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The Effect of Different Musical Tempos on Post-Exercise Recovery

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Abstract

Whether you choose to cruise to an electronic mix on a 5k run or head bob to classic rock in preparation for a lift on bench press, it is evident that listening to music while exercising has become a popular trend. Understanding the physiological effects created by music could reveal underlying reasons for this music-exercise integration. The purpose of this study is to determine whether fast and slow tempo music has an impact on post-exercise recovery rate. Twenty-eight healthy, 20-25 year old subjects participated by biking on a stationary bicycle until they reached a heart rate value that is twice their resting heart rate. Post-exercise recovery rate was determined based on data gathered on heart rate, breathing rate, and blood pressure for five minutes without music. This process was then repeated for each participant with the addition of either fast or slow tempo music during the post-exercise recovery time. The conclusion of this study revealed that fast tempo music caused a slower post-exercise recovery rate in terms of significant heart rate and breathing rate data. However, slow tempo music did not have a significant impact on post-exercise recovery for heart rate and breathing rate. Blood pressure rate during post-exercise recovery also revealed no significance for neither slow tempo or fast tempo music.

Introduction

From the peaceful sounds of nature to electric beats filling nightclubs, our daily lives are filled with a variety of rhythmic tones and tempos. There is no doubt music can have great motivational and psychological influence on the human experience. It even seems to have some performance enhancing quality as many people utilize it during times of exercise and physical exertion. Athletes blare warmup music before showcasing performances and people bring music along to accompany workouts at gyms. It is well documented through research that music has a dynamic influence over physiological and psychological aspects on the body during exercise.

Various studies have shown the ability of music to elicit physiological and psychological responses. Blood pressure, heart rate, cadence, power output, and emotional response are often dependent on the tempo of the music selected during physical activity. A study showed increased and decreased blood pressure occurred corresponding to high frequency and low frequency music respectively (Sakamoto, 2002). Additional studies showed that classical music, along with other audio relaxation tools, significantly lowered blood pressure after participating in a stressful task (Chafin, 2004; Hsin-Yi, 2008). It was also shown that muscle power output is higher in athletic performance after exposure to warm-up music (Jarraya, 2012; Chtourou, 2012). Another study focused on measuring heart rate variability, the time between each beat, as a determinant of sympathetic and parasympathetic nervous system activity. The results confirmed only excitative, fast-paced music decreased the high frequency component of heart rate variability, thus decreasing the activation of the parasympathetic nervous system (Iwanaga, 2005). An additional study investigated the effects of “relaxing”, slow paced music during exercise and concluded that it did not have a significant impact on autonomic response (Yamashita, 2006). Therefore, these results infer that excitative music may put the body at a heightened level, better preparing the body for physical exertion; whereas, slow paced music may not elicit any significant effect.

Not only does pre-workout music have influence on physiological processes, but selective music played during exercise seems to have similar effects. Workouts have been found to be prolonged and strengthened with the playing of faster tempo music, where the synchronization of the athlete with the music improves work output and energy efficiency (Terry, 2011; Karageorghis, 2012). Measuring percentage of subject maximal heart rate, a preferential relationship between physical exertion and musical tempo preference was noticed (Karageorghis, 2006). Also, a proportional relationship has been found between increasing music tempo and increased breathing rates observed (Bernardi, 2006; Haas 1986). Thus, synchronizing music to the physical rhythm of exercise cadence may play an important role in increasing power output and endurance.

It also has been found that part of music's physiological influence may come from a psychological standpoint. In studies focused on the effect of relaxing music on subjective anxiety, systolic blood pressure and heart rate, participants exposed to calming music experienced less reported anxiety, lower heart rate and blood pressure (Knight, 2011; Lee, 2005). Other studies have shown that the tempo of music played influenced the athlete's psychological perception of the workout, where participants reported the workout of the same intensity to be less strenuous when fast tempo music played (Eliakim, 2013).

Our study investigated the question: Will different music tempos affect post-workout recovery? To explore this, we obtained an initial reading of resting heart rate and blood pressure for a baseline measurement. In order to elicit an elevated heart rate of double the resting value, participants then exercised via cycling. After the desired heart rate was reached and sustained for 20 seconds, participants stopped cycling and the rates at which heart rate, blood pressure and breathing rate return to baseline were measured. This trial without music was used as a positive control. This procedure was then be repeated with the addition of randomly selected fast or slow tempo music to play during the recovery period after target heart rate was reached and maintained again. This study provided greater insight into both the physiological and psychological effects music has after exercise. Based on previous studies that have demonstrated that heart rate often syncs with the tempo of music, we hypothesized that the post-exercise recovery time will be faster when participants listen to slow tempo music and prolonged with fast tempo music (Terry, 2011; Karageorghis, 2006).

