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Effects of Music Tempo on Cardiovascular  
Recovery During High-Intensity Interval  
Exercise in Recreationally Trained Adults

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# Effects of Music Tempo on Cardiovascular Recovery During High-Intensity Interval Exercise in Recreationally Trained Adults

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Bachelor Thesis 15 credits in Exercise Biomedicine Halmstad University

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## Abstract

**Background:** High-intensity interval training (HIIT) induces beneficial adaptations in cardiorespiratory fitness and autonomic nervous system (ANS) regulation. Measures such as heart rate recovery (HRR), pulse rate variability (PRV) and rate of perceived exertion (RPE) are effective indicators of recovery and training status. While music has shown ergogenic effects during exercise, its influence on autonomic recovery between HIIT intervals remains unclear.

**Aim:** This project aimed to investigate how different tempos of music affected recovery between high-intensity intervals on a stationary bicycle.

**Method:** A total of 13 participants were included, of which 38% were women and 62% men. Each test session included a 16-minute graded warm-up to determine individualised power output, followed by a rest period and then five 2-minute high-intensity intervals with 2 minutes of passive recovery between each interval. Music tempo was selected based on a randomised counter-balanced order and was played during the recovery periods. A crossover design was used, utilizing a within-subject, two factor approach. The chosen recovery markers that were analysed were HRR, percent heart rate recovery (%HRR), heart rate recovery rate ( $HRR_{rate}$ ), average percent of heart rate max ( $\%HR_{max\_ave}$ ), PRV and RPE.

**Results:** There were no interaction effect for tempo x interval for any variable. Although, significant main effects for interval were shown in all variables. Pairwise comparisons showed significant differences for  $HRR_{rate}$  (intervals 1, 3 and 4 had a lower rate than interval 5,  $p < 0.05$ ),  $\%HR_{max\_ave}$  (intervals 2, 3, 4 and 5 had higher  $\%HR_{max\_ave}$  compared to interval 1,  $p < 0.001$ , and intervals 4 and 5 showed higher  $\%HR_{max\_ave}$  than interval 2,  $p < 0.01$ ), PRV (intervals 3 and 4 had lower PRV, compared to interval 1,  $p < 0.05$ ) and for RPE recorded in the beginning ( $RPE_{start}$ ) and end ( $RPE_{end}$ ) of each recovery period ( $RPE_{start}$  showed higher values for interval 2, 3, 4 and 5 compared to interval 1,  $p < 0.05$ , and for  $RPE_{end}$  intervals 1, 2, 3 and 5 had lower values compared to interval 4,  $p < 0.05$ ). HRR and %HRR showed no significant pairwise comparisons, but trends for difference between intervals were found. No main effects for music tempo were found.

**Conclusions:** These findings suggest that the tempo of music does not affect the recovery of the chosen recovery markers. However, significant differences were observed in all recovery variables across the interval bouts, suggesting that cardiovascular recovery dynamics change over the course of repeated intervals.

# Sammanfattning

**Bakgrund:** Högintensiv intervallträning (HIIT) inducerar gynnsamma fysiologiska anpassningar av både den kardiovaskulära kapaciteten och det autonoma nervsystemets (ANS) reglering. Markörer såsom hjärtfrekvensåterhämtning (HRR), pulsfrekvensvariabilitet (PRV) och upplevd ansträngningsnivå (RPE) används ofta som indikatorer för återhämtningsförmåga och träningsstatus. Även om musik har visat sig ha prestationshöjande effekter under fysisk aktivitet, är dess potentiella påverkan på autonom återhämtning mellan HIIT-intervaller inte tillräckligt utforskad.

**Syfte:** Syftet med denna studie var att undersöka hur musik med olika tempo påverkar återhämtning mellan högintensiva intervaller på träningscykel hos vuxna motionärer.

**Metod:** Studien inkluderade 13 deltagare (38 % kvinnor, 62 % män). Varje testsession inkluderade en 16 minuter lång stegrande uppvärmning för att fastställa individuell arbetsbelastning, följt av en viloperiod samt fem 2-minuters högintensiva intervaller med 2-minuters passiv återhämtning mellan intervallerna. Musiktempo tilldelades enligt en randomiserad och motbalanserad ordning och spelades under återhämtningsperioderna. En crossover-design med inomindividuell ansats och två faktorer tillämpades. De fysiologiska utfallsvariablerna var HRR, procentuell hjärtfrekvensåterhämtning (%HRR), hjärtfrekvensåterhämtningens hastighet ( $HRR_{rate}$ ), genomsnittlig procent av maximal hjärtfrekvens ( $\%HR_{max\_ave}$ ), PRV samt RPE.

**Resultat:** Ingen signifikant huvudeffekt observerades för interaktionen mellan musiktempo och intervall för någon av de analyserade variablerna. Dock fanns signifikanta huvudeffekter för intervaller hos samtliga variabler. Parvisa jämförelser visade signifikanta skillnader för  $HRR_{rate}$  (intervall 1, 3 och 4 hade en lägre återhämtningshastighet jämfört med intervall 5,  $p < 0,05$ ),  $\%HR_{max\_ave}$  (intervall 2, 3, 4 och 5 hade högre  $\%HR_{max\_ave}$  jämfört med intervall 1,  $p < 0,001$ , och intervall 4 och 5 visade högre  $\%HR_{max\_ave}$  än intervall 2,  $p < 0,01$ ), PRV (intervall 3 och 4 hade lägre PRV jämfört med intervall 1,  $p < 0,05$ ), samt för RPE uppmätt i början ( $RPE_{start}$ ) och slutet ( $RPE_{end}$ ) av varje återhämtningsperiod.  $RPE_{start}$  visade högre värden för intervall 2, 3, 4 och 5 jämfört med intervall 1 ( $p < 0,05$ ), och för  $RPE_{end}$  hade intervall 1, 2, 3 och 5 lägre värden jämfört med intervall 4 ( $p < 0,05$ ). HRR och %HRR visade inga signifikanta parvisa skillnader, men trender mellan intervaller observerades. Inga huvudeffekter av musiktempo påträffades.

**Slutsats:** Studien indikerar att musikens tempo inte har någon avgörande inverkan på

återhämtning mätt via de valda återhämtningsmarkörerna mellan högintensiva intervaller hos rekreationstränade individer. Däremot observerades signifikanta skillnader i samtliga återhämtningsmått mellan de olika intervallerna, vilket tyder på att den kardiovaskulära återhämtningsdynamiken förändras under upprepade intervaller.

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# Background

## High-Intensity Interval Training

High-intensity interval training (HIIT) can improve both fitness and health in individuals of all ages (Atakan et al., 2021). The training concept of HIIT comprises short bursts of intense exercise followed by a short period of active or passive rest (Coates et al., 2023). HIIT is typically characterised by repeated bouts of near-maximal effort, generally performed at an intensity corresponding to  $\geq 80\%$ , and often between 85–95%, of an individual's maximum heart rate ( $HR_{max}$ ; MacInnis & Gibala, 2017). One of the major benefits of HIIT training is that a lower training volume is required to improve maximal oxygen uptake ( $\dot{V}O_{2max}$ ), compared to moderate-intensity continuous training. The increase in  $\dot{V}O_{2max}$  may be attributed to several physiological adaptations, all of which contribute to improved oxygen transport capacity (Atakan et al., 2021). HIIT at 90-95% of  $HR_{max}$  shows greater improvements in  $\dot{V}O_{2max}$  compared to the same total work at 70% of  $HR_{max}$  or at lactate threshold (Helgerud et al., 2007). A high  $\dot{V}O_{2max}$  is a key indicator of cardiorespiratory fitness and is associated with a lower risk of cardiovascular disease, coronary heart disease, and all-cause mortality (Kodama et al., 2009).

In addition to the impact on aerobic capacity, HIIT is also an effective strategy for reducing total body fat, visceral fat, and abdominal fat in both normal-weight and overweight individuals (Maillard et al., 2018). Moreover, HIIT has been shown to exert positive effects on cardiac autonomic function. After two weeks of training, HIIT has demonstrated greater efficacy than moderate-intensity continuous training in improving cardiac autoregulation (Alansare et al., 2018). Furthermore, a three-week HIIT intervention has been associated with significant improvements in heart rate variability (HRV) (Besier et al., 2019), while trained endurance athletes have exhibited enhanced acute heart rate recovery (HRR) following HIIT (Stöggl & Björklund, 2017). These cardiovascular and metabolic adaptations highlight the role of HIIT not only in improving cardiorespiratory fitness but also in modulating the autonomic nervous system (ANS). The regulation of the ANS is crucial for maintaining physiological homeostasis, optimising recovery, and enhancing resilience to both physical and psychological stressors (Marieb & Hoehn, 2019, p. 564).

