10.875, CI= 0.006 to 0.035) and reduced the percentage of light sleep (P=0.034, F=6.893, CI=-0.038 to -0.002). No differences were detected for other measures of sleep quality and duration (P>0.05). Correlation analysis revealed no relationships between sleep variables with workload metrics and POMS.

Post-hoc correlation analysis determined a positive association between percentage of deep sleep and MRR (r=0.675, P=0.004, CI=<0.001 to 0.001) and negative association between percentage of deep sleep and MHR (r=-0.715, P=0.002, CI=-0.006 to -0.002). In contrast, there was a negative association between percentage of light sleep and MRR (r=-0.549, P=0.028, CI=-0.001 to <-0.001) and a positive association between percentage of light sleep and MHR (r=0.652, P=0.006， CI=0.001 to 0.006).

Insert Figure 4

Insert Table 2

3.3 Autonomic nervous system regulation

A main effect was observed with an increase in PNS Index (P<0.001, F=26.090), MRR (P=0.003, F=9.938), SNS index (P=0.003, F=9.382), MHR (P=0.001, F=13.191) and SI (P=0.002, F=10.318).

Compared with the control group, PNS Index (P<0.001, CI=0.796 to 2.039) and MRR (P=0.003, CI=48.765 to 243.235) increased. SNS Index (P=0.015, CI=-1.880 to -0.185), MHR (P=0.001, CI= -17.112 to -4.638) and SI (P=0.036, CI=-7.624 to -0.226) decreased in the Post HRV-biofeedback group.

Compared with the Pre HRV-biofeedback group, PNS Index (P<0.001, CI=0.820 to 2.062), and MRR (P=0.009, CI=31.390 to 225.860) increased, SNS Index (P=0.003, CI=-2.117 to -0.423), MHR (P=0.016, CI=-15.612 to -3.138) and SI (P=0.002, CI=-9.799 to -2.401) decreased in the Post HRV-biofeedback group (Table 2). There were no differences observed between the control and Pre HRV-biofeedback conditions (Table 3).

Correlation analysis revealed no relationships between HRV with workload metrics and POMS.

Insert Table 3

Insert Figure 5

3.4 Profile of mood states

A main effect was detected for anger (P=0.006, F=7.573), panic (P=0.031, F=4.288), tension (P=0.011, F=6.284), depression (P=0.010, F=6.016), fatigue (P<0.001, F=16.901) and total mood disturbance (P=0.001, F=11.225).

Post hoc pairwise comparisons revealed that there was a difference between the HRV-biofeedback and control conditions for anger (P=0.020, CI=-6.260 to -0.490), tension (P=0.033, CI=-5.538 to -0.212), depression (P=0.023, CI=-5.639 to -0.361), fatigue (P=0.001, CI=-7.121 to -2.129) and total mood disturbance (P=0.003, CI=-26.746 to -5.504). Differences were also apparent for anger (P=0.020, CI=-6.635 to -0.865), tension (P=0.020, CI=-5.578 to -0.462), depression (P=0.023, CI=-5.639 to -0.361), fatigue (P=0.001, CI=-7.121 to -2.129) and total mood disturbance (P=0.002, CI=-27.264 to -6.004) when comparing the HRV-biofeedback to Pre HRV-biofeedback conditions. No differences were observed between control group and Pre HRV-biofeedback groups (Table 3). Correlation analysis revealed no relationships between POMS with sleep variables, HRV and workload metrics.

Insert Table 4

Insert Figure 6

4 Discussion

This study investigated the efficacy of pre-sleep HRV-biofeedback on autonomic function, mood and sleep in elite bobsleigh athletes. In the majority of athletes, HRV-biofeedback prior to a single night's sleep increased sleep efficiency (6/8 athletes), deep sleep duration (7/8 athletes), and decreased light sleep duration (7/8 athletes). However, there were large individual differences for improvements in SOL (5/8) and total sleep time (4/8). This could be linked to the observation that superior sleep quality was preceded by parasympathetic dominance and a reduction in negative mood states for only some athletes. Taken together, we can partially accept our hypothesis given that pre-sleep HRV-biofeedback improved autonomic function and mood, which was followed by superior sleep quality.