Materials

Several instruments were used for our experiment for physiological measurements. This includes a digital pulse oximeter (Norwin Medical Inc. Plymouth, Minnesota. Model#3016443), a digital wrist cuff blood pressure monitor (WrisTech™. Linden, New Jersey. Model#JB5538), the BSL Respiratory Effort Transducer (BIOPAC® Systems, Inc. Goleta, California.

Model#SS5LB), a bicycle ergometer (Schwinn Airdyne. Vancouver, Washington.), a pair of Bose over-the-ear noise-canceling headphones, and a computer equipped with BIOPAC® Systems, Inc. software.

The digital pulse oximeter was used to monitor heart rate of the participant. Measurements were taken via a finger clip on the right index finger for each participant. Baseline heart rate measurements were necessary to determine the target heart rate to be reached by the participants before workout recovery and to record heart rate throughout the experiment. The digital, battery-powered blood pressure monitor measured blood pressure of the participant before and in set increments during post-exercise recovery. The cuff was strapped onto the left wrist of the participants with the reading display on the palm side of the arm. Breathing rate was calculated from the respiratory data recorded with the SS5LB Respiratory Effort Transducer and BIOPAC® software. This respiratory device connected to the BIOPAC® software consisted of a small tension sensor and a flexible strap which wrapped around the upper chest. The participants utilized the bicycle ergometer to double their resting heart rates before post-exercise data could be obtained. The Bose headphones allowed participants to listen to music post-exercise and also canceled sound during the positive control trial where no music was elicited.

Prior to the beginning of the actual experiment, the equipment was tested for accuracy and assurance of proper use. Using one of us as the experimental tester, we inspected the heart rate monitor, the digital wrist cuff blood pressure monitor, and the SS5LB Respiratory Effort Transducer.

Methods

Twenty-eight volunteers, 14 males and 14 females, aged 20-25 years were randomly selected from the student population of University of Wisconsin-Madison. Participants reviewed and signed a consent form in order to participate in the study. An overview of the experimental procedure was explained to the participants (Figure 1).

Participants sat on a bicycle ergometer and the measuring equipment was applied. The pulse oximeter was placed on the right forefinger, the SS5LB Respiratory Effort Transducer around the chest in the mid-pectoral region, a sphygmomanometer around their left wrist and Bose noise-canceling headphones on their ears. Resting heart rate and blood pressure were then recorded and the Respiratory Effort Transducer was calibrated. The participants were then instructed to pedal at a steady, vigorous pace on the bicycle ergometer while their heart rate was monitored. Once they reached a heart rate value twice that of their resting heart rate--a value that was chosen arbitrarily, yet ensures that participants enter an endurance range that correlates to their physical abilities--biking continued for an additional 20 seconds. The participants were then instructed to stop pedaling and heart rate, blood pressure and breathing rate measurements were taken. For this initial trial, no music was administered. Heart rate was measured every 30 seconds for five minutes, blood pressure was taken four times over 1.25 minute intervals, and breathing rate was continuously measured via the SS5LB Respiratory Effort Transducer. These measurements were taken over the span of the entire recovery period, which entails the duration from when participants stop pedaling to the point at the end of recovery in which they have approached their resting heart rate. These recordings served as a positive control for each individual participant.

After one minute passed after resting heart rate was reestablished, the participants were again instructed to pedal at the same intensity until their heart rate had doubled their resting rate and had been sustained for 20 seconds. Once instructed to cease pedaling, the participants recovered while one of the randomly selected music tempos played (Fast 180bpm, Slow 60bpm). The music was played throughout the entire recovery period of five minutes. Heart rate, blood pressure and breathing rates were recorded in the same increments as listed above in the experimental control during this second recovery period. After all measurements were taken, the equipment was detached and the participant dismounted the bicycle ergometer. For the statistical analysis, differences among the treatment were analyzed using the Wilcoxon Signed-Rank Test and the results with $p\text{-value} < 0.05$ will be considered significant.