## **Assessment of Intensity during High-Intensity Interval Training**

The intensity of HIIT can be assessed through both objective and subjective measures. One common objective indicator is the percentage of  $HR_{max}$  ( $\%HR_{max}$ ; MacInnis & Gibala, 2017). Since individual  $HR_{max}$  tests cannot always be conducted, a formula is often used to estimate  $HR_{max}$  (Gellish et al., 2007). This method is used across various fields; however, due to substantial individual variability in  $HR_{max}$ , it has certain limitations. Therefore, a subjective measure of intensity, such as Borg's Rating of Perceived Exertion (RPE) scale, can serve as a useful complementary tool (Borg, 1998; Coates et al., 2023). The RPE scale ranges from 6 to 20 and measures an individual's perceived exertion. A score of 6 corresponds to no exertion, while a score of 20 represents maximal exertion (Borg, 1998). The scale is closely related to HR (Scherr et al., 2013), where each increment roughly corresponds to a 10 beats per minute (bpm) increase for a 20-year-old individual. For example, a rating of 6 on the Borg scale corresponds to a HR of approximately 60 bpm (resting HR), while a rating of 20 corresponds to around 200 bpm, which reflects the estimated  $HR_{max}$  for someone in their twenties (McArdle et al., 2008, p. 520-521). RPE is a practical and widely applicable tool for subjectively assessing exercise intensity during HIIT, where an RPE between 14 and 20 is generally considered to represent high intensity from a health context (Coates et al., 2023).

## **The Autonomic Nervous System and Exercise Regulation**

The ANS continuously transmits signals to various organs to maintain homeostasis (Marieb & Hoehn, 2019, p. 564). It comprises motor neurons that innervate smooth muscle, glands, visceral organs, and the cardiac muscle, regulating involuntary physiological functions. Through the ANS, subconscious adjustments occur in the body, including modulations in HR, blood pressure, and body temperature. The ANS is further divided into two branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) (Marieb & Hoehn, 2019, p. 565). The SNS is responsible for the "fight or flight" response, increasing HR, blood pressure, and energy mobilisation, while the PNS facilitates "rest and digest" functions, promoting recovery and homeostasis.

Understanding the interaction between SNS and PNS activity provides valuable insight into how these systems balance each other. During exercise, the SNS is predominantly active,

facilitating physiological adaptations to meet increased metabolic demands (Halson, 2014). The SNS accelerates HR, increases respiratory rate, stimulates sweat production, and constricts certain visceral blood vessels to prioritise blood flow to the skeletal muscles and cardiac muscle, all of which are characteristic responses to physical exertion (Marieb & Hoehn, 2019, p. 566–567). Following exercise and during recovery periods, the PNS becomes more active, promoting physiological restoration and energy conservation (Halson, 2014; Dupuy et al., 2022). Rather than functioning in isolation, the SNS and PNS operate dynamically, with a continuous interplay between activation and deactivation to maintain physiological stability (Marieb & Hoehn, 2019, p. 566–567).

Since HIIT comprises alternating periods of high-intensity exercise and low-intensity or passive recovery, effective regulation between the PNS and SNS is crucial. During high-intensity intervals, rapid SNS activation is essential to optimise performance, while during recovery periods, PNS modulation must occur swiftly to maximise physiological restoration and prepare the body for the next interval. HIIT has been shown to enhance cardiac autonomic modulation in physically inactive, sedentary men (O’Driscoll et al., 2018; Matsuo et al., 2014), healthy university students (Perkins et al., 2017), and healthy women (Oliveira et al., 2022).

## **Measures of Autonomic Nervous System Activity**

Measuring the activity of the ANS can be an effective method for assessing recovery. ANS activity can be evaluated in various ways, but common parameters include HRR, HRV, and pulse rate variability (PRV; Halson, 2014; Lundstrom et al., 2023). HRR refers to the rate at which HR declines after exercise and is considered a marker of autonomic function and training status in athletes (Halson, 2014). During exercise, HR increases due to heightened SNS activity and reduced PNS activity. HRR reflects the opposing autonomic response, with increased PNS and reduced SNS activity. HRR is typically measured over 30 seconds to 2 minutes (Halson, 2014). A faster HRR is a known indicator of greater cardiovascular performance and health (Facioli et al., 2021). Well-trained male endurance athletes exhibited a faster HRR and PNS reactivation compared to untrained men following maximal exercise (Dupuy et al., 2022). The PNS is a vital part of the HRR time, and a delayed response may not only be a risk factor of metabolic syndrome but an imbalance in the autonomic nervous system (Kizilbash et al., 2006). A delayed HRR post-exercise has also been shown to predict both cardiovascular and non-

cardiovascular mortality in patients without cardiovascular disease (Sydó et al., 2018; Kokkinos et al., 2012).

HRV analysis measures beat-to-beat fluctuations in cardiac rhythm, assessing variability over a set time using R-R intervals from an electrocardiogram or interbeat intervals from pulse rate. When interbeat intervals from pulse rate are assessed, this is referred to as PRV (Lundstrom et al., 2023). Unlike average HR, HRV and PRV focuses on the variability within the HR sequence. HRV and PRV have been well studied since the 1970s and is understood as a reflection of ANS balance, with higher variability indicating increased PNS activity (Lundstrom et al., 2023). Athletes with a higher fitness level also experience a faster decrease in HRV as HR increases (Mongin et al., 2022). Exercise increases HR to meet higher metabolic demands, while time and frequency domain HRV and PRV measures decrease significantly. Despite method and exercise mode variations, the general pattern shows a dose-response relationship where HRV and PRV decreases with exercise intensity (Lundstrom et al., 2023). The most common time-domain measurement for HRV and PRV is root mean square of successive differences (RMSSD). A low RMSSD is an indicator of autonomic dysfunction (Immanuel et al., 2023).

Training interventions that lead to improved performance have been associated with moderate increases in post-exercise HRV and PRV, indicating an enhancement of post-exercise PNS HR modulation as a positive adaptation to training (Bellenger et al., 2016). This finding aligns with observed changes in resting HRV and post-exercise HRR, which also suggest an increase in PNS modulation and/or a reduction in SNS activity in the case of HRR. These adaptations reflect an improved capacity to restore homeostasis following an exercise-induced stressor (Bellenger et al., 2016).

HRR and PRV can also be used to monitor fatigue in athletes. In well-trained cyclists, a decrease in HRR after a period of HIIT training was associated with reduced average power during a 40 km time trial (Lamberts et al., 2010). A reduction in PRV has been suggested as a potential indicator of overtraining syndrome in athletes (Mourrot et al., 2004). Monitoring HRR and PRV following exercise can provide valuable insights into the effectiveness of recovery between or after training bouts.

## **The Influence of Music on Exercise and Autonomic Nervous System Activity**

Listening to music while performing aerobic training is a well-researched area (Greco et al., 2022; Wu et al., 2022; Thakare et al., 2017; Karageorghis & Priest, 2011; Dobashi et al., 2021). The ergogenic effects from music can be beneficial when performing both muscle-strengthening exercises and cardiorespiratory exercises, especially in recreationally trained individuals (Greco et al., 2022). Music can reduce the perception of fatigue during both moderate- and high-intensity exercise (Greco et al., 2022; Wu et al., 2022). This effect may be explained by the attentional limitation theory and the selective sensory filtering theory (Wu et al., 2022). The attentional limitation theory and the selective sensory filtering theory both propose mechanisms through which music may influence perceived exertion during exercise. While the former suggests that the brain's limited attentional capacity can be partially occupied by music, thereby reducing focus on fatigue, the latter proposes that music acts as a preferred stimulus, leading the brain to filter out internal signals such as discomfort or physical strain (Wu et al., 2022). Listening to music during exercise has been shown to increase both the average exercise duration and the maximum HR achieved in untrained, young adults (Thakare et al., 2017). Karageorghis & Priest (2011) showed that music has ergogenic effects on performance during HIIT, but their study does not address the role of music during recovery between HIIT bouts.

Listening to slow or fast music during exercise has been shown to have an impact on both HR and RPE (Wu et al., 2022). Slow music was defined as music with a tempo between 55-100 beats per minute (bpm), while fast music was defined as music with a tempo between 120-160 bpm (Jones et al., 2017; Wu et al., 2022). Listening to fast music during passive rest between sprint intervals improved sprint cycling performance in active men (Dobashi et al., 2021). An experimental study by Jones et al. (2017) found that HR was faster during the initial recovery periods between high-intensity intervals in male runners who listened to slow or fast music, compared to those who listened to no music. However, there is limited evidence to suggest that music accelerates the onset of the PNS activity and suppression of SNS activity between HIIT intervals. These findings may be important for optimising athletic training strategies and understanding different factors that affect the balance between SNS and PNS, indicating a need for further research.

All taken together, there remains a limited understanding of how music tempo affects markers of recovery between bouts of HIIT.

## **Aim**

This study aims to examine whether slow or fast tempo music influences recovery markers – specifically HRR, PRV, and RPE – between bouts of high-intensity interval training with passive rest in recreationally trained adults aged 20 to 35.