The need for adequate sleep to enhance mental health and performance has been emphasised by the International Olympic Committee.[28] Regardless, 50% of athletes exceeded the clinical threshold for poor sleep quality and 53% reported sleep complaints prior to the 2016 Rio Olympic Games.[29,30] According to the National Sleep Foundation, adults are advised to have 7-9 h of sleep per night.[31] In addition to a sufficient duration of sleep, adults are also recommended to achieve good levels of sleep quality with a combination of >85% sleep efficiency, <30 minutes SOL and <20 minutes of time awake encouraged.[32] Only 3/8 of the Chinese Winter Olympic bobsleigh athletes met these generic sleep duration and quality guidelines. Notably, HRV-biofeedback resulted in an increase to 5/8 during this standard training period (Table 2 and Figure 4). Despite these positive findings, it is worth highlighting that approximately one quarter of individuals achieving these sleep durations perceive their sleep quality as fairly or very bad.[30] Furthermore, this one size fits all approach does not indicate that each athlete achieved optimal levels of sleep for recovery and performance.[33] Indeed, Olympic athletes may require as much as 10 h of sleep per night,[34] although this will be dependent on the age of the athlete and performance demands.

In line with previous research, we showed that HRV-biofeedback before a single night's sleep can improve sleep quality through reducing the duration of light sleep (Stage 1) but had no effect on SOL and total sleep duration.[12] Although our results showed that there were high levels of individual differences for SOL and total sleep duration. This reemphasises the presence of individual variability for HRV and sleep parameters in elite athletes. On the contrary to Ebben and colleagues, we also observed an increase in sleep efficiency and deep sleep duration (Stage 2) (Figure 4). Whilst our changes in sleep effciency, percentage of deep sleep, and percentage of light sleep were relatively small for some individuals, even marginal improvements in sleep quality could be of relevance for bobsleigh performance.[35] To our knowledge this is the first study to demonstrate that pre-sleep HRV-biofeedback offers a practical therapeutic strategy to improve sleep quality for some Olympic athletes. It is also concievable that the benefits of HRV-biofeedback may be greater during periods of high physiological and pyschological stress when sleep may be impaired more, such as competition phases.[29,30] However, further testing in competition can prove difficult or even undesirable as it can lead to further unneccessary stress for the athlete and impair performance. It would also be interesting to see the cumulative effects of this approach over longer periods because consecutive days of poor sleep can potentially hinder components of athletic performance, such as muscle recovery, immune defence and nuerocogntive fuction.[7]

As evening training sessions can result in higher levels of psychophysiological arousal and increased sympathetic activity,[3,35] this could partially explain why many athletes did not meet the general sleep duration and quality guidelines.[31, 32] In contrast, improvements in sleep quality after HRV-biofeedback may have been underpinned by a decrease in sympathetic and increase parasympathetic activity prior to sleep (Figure 5) or by improved mood (Figure 6). In support of the former, we revealed a positive association for MRR and negative association for MHR with percentage of deep sleep and vice versa for percentage of light sleep (Table 2 and Figure 4).[37] In general, our findings correspond with Prinsloo et al, who reported a shift towards parasympathetic activity and relaxation during and after a single HRV-biofeedback session in those exposed to regular work-related stress.[38] Such alterations in autonomic activity may assist sleep through enhancing cardiorespiratory resting function during sleep.[39]

Negative mood states are common in athletes during periods of psychological and physical strain and can cause poor sleep quality.[35] Given that negative moods encourage sleep disturbances and vice versa,[7] a vicious cycle can occur whereby athletic performance deteriorates owing to mood and sleep problems. Acute changes in the autonomic nervous system and mood can directly affect one another in a bidirectional relationship.[39-41] In our study parasympathetic dominance prior to sleep was accompanied with reductions in anger, depression, fatigue, and total mood disturbance for all athletes. In addition, tension was reduced for the majority (6/8 athletes) (Figure 6). Similarly, Windthorst et al[42] determined that eight sessions of HRV-biofeedback can decrease feelings of fatigue and depression. In addition, 3-weeks of HRV-biofeedback attenuates anger and anxiety in patients with sympathetic over-arousal, which coincided with sleep benefits.[11]

5 Limitations

It should be acknowledged that this study had several limitations. Firstly, although the seven bobsleigh pilots represent the entirety of the Chinese Winter Olympic team, the sample size is relatively small; therefore, caution is advised when applying these findings to different athletic populations. This study also utilised HRV-biofeedback during a training period, it is therefore unclear how these findings will transfer if HRV-biofeedback is used during competition periods. In addition, it is conceivable that our study underestimated the capacity of HRV-biofeedback to attenuate negative moods and enhance sleep quality given that athletes often suffer from higher levels of anxiety and sleep disruption prior to competition. Future research should explore the influence of pre-sleep HRV-biofeedback during competition.