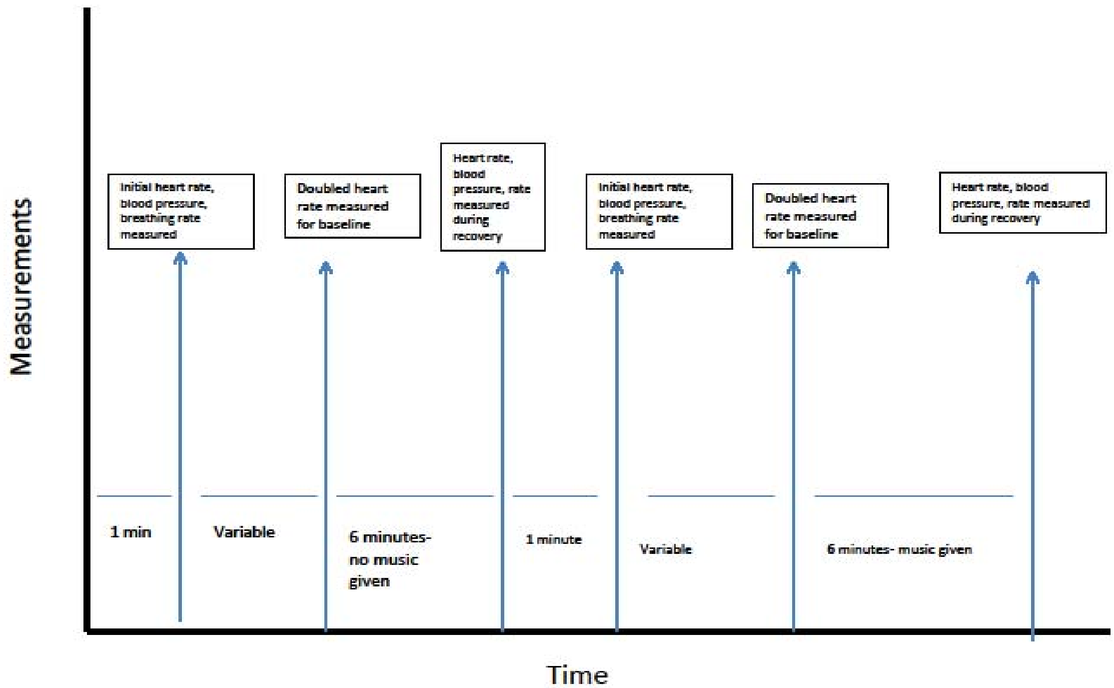

Figure 1. Experiment timeline for each participant

Results

Heart Rate Recovery

Figure 2 shows the absolute values of the difference in heart rates as soon as pedaling ceased and after five minutes of recovery time for each participant who listened to fast-tempo music as well as their personal control of no music. It was found after a five minute recovery period, the heart rates declined less when fast-tempo music played than when no music played. This data was found to be significant with a p-value of 0.036 and standard deviation of 11.59. Figure 3 represents the absolute values of the change in heart rate after five minutes of recovery time for slow-tempo music and the control of no music for all participants randomly assigned to that group. No significant difference was found in the decline of heart rate for the slow-tempo music (p-value= 0.89; SD=11.42).

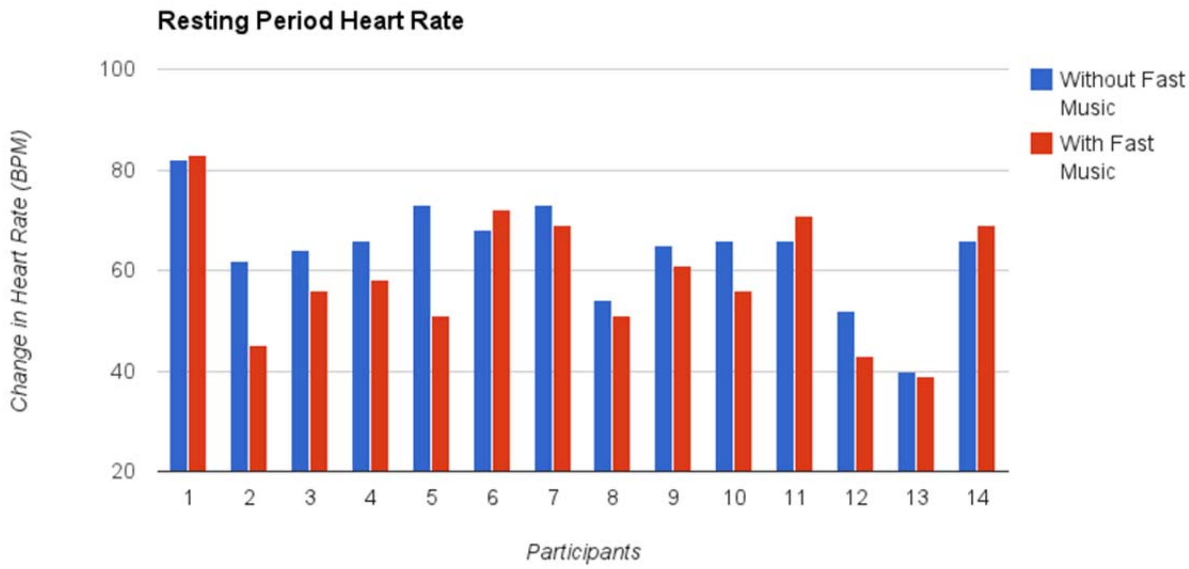

Figure 2. The change in heart rate during the resting period of self-controlled participants (n=14) subjected to fast music.