## **Research questions**

Is there a difference in HRR, PRV and RPE among recreationally trained adults aged 20 to 35 years during passive recovery between high-intensity intervals, depending on whether fast or slow music is played?

Do recreationally trained adults aged 20 to 35 years recover faster between high-intensity intervals when slow music is played, compared to fast music?

## **Method**

### **Participants**

Inclusion criteria for the study were that participants must be between 20 and 35 years old, healthy (no chronic or acute diseases), and engage in at least 150 minutes of moderate-intensity aerobic exercise per week, or at least 75 minutes of high-intensity training (Bull et al., 2020). Exclusion criteria included chronic or acute diseases, less than 150 minutes of moderate-intensity aerobic exercise or 75 minutes of high-intensity training per week, and smoking.

Fifteen participants were recruited via flyers in local gyms and via verbal communication, but due to scheduling issues only thirteen concluded the tests. The participants consisted of 38% women (n = 5) and 62% men (n = 8). Participant characteristics are displayed in Table 1.

Table 1. Information on participants ( $n=13$ ) regarding age (years), height (m), body mass (kg), body mass index ( $\text{kg}\cdot\text{m}^{-2}$ ), and weekly training hours ( $\text{h}\cdot\text{week}^{-1}$ ).

	Participants (n)	Mean $\pm$ SD
Age (years)	13	24 $\pm$ 4
Height (m)	13	1.8 $\pm$ 0.1
Body mass (kg)	13	79 $\pm$ 10
BMI ( $\text{kg}\cdot\text{m}^{-2}$ )	13	25.4 $\pm$ 2.7
Training ( $\text{h}\cdot\text{week}^{-1}$ )	13	5 $\pm$ 3

## Testing procedures

A crossover design was used, and the test sessions were conducted on two separate occasions for each participant: one with slow music and the other with fast music played during the passive recovery periods. Music tempo was selected based on a randomised counter-balanced order. The tests were conducted in the morning (8.00-10.30) with at least 24h apart. If possible, the participants were scheduled to perform their test the same time of the day for both sessions. Participants were instructed via e-mail to avoid exercise, eating and to refrain from caffeine, tobacco and nicotine for at least two hours before the test. They were also instructed to wear appropriate workout clothes for indoor exercise and suitable training shoes. A copy of the informed consent (Appendix 1) was included in the e-mail.

Before the first test session, participants were asked to sign the informed consent. They were also asked to answer brief questions about their physical activity and health, and whether they had followed the pre-test instructions regarding food, nicotine, caffeine, and training. The participants height and body mass were measured. Age, sex and weekly exercise duration were noted. Participants were equipped with a polar H10 HR monitor (Polar Electro, Kempele, Finland) that was connected to an Apple iPhone 12 mini (iOS 18.3) and to the Polar Beat application (version 3.5.9). Over-ear headphones were used (Jabra Evolve2 75) and set to 85dB. The participants were also introduced to the RPE scale (Borg, 1998; Appendix 2) and were recommended to try the bicycle (BikeErg Concept II, Morrisville, Vermont, US; Turner & Rice, 2020) before the test started.

All tests started with a 16-minute graded warm up on the stationary bicycle to determine the power output (PO) at which each participant would cycle in order to achieve high-intensity exercise (>80% of  $HR_{max}$ ) during the following intervals. Participants began cycling at 50 W and increased 30 W every 4-minutes until 140 W. To determine the necessary PO for the following experimental tests, the average HR from the final minute at each PO-level during the warm up was plotted (Figure 1) and a linear trendline was computed to calculate the predicted PO at predicted  $HR_{max}$  as determined by  $HR_{max} = 207 - 0.7 \times \text{age}$  (Gellish et al., 2007). The PO corresponding to 100% of the predicted  $HR_{max}$  was then used for the following experimental trials. The same PO calculated at the first test session was also used for the second session. If the test participants were unable to maintain the prescribed PO during the intervals, it was adjusted to 85% of  $HR_{max}$ .

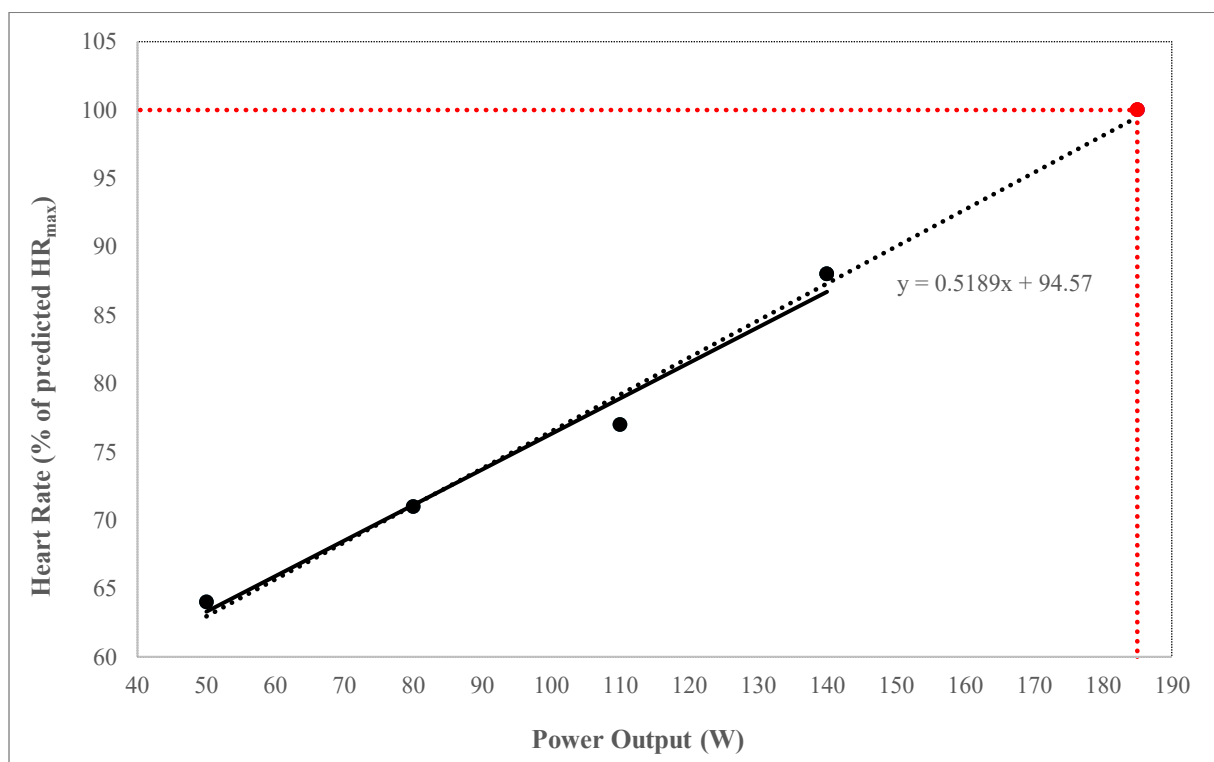


Figure 1. Example of a calculation for estimating power output (W) at predicted  $HR_{max}$  for the participants. The average HR (% of predicted  $HR_{max}$ ) from the final minute of each workload represents the four black points in the diagram. A linear trendline was generated, and its equation was used for calculation,  $y$  representing predicted  $HR_{max}$  and  $x$  power output. In this particular instance, the PO at predicted  $HR_{max}$  was 185 was indicated by the vertical dotted red line.

Following the warm-up, participants underwent a 5-minute period of passive rest before beginning the first experimental trial. Once the rest period concluded, the high-intensity intervals commenced. 5 sets of 2-minute bicycle intervals at the PO that had been estimated to correspond with 85-100% of the participants  $HR_{max}$  were performed. Between each interval was 2 minutes of passive recovery. No music was played during the high intensity intervals, only during the passive recovery periods. During the exercise intervals the test leaders encouraged the test subjects to keep going. The participants RPE was recorded at the beginning and end of each passive recovery period to assess recovery. The test ended after the fifth and final recovery session. HR measurements were recorded during the whole test. A flow chart of the whole testing procedure is shown in Figure 2.