6 Practical Applications

Pre-sleep HRV-biofeedback can be considered a practical strategy that may enhance recovery and performance. However, the presence of individual variability suggests that the benefits of pre-sleep HRV-biofeedback can be optimised through an individualised athlete approach.[43] These are important findings given that the majority of studies on sleep in elite athletes have focussed on characterising and better understanding 'the problem', while the major strength of the current study is that it directly investigates a potential solution.

7 Conclusions

In summary, there is individual variability in the efficacy of pre-sleep HRV-biofeedback on some parameters of autonomic function, mood and sleep. Our findings demonstrate that HRV-biofeedback can increase sleep efficiency, deep sleep, and decrease light sleep. These benefits might be underpinned by parasympathetic dominance and a reduction in negative mood states.

7 Acknowledgements

The authors would like to thank the national bobsleigh team coach, doctor, participating athletes and the financial support of the National Key R&D Program of China (2018YFF0300801).

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Figure captions

Figure 1: Experimental protocol

Figure 2: The three stages of Bodhi tree growth that represent low, medium and high mental coordination and respiratory control

Figure 3: Schematic diagram of air-mattress installation

Figure 4: Individual responses with mean ± standard deviation for (a) Light sleep time (LST), (b) Deep sleep time (DST), (c) Rapid eye movement (REM), (d) Time awake (TA), (e) Sleep efficiency (SE), (f) Sleep onset latency (SOL) and (g)Total sleep time (TS) (n=8). *= a significant difference between control and HRV-biofeedback ($P<0.05$).

Figure 5: Individual responses with mean ± standard deviation for (a) Sympathetic nervous system index (SNS index), (b) Mean heart rate (MHR), (c) Stress index (SI), (d) Parasympathetic nervous system index (PNS index) and (e) Mean RR interval (MRR) (n=8). *= a significant difference between pre and post HRV-biofeedback ($P<0.05$). **= a significant difference between pre and post HRV-biofeedback ($P<0.01$). ∇= a significant difference between control and post HRV-biofeedback ($P<0.05$). $\nabla\nabla$= a significant difference between control and post HRV-biofeedback ($P<0.01$).

Figure 6: Individual responses with mean ± standard deviation for (a) Anger, (b) Tension, (c) Depression, (d) Fatigue and (e) Total mood disturbance (n=8). *= a significant difference between pre and post HRV-biofeedback ($P<0.05$). **= a significant difference between pre and post HRV-biofeedback ($P<0.01$). ∇= a significant difference between control and post HRV-biofeedback ($P<0.05$). $\nabla\nabla$= a significant difference between control and post HRV-biofeedback ($P<0.01$).

Table titles and captions

Title - Table 1: Workload metrics for bobsleigh athletes in control and HRV-biofeedback conditions (n=8).

Caption - Day training (DT), evening training (ET), and rating of Perceived Exertion (RPE). Values expressed as mean with the 95% confidence interval.

Title - Table 2: The sleep onset times and wake times for individual bobsleigh athletes (n=8).

Title - Table 3: Measures of HRV in the control condition and pre and post the HRV-biofeedback condition (n=8).

Caption - Sympathetic nervous system index (SNS index), mean heart rate (MHR), stress index (SI), parasympathetic nervous system index (PNS index), Root mean square of successive RR interval differences (RMSSD), mean RR interval (MRR), low-frequency (LF), high-frequency (HF) and low-frequency and high-frequency ration (LF/HF). Values expressed as mean and 95% confidence interval. *= a significant difference between pre and post HRV-biofeedback (P<0.05). **= a significant difference between pre and post HRV-biofeedback (P<0.01). ∇= a significant difference between control and post HRV-biofeedback (P<0.05). ∇∇= a significant difference between control and post HRV-biofeedback (P<0.01).

Title - Table 4: Profile of mood states in the control condition and pre and post the HRV-biofeedback condition (n=8).

Caption - Values expressed as mean and 95% confidence interval. *= a significant difference between pre and post HRV-biofeedback (P<0.05). **= a significant difference between pre and post HRV-biofeedback (P<0.01). ∇= a significant difference between control and post HRV-biofeedback (P<0.05). ∇∇= a significant difference between control and post HRV-biofeedback (P<0.01).