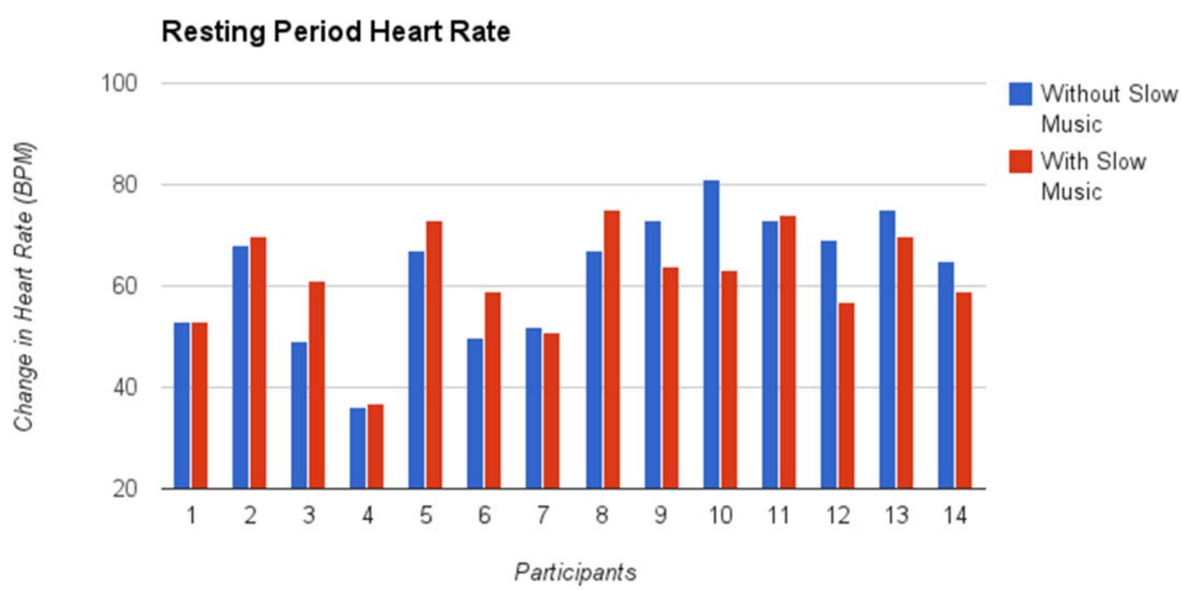

Figure 3. The change in heart rate during the resting period of self-controlled participants (n=14) subjected to slow music.

Blood Pressure Recovery

The change in blood pressure recorded over the five minute recovery periods was analyzed by testing for significance of the changes in systolic as well as diastolic values between both the control trial and experimental trial for fast-tempo participants, as well as for the control and experimental trials of the slow-tempo music. Overall, no significance was found for fast-tempo music on recovery rates of systolic and diastolic pressures (Systolic: p-value= 0.44, SD= 12.75; Diastolic: p-value= 0.48, SD= 12.75). Also, no significance was found for slow-tempo music on recovery rates of systolic and diastolic pressures (Systolic: p-value= 0.93, SD= 11.25; Diastolic: p-value= 0.11, SD= 7.44). The varying sample sizes for each blood pressure recording resulted from invalid blood pressure readings that were not incorporated in analysis. Figure 4 represents the absolute values of the changes in diastolic pressure for slow-tempo music for each of participants in that group. Figure 6 shows the systolic pressures for the slow-tempo music participants. Figure 5 shows the changes in diastolic measurements for the fast-tempo music participants, while Figure 7 shows the systolic changes for these participants.