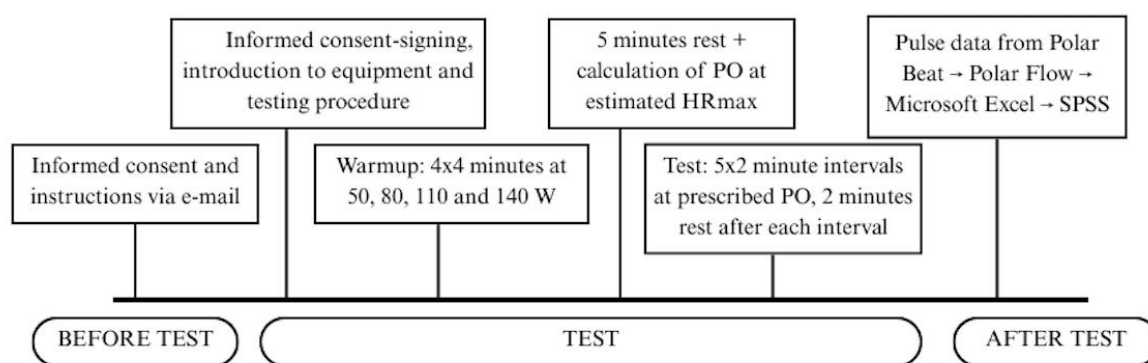


Figure 2. Flow chart visualising the testing procedure. Two test sessions were performed, including a graded warm-up, 5 minutes of passive recovery and then five 2-minute intervals with 2 minutes of passive recovery in between, where either slow or fast music was played. HR data were collected during the whole test session and RPE was recorded in the beginning and end of each passive recovery period.

## Music selection

The music was categorised into fast and slow tracks, with fast music having a tempo between 150-160 bpm (Wu et al., 2022) and slow music between 55-68 bpm (Jones et al., 2017). In addition to tempo, three criteria guided the selection of music: (1) the music required to have a clear tempo to evoke positive emotions in the participants (Wu et al., 2022), (2) music with political messages was excluded, and (3) songs with religious messages were excluded. Five fast and five slow songs were selected and played in the same order for all participants (Table 2).

Table 2. List of tracks played during the rest period. The list includes the track title, artist(s), year of release, and official bpm. The songs are listed in the order in which they were played during the test.

Track title	Artist(s)	Year of release	Official bpm
<b>Slow tempo</b>			
At Last	Etta James	1960	56
At the River	Groove Armada	1998	68
Can You Feel the Love Tonight	Elton John	1994	67
I Wanna Be Yours	Arctic Monkeys	2013	67
All You Ever Wanted	The Black Keys	2008	59
<b>Fast tempo</b>			
Ain't My Fault – R3hab Remix	Zara Larsson, R3hab	2016	150
Wavin' Flag – Coca-Cola Celebration Mix	K'NAAN	2010	152
Feel It Still	Portugal. The Man	2017	158
Pump It	Black Eyed Peas	2005	154
Good Feeling (feat. Rhys Lewis)	Bakermat, Rhys Lewis	2023	150

## Data Analysis

HR data collected during the test sessions were transferred from the Polar Beat application to Polar Flow and from there it was converted and transferred to Microsoft Excel (version 16.95.1) for analyses. HRR was calculated as the difference in HR between second 1 and second 120 of the 2-min recovery periods and was also calculated as the as the difference in %HR<sub>max</sub> between second 1 and second 120 of the 2-min recovery periods (%HRR). HRR and %HRR were analysed to determine the initial speed of recovery, as an indicator of ANS function (Halson, 2014). The rate of HRR (HRR<sub>rate</sub>) was calculated as the slope of the linear regression fitted to the HR data during the 2-min recovery periods, where the slope of the line reflects the rate of decline in HR for each second (Alfaifi et al., 2016). The average %HR<sub>max</sub> (%HR<sub>max\_ave</sub>) during the 2-min recovery periods was analysed to provide information about the overall cardiovascular load (McArdle et al., 2008, p. 519-520) and was calculated by determining the average HR during the 2-minute recovery period and dividing it by the participants estimated HR<sub>max</sub>. PRV was analysed to evaluate PNS reactivation and was calculated using RMSSD. This was done by measuring the difference in HR between each consecutive second during the 2-minute

passive recovery period, calculating the mean of the squared differences, and then taking the square root of that mean (Immanuel et al., 2023; Lundstrom et al., 2023).

## **Ethical and social considerations**

### **Ethical guidelines & informed consent**

This project followed the ethical principles from the Declaration of Helsinki (The World Medical Association, 2024). All participants were provided with information about the project and any potential risks, after which they signed an informed consent form (Appendix 1). Participants had the right to withdraw from the project at any time. Collected data were stored on a USB drive that was accessible only to the project leaders. Participants had the right to access any data associated with only with themselves at any time. The risks associated with HIIT include mental strain and significant muscle soreness. To reduce the risk of these, one of the inclusion criteria was that participants must meet the general physical activity recommendations (Bull et al., 2020).

### **Social considerations**

Through this project, we aimed to contribute to Goal 3.4 of the 2030 Agenda, which seeks to reduce the number of deaths from non-communicable diseases and promote mental health (United Nation, n.d.). By optimising recovery between intervals, performance levels can be enhanced, and the risk of overtraining can be avoided. Identifying ways to optimise recovery and thus reduce the risk of overtraining could potentially lessen the burden on healthcare systems, which in turn may lead to savings in healthcare costs. Both men and women were recruited as participants to contribute to the reduction of discrimination against women in research contexts, in accordance with Goal 5.1 of the 2030 Agenda (United Nation, n.d.).

### **Statistical analysis**

Data were analysed using IBM SPSS Statistics for Mac (version 29.0.2.0; IBM Corp., Chicago, USA). The Shapiro–Wilk tests confirmed that the assumption of normality was not violated. Two-way repeated measures ANOVAs were conducted to examine the effect of music tempo (within-subjects factor: fast vs. slow) on recovery patterns across the five interval bouts (within-

subjects factor: intervals 1–5). Mauchly’s Test of Sphericity was used to assess the assumption of sphericity. Where this assumption was violated ( $p < 0.05$ ), the Greenhouse–Geisser correction was applied; otherwise, sphericity-assumed results were reported. Significant interaction or main effects were followed-up using Bonferroni-adjusted pairwise comparisons. Statistical significance was set at  $p < 0.05$ .

The same participants completed two test sessions with different music tempos, and the following parameters were analysed: HRR, %HRR,  $HRR_{rate}$ ,  $\%HR_{max\_ave}$ , PRV and RPE.

Although RPE is an ordinal variable and its inclusion in parametric analyses like ANOVA is not strictly statistically appropriate, this approach is commonly accepted in sports science literature. Therefore, RPE was included in the ANOVA to allow for consistent and comparative analysis across all measured parameters.

All variables are reported as mean (M)  $\pm$  standard deviation (SD), except for RPE which are reported as median and interquartile range (IQR).

## Results

Minor differences were observed between the slow and fast music conditions across the analysed recovery variables. A comparative overview of the results from the two test sessions is presented in Table 3, highlighting the variable-specific outcomes for each music tempo.

*Table 3. Showing differences between variables depending on music tempo. Calculated as slow – fast condition for each interval. Differences are presented for heart rate recovery (HRR), percentage of maximum heart rate (%HRR), the rate of heart rate recovery ( $HRR_{rate}$ ), the average percent of maximum heart rate ( $\%HR_{max\_ave}$ ), pulse rate variability (PRV) and rating of perceived exertion at the start ( $RPE_{start}$ ) and end ( $RPE_{end}$ ) of each recovery period.*

Interval	$\Delta HRR$ (bpm)	$\Delta \%HRR$ (%)	$\Delta HRR_{rate}$ (bpm·s <sup>-1</sup> )	$\Delta \%HR_{max\_ave}$ (%)	$\Delta PRV$ (s)	$\Delta RPE_{start}$ (6-20)	$\Delta RPE_{end}$ (6-20)
1	-2	-2	-0.03	-2	0	0	0
2	-3	-2	0	-1	0	1	1
3	0	0	0.01	1	0.03	0	0
4	-2	-1	-0.01	-1	-0.05	0	1
5	0	0	0.02	-1	0	0	0

There were no tempo x interval interaction effects ( $p > 0.05$ ) for any of the analysed variables (Table 4). However, main effects for interval were observed for HRR ( $p = 0.002$ ), %HRR ( $p = 0.004$ ),  $HRR_{rate}$  ( $p = 0.001$ ), %HR<sub>max\_ave</sub> ( $p < 0.001$ ), PRV ( $p = 0.001$ ) and RPE ( $p < 0.001$ ). No significant main effects for music tempo were found.

*Table 4. Showing tempo x interval interaction effect for chosen physiological markers (df and p-value). Analysed variables were heart rate recovery (HRR), difference in percentage of maximum heart rate (%HRR), the rate of heart rate recovery ( $HRR_{rate}$ ), the average percent of maximum heart rate (%HR<sub>max\_ave</sub>), pulse rate variability (PRV) and rating of perceived exertion (RPE)*

Variable	Interaction effects for tempo x interval
<b>HRR</b>	$F_{4,48} = 0.39, p = 0.82$
<b>%HRR</b>	$F_{4,48} = 0.39, p = 0.81$
<b><math>HRR_{rate}</math></b>	$F_{4,48} = 1.0, p = 0.42$
<b>%HR<sub>max_ave</sub></b>	$F_{4,48} = 0.32, p = 0.86$
<b>PRV</b>	$F_{4,48} = 0.13, p = 0.92$
<b>RPE</b>	$F_{4,48} = 0.55, p = 0.70$

HRR and %HRR during each passive recovery period were analysed to determine the initial speed of recovery following the intervals. A significant main effect of interval was found for HRR ( $p = 0.002$ ), with pairwise comparisons indicating a lower recovery rate for interval 3, compared to interval 5 ( $p = 0.051$ ); see Figure 3. For %HRR, a significant main effect of interval was observed ( $p = 0.004$ ). Pairwise comparisons indicated a noticeable difference between interval 3 and interval 5, with a trend toward a lower %HRR in interval 3, suggesting less effective recovery. Although this difference did not reach statistical significance ( $p = 0.07$ ), it points to a potential effect; see Figure 4.

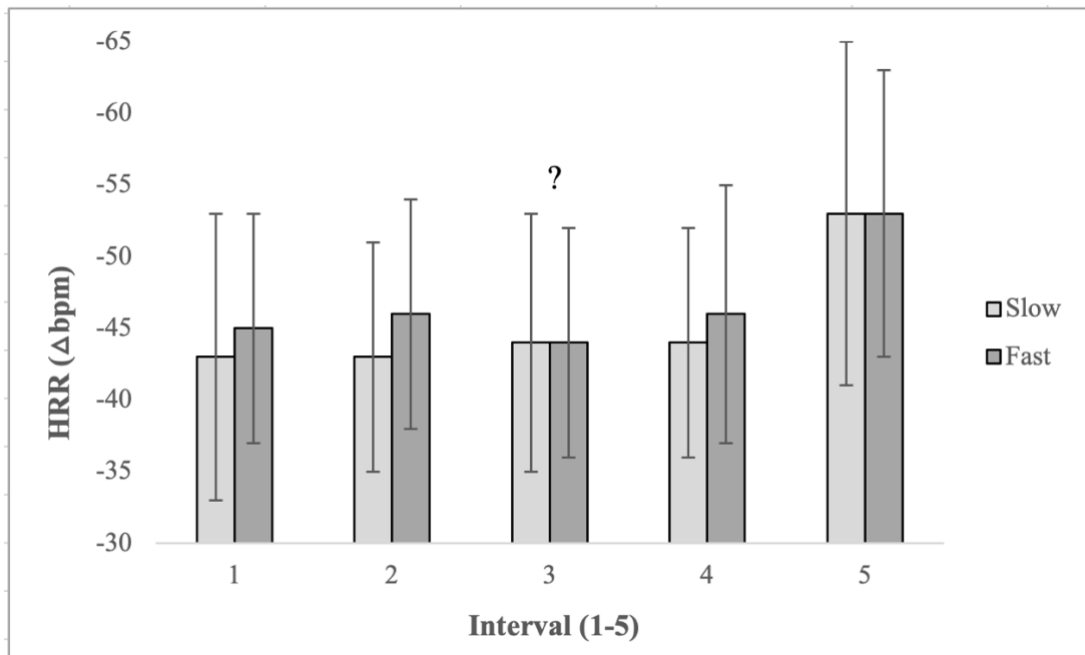


Figure 3. Showing differences ( $M \pm SD$ ) in heart rate recovery (HRR) between interval 1-5 for slow and fast music. ? = Noticeable difference for interval 3, showing a lower recovery rate and thereby less effective recovery, compared to interval 5 ( $p < 0.051$ ).

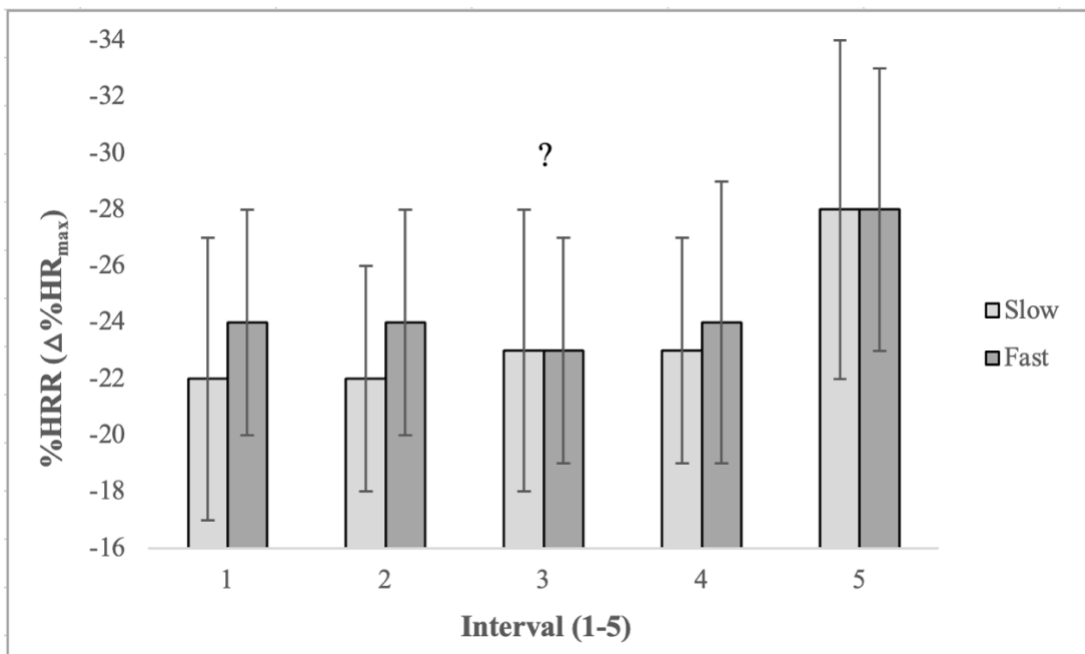


Figure 4. Showing differences ( $M \pm SD$ ) in percentage of maximum heart rate %HRR between interval 1-5 for slow and fast music. ? = Potential difference between interval 3 and interval 5 ( $p < 0.07$ ), indicating a smaller decrease in %HRR and thereby a delayed cardiovascular recovery for interval 3, compared to interval 5.

$HRR_{rate}$  was analysed to determine the rate of decline in HR for each second of the recovery period. A significant main effect of interval was observed ( $p = 0.001$ ), with pairwise comparisons revealing that HR declined more rapidly in interval 5 compared to intervals 1 ( $p = 0.004$ ), 3 ( $p = 0.004$ ), and 4 ( $p = 0.003$ ); see Figure 5.

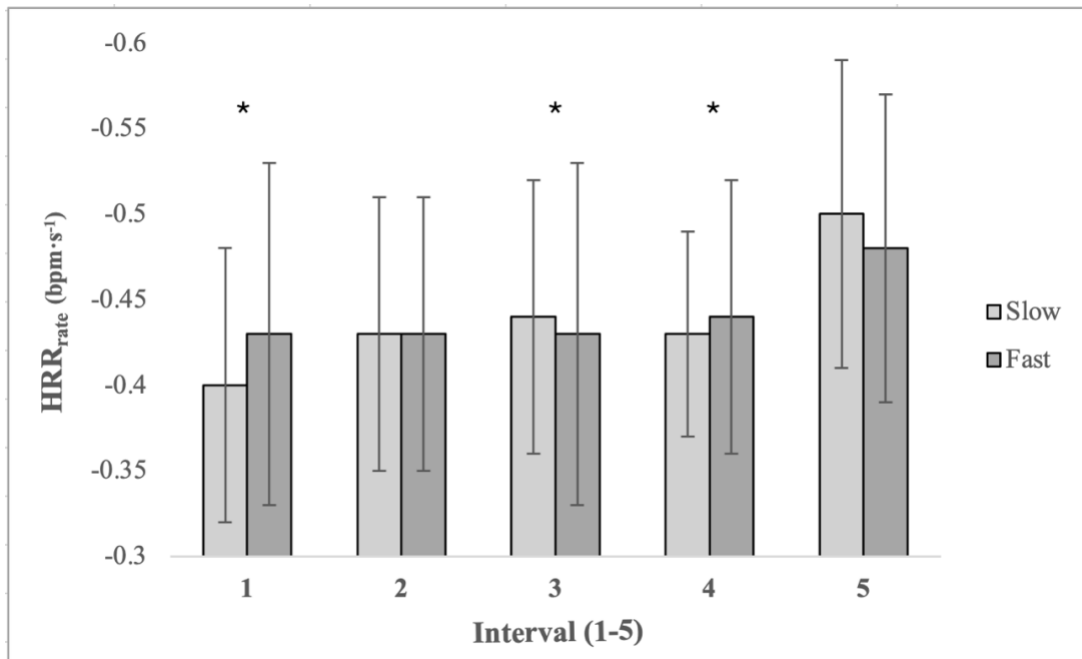


Figure 5. Showing differences ( $M \pm SD$ ) in the rate of heart rate recovery ( $HRR_{rate}$ ) between interval 1-5 for slow and fast music. \* = Slower decline in HR compared to interval 5 ( $p < 0.05$ ).