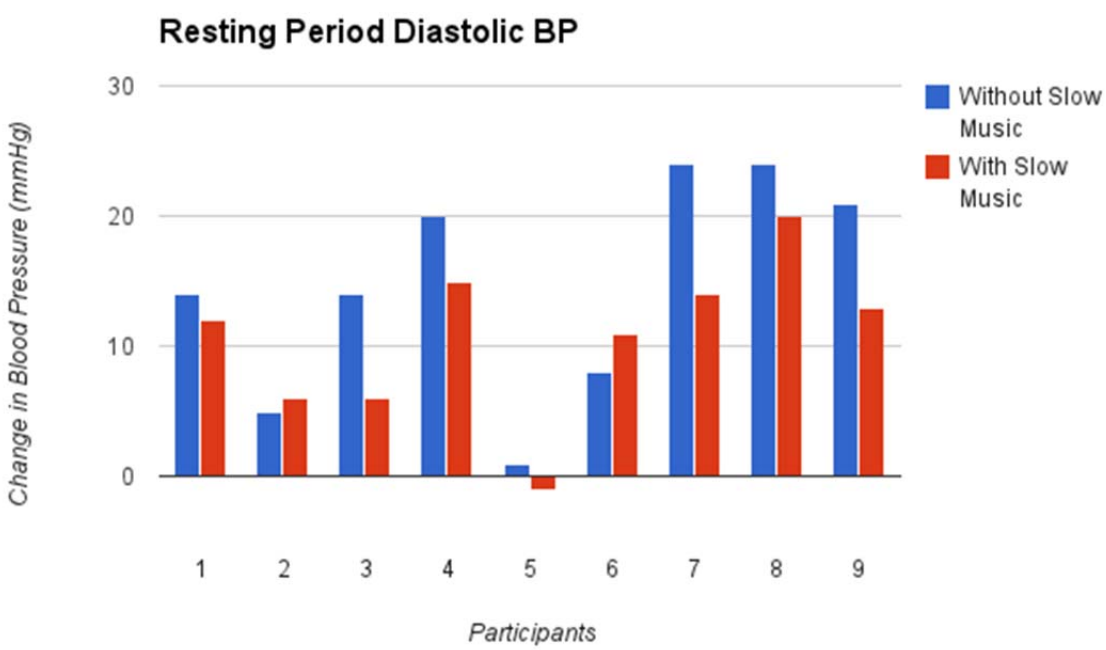

Figure 4. The change in diastolic blood pressure during the resting period of self-controlled participants (n=9) subjected to slow music. A negative value indicates an increase in blood pressure over the recovery period.

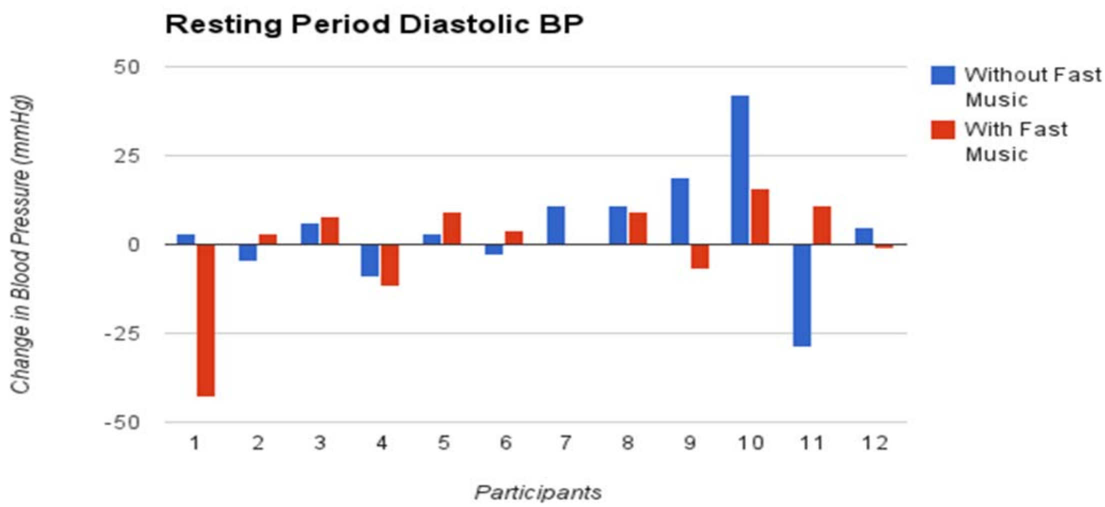

Figure 5. The change in diastolic blood pressure during the resting period of self-controlled participants (n=12) subjected to fast music. A negative value indicates an increase in blood pressure over the recovery period.

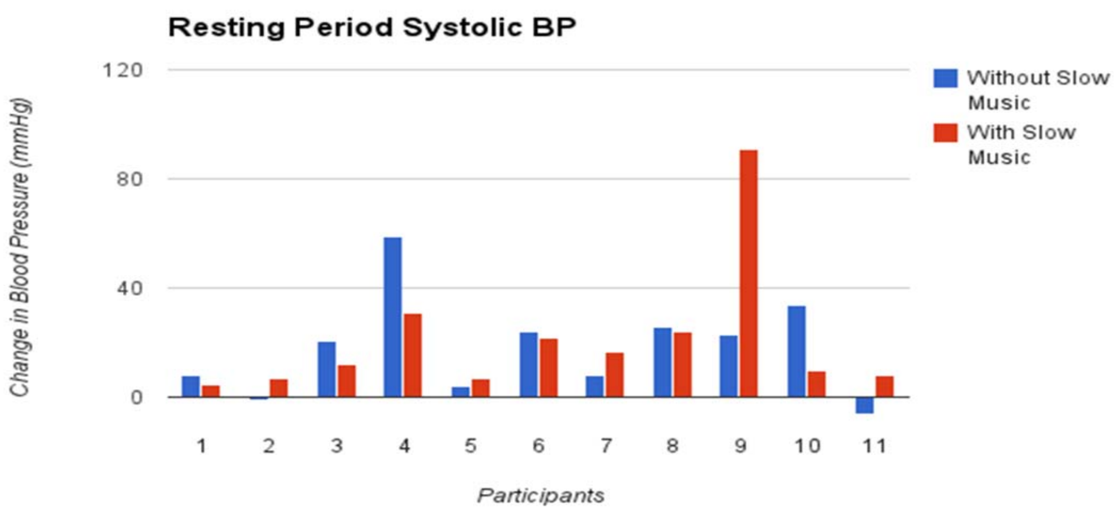

Figure 6. The change in systolic blood pressure during the resting period of self-controlled participants (n=11) subjected to slow music. A negative value indicates an increase in blood pressure over the recovery period.