To provide information about the overall cardiovascular load during the recovery periods,  $\%HR_{max\_ave}$  was analysed. A significant main effect across intervals was found ( $p < 0.001$ ). Follow-up pairwise comparisons indicated significant differences in  $\%HR_{max\_ave}$ , with interval 1 showing a lower cardiovascular load compared to intervals 2, 3, 4, and 5 ( $p < 0.001$ ). Additionally, interval 2 exhibited a lower load than interval 4 ( $p = 0.01$ ) and interval 5 ( $p = 0.004$ ); see Figure 6.

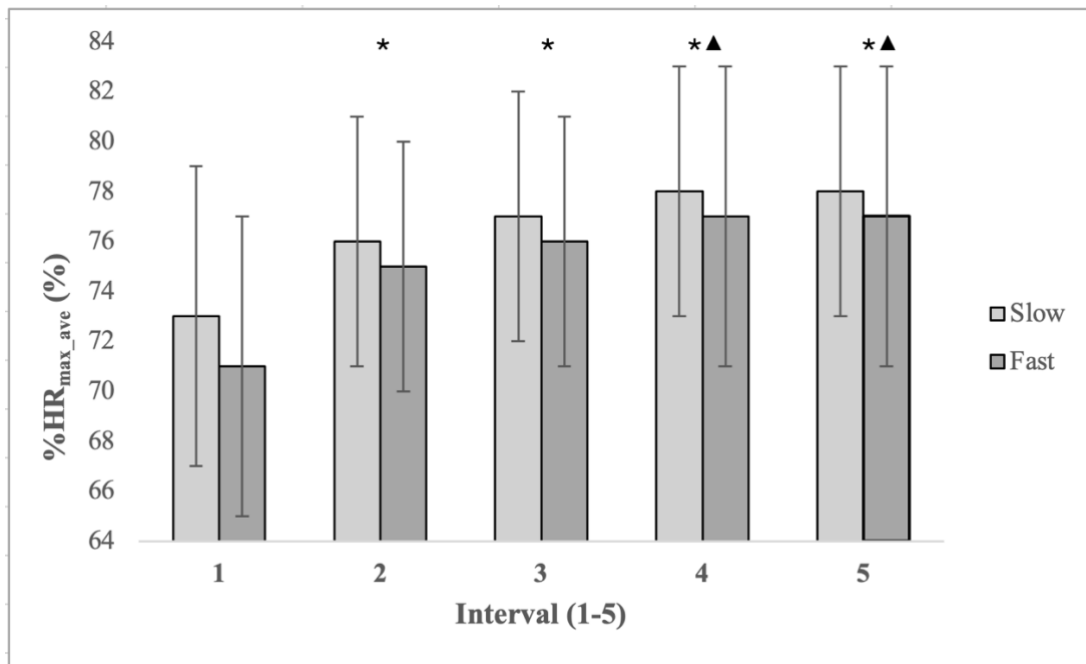


Figure 6.  $M \pm SD$  values of average percentage of maximum heart rate ( $\%HR_{max\_ave}$ ) during recovery periods, presented across intervals 1 to 5 for both slow and fast music conditions.

\* = Higher cardiovascular load compared to interval 1 ( $p < 0.001$ ). ▲ = Higher load compared to interval 2 ( $p < 0.01$ ).

For PRV, the main effect across intervals was also significant ( $p = 0.001$ ). Pairwise comparisons showed significant differences in PRV between interval 1 and interval 3 ( $p = 0.02$ ), as well as between interval 1 and interval 4 ( $p = 0.03$ ), indicating greater PNS reactivation during recovery following interval 1; see Figure 7.

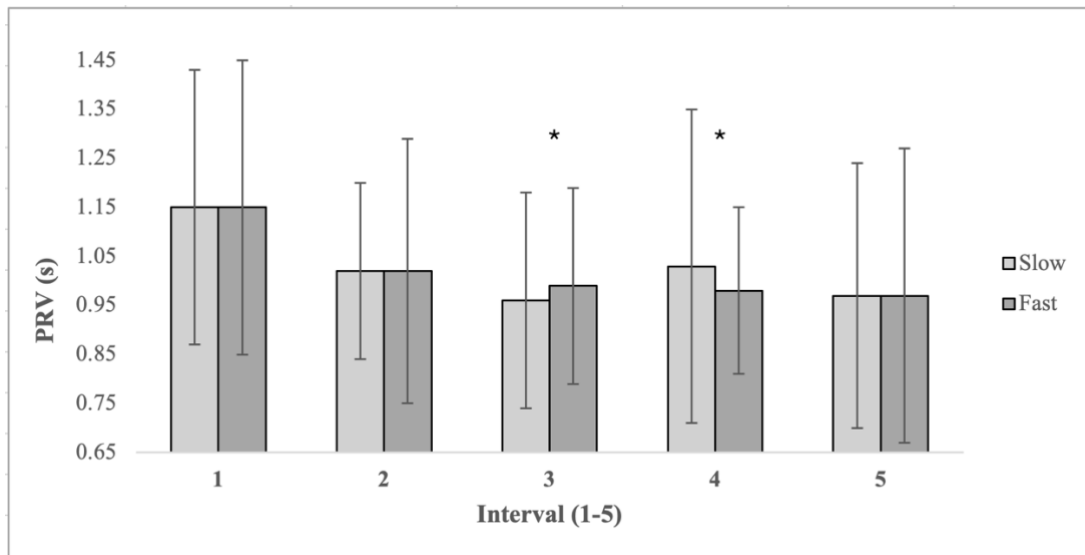


Figure 7. Showing differences in pulse rate variability (PRV;  $M \pm SD$ ) between interval 1-5 for slow and fast music. \* = Lower PRV, and thus reduced PNS reactivation, compared to interval 1 ( $p < 0.05$ ).

The result shows significant main effects for intervals for RPE at the start ( $RPE_{start}$ ) and end ( $RPE_{end}$ ) of the recovery periods ( $p < 0.001$ ). For  $RPE_{start}$ , pairwise comparisons showed significantly lower RPE following interval 1 compared to intervals 2 ( $p = 0.03$ ), 3 ( $p = 0.02$ ), 4 ( $p = 0.004$ ), and 5 ( $p = 0.03$ ), indicating that participants perceived the effort as less demanding at the start of the recovery period after the first interval; see Figure 8. For  $RPE_{end}$ , ratings were significantly higher following interval 4 compared to intervals 1 ( $p = 0.002$ ), 2 ( $p = 0.02$ ), 3 ( $p = 0.03$ ), and 5 ( $p = 0.02$ ), suggesting greater residual exertion at the end of the recovery period after the fourth interval; see Figure 9. The difference in RPE ( $\Delta RPE$ ) between  $RPE_{start}$  and  $RPE_{end}$  for slow and fast music is shown in Table 5.

Table 5. The change in ratings of perceived exertion ( $\Delta RPE$ ) calculated as the difference between ratings at the beginning and end of each recovery period, for slow and fast music.

Variable	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5
$\Delta RPE$ (slow)	-5	-4	-6	-5	-7
$\Delta RPE$ (fast)	-5	-4	-6	-6	-6

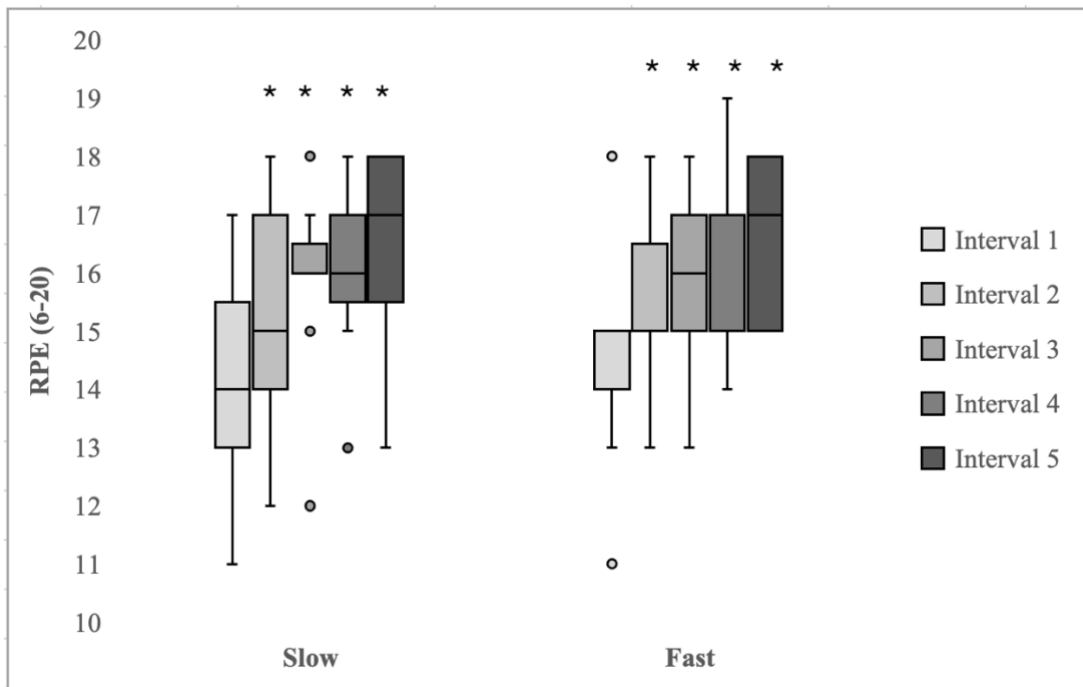


Figure 8. Differences in rating of perceived exertion (RPE; median, IQR and outliers) across interval 1–5 for slow and fast tempo music at the start of the recovery period. \* = Higher RPE compared to interval 1 ( $p < 0.05$ ).