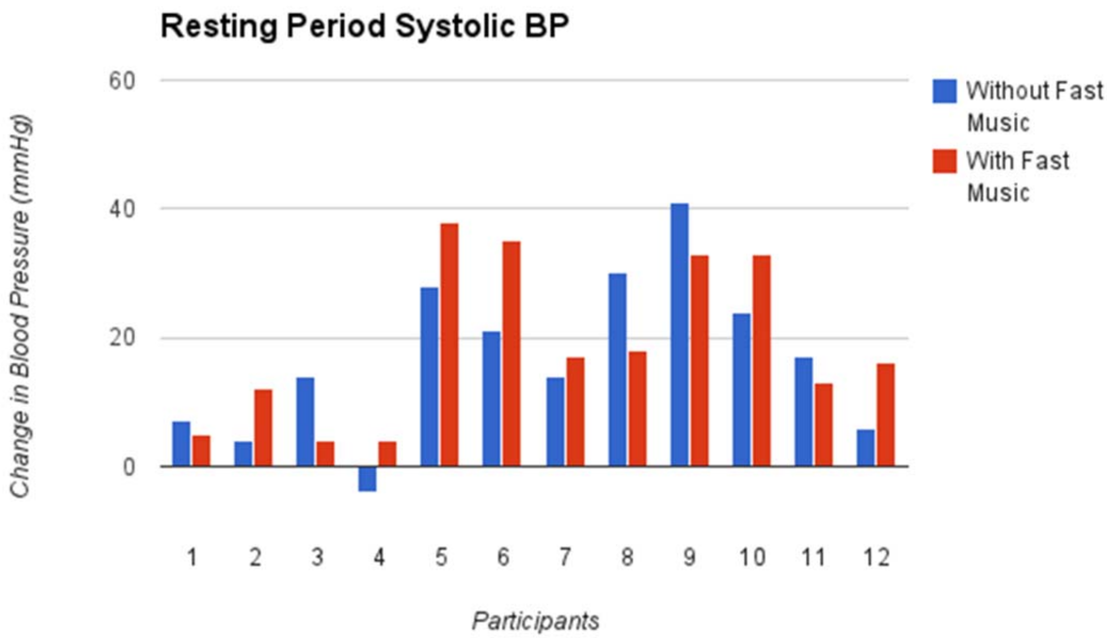

Figure 7. The change in systolic blood pressure during the resting period of self-controlled participants (n=12) subjected to fast music. A negative value indicates an increase in blood pressure over the recovery period.

<u>Breathing Rates</u>

The average number of breaths taken in the first minute of recovery for all participants in each experimental music groups was compared to the average number of breaths in the first minute of the no music control for each group (Figure 8, 9). Figure 8 represents the data for the fast-tempo music experimental group, and Figure 9 shows the data from the slow-tempo music participants. Overall, there were more breaths taken in the first minute of recovery for both fast-tempo and slow-tempo music compared to the controls. The average percent increase of breaths for fast-tempo music was 9.15% which equates to 2 additional breaths per minute. Although slow-tempo music was shown to also have an increased amount of breaths taken in recovery compared to the control, the average percent increase was less than the fast with a 7.6% increase which corresponds to 1.46 additional breaths while listening to slow music. Although both music types increased breathing rate during recovery, significance was found only for the fast-tempo music with a p-value of 0.041 and standard deviation of 5.00. The difference in the amount of breaths taken for the slow-tempo music was not significant with a p-value of 0.222 and a standard deviation of 4.56.