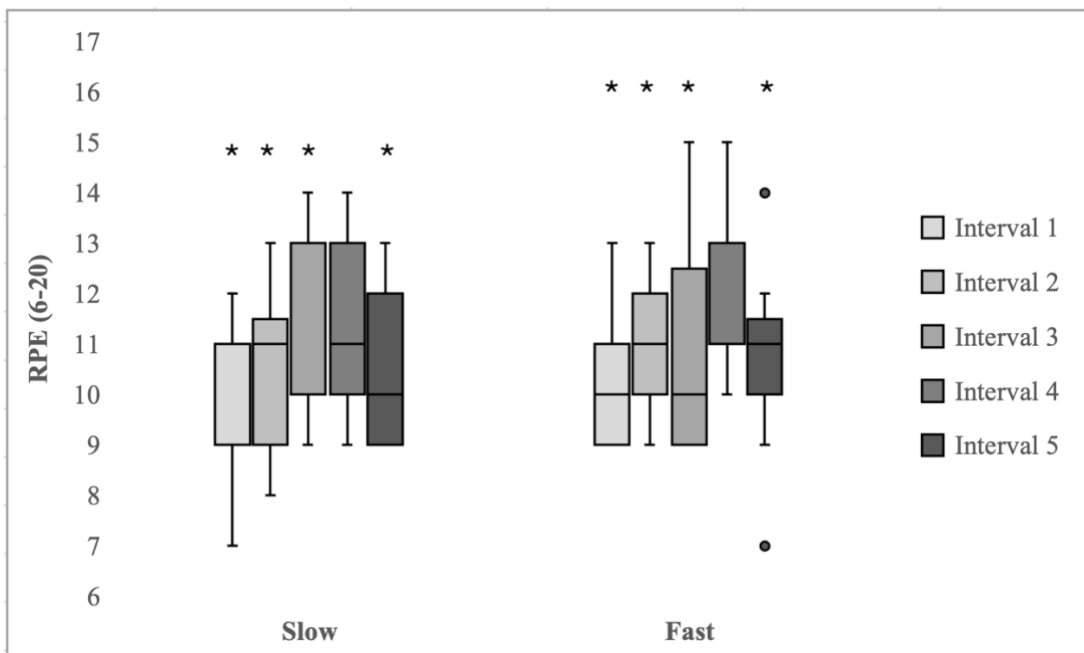


Figure 9. Differences in rating of perceived exertion (RPE; median, IQR and outliers) across interval 1–5 for slow and fast tempo music at the end of the recovery period. \* = Lower RPE compared to interval 4 ( $p < 0.05$ ).

## Discussion

This study analysed how slow and fast music affected HRR, %HRR,  $HRR_{rate}$ ,  $\%HR_{max\_ave}$ , PRV and RPE during recovery periods between high-intensity training intervals. The results revealed that: 1) Music tempo (slow vs. fast) had no significant effect on any of the recovery variables across intervals; and 2) Significant differences were observed in all recovery variables across the interval bouts, suggesting that cardiovascular recovery dynamics change over the course of repeated intervals.

### Results discussion

The results of the present study, showing no significant changes in HRR dynamics depending on music tempo, align well with previous research by Wu et al. (2022) and Dobashi et al. (2021), who found that music tempo did not significantly influence HR during exercise. Wu et al. (2022) further emphasized that HR is primarily driven by exercise intensity rather than external stimuli such as music, a conclusion that is supported by the present findings. Schaun et al. (2018) also concludes that  $\%HR_{max\_ave}$  increases across intervals which is a trend that can be observed in present study as well. Similarly, Jones et al. (2017) reported no significant relationship between music tempo and RPE, which corresponds with the lack of RPE variation observed in this study across different tempo conditions.

The observed decrease in PRV across the interval bouts is consistent with findings from previous studies who found that HIIT acutely lowered HRV as intervals went along (Kiviniemi et al., 2014; Stuckey et al., 2011; Schaun et al., 2018). This acute reduction is a result of temporary suppression of the PNS (Buchheit et al., 2007). This pattern was also evident in the present study, where pairwise comparisons showed significantly lower PRV in interval 3 compared to interval 1; see Figure 5. The observed pattern showed that the  $HRR_{rate}$  was faster during the passive recovery period following interval 5, compared to interval 1, 3 and 4. One possible explanation for this pattern is that by the fifth interval, participants may have reached a state of heightened autonomic activation, leading to a stronger PNS reactivation during the passive recovery phase. This could result in a higher  $HRR_{rate}$  following interval 5, as the body attempts to restore homeostasis after cumulative exertion (Bellenger et al., 2016). The steeper  $HRR_{rate}$  observed after interval 5 may therefore reflect a more pronounced shift in autonomic balance compared to earlier intervals. According to Buchheit

et al. (2007), PNS reactivation occurs more rapidly following moderate intensity continuous training compared to HIIT, suggesting that HIIT acutely delays ANS recovery. This delay is likely due to the higher load and metabolic stress on the SNS imposed by HIIT protocols. Kiviniemi et al. (2014) noted that a short-term HIIT intervention that lasted two weeks did not significantly alter acute autonomic responses. However, over time, HIIT has been shown to enhance PNS modulation and improve PRV, suggesting beneficial long-term adaptations with consistent training. In the current study, significant main effects and pairwise differences between intervals further support the notion that recovery responses are dynamic and evolve over the course of a HIIT session. This progression aligns with earlier research indicating that repeated high-intensity efforts result in gradually increased autonomic strain, which may reduce recovery efficiency as the session progresses (Mourot et al., 2004).

Taken together, these findings reinforce the importance of using autonomic markers such as HRR and PRV to monitor training stress and recovery. The variables provide an indicator on fitness levels and autonomic recovery. Understanding these dynamics is essential for optimising training protocols, managing fatigue, and promoting long-term cardiovascular health. Although music tempo does not appear to directly influence cardiovascular markers such as HR, PRV or RPE during HIIT, there is evidence suggesting that music can affect neural activity and emotional states. For instance, Ballmann (2021) demonstrated that different tempos activate distinct brain regions during functional magnetic resonance imaging, highlighting music's potential role in modulating the brain's response to exercise. This suggests a possible neurological basis through which music may influence recovery processes which is an area that remains underexplored and could be a valuable direction for future research.

## **Methods discussion**

The methodology used in this study was both cost-effective and easy to replicate, contributing to the study's reliability. The calculation of PO served as an effective tool for standardisation across a diverse group of participants. Given the aim of assessing physiological recovery based on HR, the chosen data collection method was appropriate. The crossover design with two within-subject factors, along with the collection of both HR and RPE data, justified the use of a repeated measures ANOVA as the primary statistical analysis. Furthermore, the application of the Bonferroni correction helped minimise the risk of type-I errors.

There were, however, several limitations to this study. One key limitation was the predetermined music playlists, which restricted participants from choosing the order or specific songs. It is possible that allowing participants to select music within the given bpm range based on personal preference could have yielded different results (Silva et al., 2021). Another limitation was that testing was conducted at two different locations, one of which had a lower temperature. The difference in temperature could have affected the standardisation of the test conditions, since cooler temperatures can affect HR (Lossius et al., 1994). To minimise this variability, all participants completed both of their tests at the same location.

Additionally, while participants were instructed to abstain from nicotine, caffeine, and food two hours prior to testing, there was no objective verification of compliance. Although participants were questioned about their recent intake and habits, their responses could not be independently confirmed. Similarly, physical activity levels were self-reported, which introduces a degree of subjectivity and potential inaccuracy (Ainsworth et al., 2015). Participants estimated their weekly training volume and categorised training intensity, but some expressed uncertainty in differentiating between moderate and high-intensity exercise.

Since the majority of the selected recovery markers were derived from HR data, any inaccuracies in data recording could have affected most of the measured parameters. Although several previous studies support the results of this investigation, it remains difficult to draw firm conclusions, as most of the existing research focuses on the exercise bouts rather than the recovery intervals. Additionally, inconsistencies in the bpm ranges used across studies make it challenging to determine how music tempo specifically interacts with physiological recovery markers.

This variability in fitness levels limits the applicability of the results to a specifically defined population. Among the participants, some engaged in regular moderate-intensity strength training, while others met physical activity recommendations through physically demanding occupations. A few participants also reported performing high-intensity workouts once or twice per week. While this heterogeneity provides a representative sample of recreationally active individuals within the target age range, it also limits conclusions about how fitness level or training background may influence recovery outcomes.

Given these insights, future studies may benefit from replicating the present design but incorporating self-selected music to examine whether individual preference alters cardiovascular recovery markers such as HRR and PRV. Additionally, combining physiological data with neurological measures could provide a more comprehensive understanding of the mechanisms through which music, and specifically tempo, may impact both perceived and physiological recovery processes during interval-based exercise.

## **Conclusion**

This study showed that the music tempo does not affect the chosen physiological markers during recovery periods between bouts of HIIT. However, significant differences were observed in all recovery variables across the interval bouts, suggesting that cardiovascular recovery dynamics shift progressively during the recovery periods that follow repeated high-intensity efforts. Future research incorporating neurological measures may provide deeper insight into potential mechanisms of music influence. Additionally, further studies should aim to identify strategies for optimizing recovery intervals to enhance training performance.

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# Appendix 1

## **Information till dig som ska delta i en undersökning kring hur musikens hastighet påverkar återhämtningen mellan högintensiva intervaller. Projektet genomförs av studenter under utbildning.**

### **Information till forskningspersoner**

Vi vill fråga om du vill delta i ett forskningsprojekt som undersöker hur musikens hastighet påverkar pulsen under återhämtningen mellan högintensiva intervaller, på cykel. I följande dokument kommer du att få information om projektet och vad det innebär att delta.

### **Vad är det för ett projekt och varför vill ni att jag ska delta?**

Detta projekt är ett examensarbete av studenter på programmet Biomedicin – inriktning träningsfysiologi på Högskolan i Halmstad. Projektets upplägg är granskat och godkänt av ansvariga på utbildningen. Ansvariga för projektet är studenterna Wilma Lund och Saga Kullberg under handledning av Craig Staunton.

Vi skulle vilja rekrytera dig som testperson eftersom du uppfyller de kriterier vi satt upp för deltagarna i vårt projekt. Vi hoppas med detta projekt kunna öka kunskaperna kring hur man återhämtar sig så effektivt som möjligt mellan högintensiva intervaller för att kunna optimera träningen på bästa sätt.

### **Hur går projektet till?**

Att vara med i projektet innebär att du deltar vid två testtillfällen, antingen i Halmstad eller i Varberg. Du kommer att utföra samma typ av test vid båda tillfällena men med olika sånger som spelas mellan intervallerna som utförs. Under testtillfälle 1 kommer du att få svara på frågor om din ålder, ditt kön, eventuell medicinering samt hur fysiskt aktiv du är en normal vecka. Du kommer även att mätas och vägas. När du har fyllt i enkäten kommer testledarna att ge dig en genomgång av utrustningen som kommer att användas. I denna studie är det en motionscykel, ett pulsband kopplat till en pulsklocka och Borg-skalan. Du kommer att få en genomgång av samtliga och testledarna hjälper dig att ställa in cykeln korrekt. Du kommer även ges en möjlighet att testa cykeln för att vänja dig.

Vid testen kommer du att få värma upp på cykeln i ca 15 minuter innan testet börjar. Uppvärmningen följs av några minuter passiv vila, där du sitter still på cykeln. När vilan är slut kommer du att cykla i 2 minuter på ett motstånd där du når upp till 85-100% av din uppskattade maxpuls. Efter intervallen kommer du att vila i 2 minuter sittande på cykeln utan att trampa. Långsam eller snabb musik kommer att spelas under vilan och testledarna kommer att notera din puls samt fråga hur ansträngd du upplever dig vara med hjälp av Borg-skalan. Din puls kommer att följas under hela vilan för att kunna se hur du återhämtar dig efter intervallen. Du kommer totalt att utföra fem intervaller och proceduren ser likadan ut under hela testet. Efter sista intervallen kommer du att få sitta kvar på cykeln i tio minuter för att vi ska kunna mäta hur pulsen återgår till normalpuls. Vid det andra testtillfället kommer samtliga moment att se likadana ut men du kommer att få lyssna på annan musik under vilan mellan intervallerna.

Ett testtillfälle beräknas ta ca 60 minuter totalt. Av dig som forskningsperson krävs att du är fysiskt aktiv på medelintensiv nivå minst 150 min/vecka, eller på högintensiv nivå minst 75 min/vecka, inte röker och att du är mellan 20-35 år. Du får inte ha någon kronisk sjukdom eller ta mediciner som påverkar din hjärtrytm.

### **Möjliga följder och risker med att delta i projektet**

Högintensiv träning innebär alltid risker. Riskerna innebär bl.a. en tillfällig höjning av blodtrycket, ökad påfrestning på hjärta och lungor samt en känsla av obehag som kan upplevas när du arbetar så nära din maxpuls. Riskerna för allvarliga sjukdomsfall är mindre för friska individer. Om du upplever att den fysiska påfrestningen blir för stor har du rätt att avbryta testet när du vill.

Du kan uppleva dig trött i benen och kroppen under timmarna efter testet. Träningsvärk kan uppkomma i benen om du inte är van att utföra denna typ av träning. Träningsvärk går vanligen över inom 48 timmar. Om värken inte går över rekommenderas du kontakta 1177 eller din vårdcentral. I testlokalen finns tillgång till enklare första hjälpen-utrustning som plåster, desinficeringsmedel och tryckförband. Vid eventuella allvarligare sjukdomsfall har båda testledarna uppdaterade HLR-kunskaper. Det kommer inte finnas möjlighet att utföra testen igen men om du har frågor om resultatet eller metoderna, vänligen kontakta testledarna så hjälper vi dig.

### **Vad händer med mina uppgifter?**

Dina resultat och svar kommer endast behandlas av de ansvariga för projektet. Enligt EU:s dataskyddsförordning, GDPR, har du rätt att när som helst under projektets gång få ta del av de uppgifter som berör dig och hur de behandlas. Du har även rätt att få eventuella fel rättade. Uppgifterna som samlas in kommer att vara nödvändiga för forskningen i fråga och därför gäller inte rätten till raderingen och till begränsning. För att få tillgång till dina uppgifter kan du kontakta högskolans dataskyddsansvariga via [dataskydd@hh.se](mailto:dataskydd@hh.se). Om du känner missnöje kopplat till behandlingen av dina personuppgifter har du rätt att lämna in klagomål till Integritetsskyddsmyndigheten.

Dina svar och resultat kommer att förvaras på en USB-sticka som endast hanteras av projektets ansvariga. De insamlade uppgifterna kommer att sparas på USB-stickan under projektets gång. Personnummer kommer inte att samlas in. Du har rätt att säga nej till att dina uppgifter sparas och du behöver inte ange någon förklaring. Du har även rätt att senare ångra ditt givna samtycke till att dina uppgifter sparas. För att ångra ett samtycke ska du kontakta Saga Kullberg eller Wilma Lund (kontaktuppgifter finns nedan). Resultaten och dina personuppgifter kommer endast användas för denna forskning och USB-stickan som används för förvaring kommer att förstöras när projektet är avslutat.

### **Hur får jag information om resultatet från projektet?**

När projektet är färdigställt kommer du kostnadsfritt att få ta del av vår rapport via mail och då finns även möjlighet att ställa frågor.

### **Försäkring och ersättning**

Som testperson är du försäkrad via Högskolan i Halmstad. Vi kommer inte att betala ut ersättning för förlorad arbetsinkomst eller utgifter kopplade till projektet, i stället kommer vi att i största möjliga mån anpassa testtillfällena så att de kan ske utanför din arbetstid. Att delta i projektet är frivilligt. Du kan välja att inte delta eller att avbryta ditt deltagande när som helst under projektets gång. Om du väljer att avbryta eller inte delta kommer detta inte påverka dig på något vis.

Om du vill avbryta ditt deltagande, vänligen kontakta projektets ansvariga. Kontaktuppgifter finns nedan.

### Ansvariga för projektet

Saga Kullberg, [sagkul22@student.hh.se](mailto:sagkul22@student.hh.se), +46xxx

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## Samtycke till deltagande i projektet Hur musikens hastighet påverkar återhämtningen mellan högintensiva intervaller hos fysiskt aktiva vuxna mellan 20 och 35 år.

Jag har fått muntlig och/eller skriftlig information om studien och har haft möjlighet att ställa frågor. Jag får behålla den skriftliga informationen. Jag samtycker till att delta i projektet.

### Testperson

Plats & datum	Underskrift	Namnförtydligande

### Testledare

Plats & datum	Underskrift	Namnförtydligande

## Appendix 2

### Borg RPE Scale

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

(Borg, 1998)