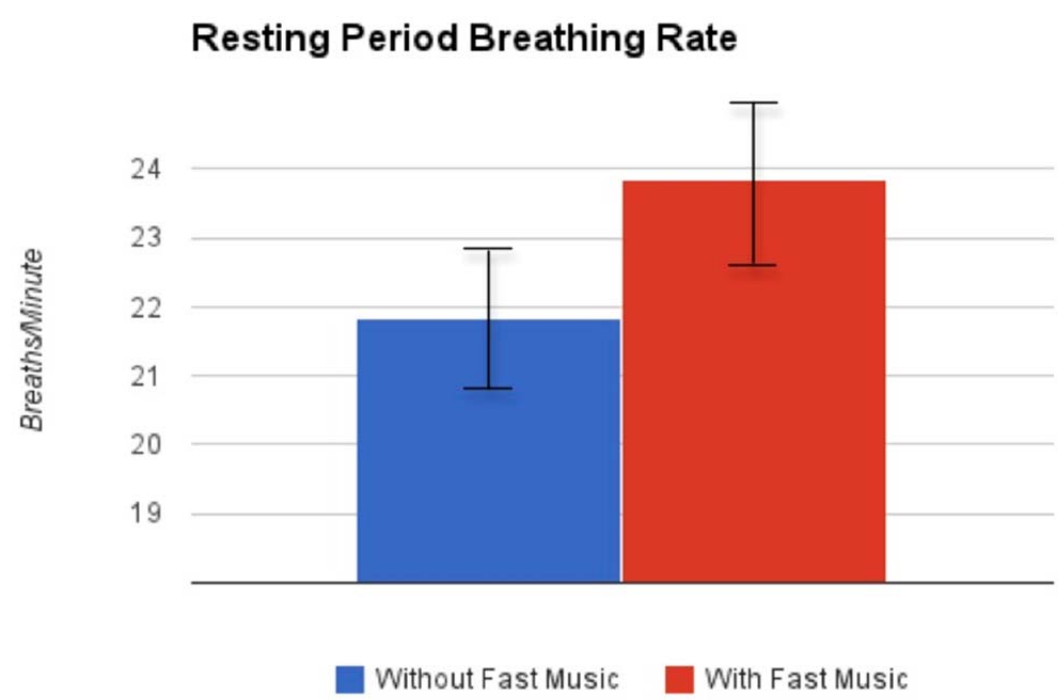

Figure 8. The average breathing rate during the resting period of self-controlled participants (n=14) subjected to fast music.

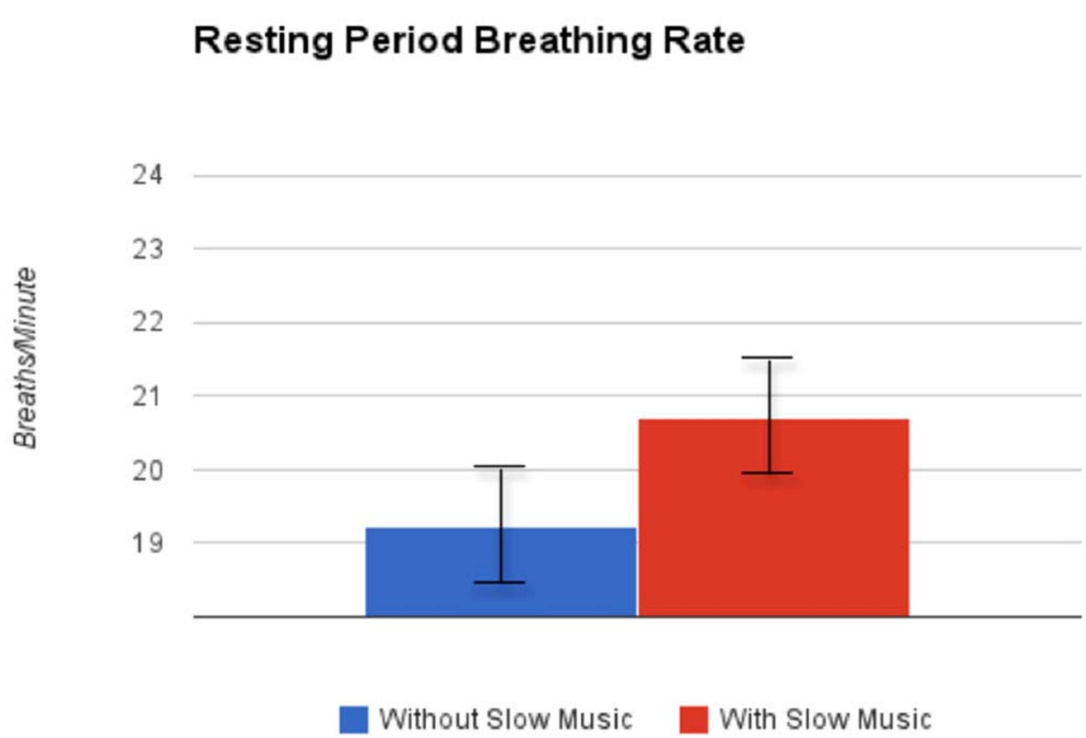

Figure 9. The average breathing rate during the resting period of self-controlled participants (n=14) subjected to slow music.

Discussion

The present study supported the hypothesis that fast tempo music caused slower post-exercise recovery rate compared to post-exercise recovery with no music. We based this conclusion on the physiological factors of heart rate and breathing rate, which were both found to significantly return to resting levels more slowly than exposing participants to an environment without music. We did not, however, find any significance with the data collected for the post-exercise recovery with slow tempo music. Therefore, we cannot conclude that slow tempo music has an impact on post-exercise recovery.

Based on previous studies, we found a comparison between fast tempo music on pre-exercise performance and post-exercise recovery. It has been found that in a resting state prior to exercise, being exposed to fast tempo music decreases the high frequency component of heart rate variability, thus decreasing the activation of the parasympathetic nervous system and putting the body at a heightened level for physical exertion (Iwanaga, 2005). The results of the present study could have the same effect on the body because of the consistency in the reduction of heart variability with fast tempo music post exercise. The music may also reduce the activation of the parasympathetic nervous system allowing the body to remain at heightened levels.

In regards to respiratory frequency, we found an increase in the post-exercise breathing rates for both the fast and slow tempo music. However, the increase in breaths taken while listening to fast tempo music increased 9.15% while the increase for slow tempo music was a lesser value of 7.6%. This finding coincides with other previous studies where compared to baseline measurements, respiratory rates increased proportionally with increasing music tempo (Bernardi, 2006; Haas, 1986). These respiratory results as well as the increased heart rates found with fast-tempo music may support the idea of synchronization of physiological components with musical tempo (Terry, 2011; Karageorghis, 2006, 2012).

It should be noted that the change in blood pressure over the course of recovery was an additional physiological factor measured. For all fast and slow tempo music time intervals the change in blood pressure was not found to be significant (Figures 4-8). Generally, the systolic blood pressure raises while bicycling, while the diastolic blood pressure remains relatively constant (Physical, 2014). Post exercise, blood pressure normally falls slightly below resting levels, then returns to a normal level post recovery. It has been found in a prior study that blood pressure returns are slow, often by several hours (Hypertens, 2000). Our data reveals this trend, however, there was no significance between either tempo of music and no music. 12 of 56 systolic and diastolic blood pressure measurements were thrown out based on unreliable blood pressure measurements of some subjects. Therefore, we cannot confidently conclude that blood pressure post-exercise is not significantly impacted by fast or slow tempo music.

We expected to see a significant difference for the post-exercise recovery with slow tempo music based on very similar research that proved slow tempo music significantly lowered heart rate and blood pressure at a faster rate than compared with trials with no music (Savitha, 2010). Compared to our study, their experiment used different equipment, had longer time intervals, and had their participants perform aerobic exercise by walking on a treadmill. The lack of significance found in our study for slow tempo music and post-exercise recovery could be due to these methodological differences, in addition to errors and limitations.

Several limitations and errors could have impacted the results and therefore could be improved upon in future studies. First, it was limited by not only a short duration of physical exertion during the exercise phase, but also a lack of an elaborate exercise regime. Future studies could include a variation of the length and type of exercise performed to see if the results are consistent. In addition, the study was conducted on healthy, 20-25 year old UW-Madison students with ranging weekly physical activity levels.To broaden our sample size, future studies could explore other demographics. This could include using subjects who have undergone a surgical procedure, illness, or stressful situation, and other ages. A larger sample size would also allow for the investigation of the sex differences.

Equipment errors additionally could be improved upon. At times the pulse oximeter, digital wrist blood pressure cuff and respiratory effort transducer used to measure heart rate, blood pressure, and respiratory cycle respectively were either inaccurate or inconsistent. This led to participants' measurements being thrown out, which reduced our data that was statistically analyzed. We suggest for future studies to thoroughly calibrate and experiment with the equipment before running the experiment. Thus measurements would be consistent and accurate.

Another limitation with our study was the time constraint. Ideally, to conduct this experiment, we would have had much more time to conduct each trial run. We tried to keep the total time of each run around 15 to 20 minutes to appease our participants. Further studies may want to allot more time to specific parts of the experiment such as increasing the time the participant is kept at a doubled heart rate or a longer resting period between trials.

The conclusion of this study that fast tempo music causes slower post-exercise recovery in regards to keeping the heart rate and breathing rate at higher levels compared to no music could have implications on overall exercise performance. Music played during exercise has been found to increase arousal and act as a distraction of the discomfort that might be related to exercise for the exerciser (Terry, 2006). Therefore, the lengthened arousal that fast tempo music causes post-exercise, may encourage a person to exercise longer. This may cause exercise facilities or sports teams to play fast tempo music in weight rooms and indoor running tracks to promote better fitness results.

More implications from this study is that generally whether no music or slow music is listened to while cooling down, heart rate, blood pressure, and breathing rate will decrease to normal levels at an equal rate. Those who exercise do not have to listen to slow tempo music to cool down quicker.

We cannot make any conclusions that post exercise recovery is independent of the music preferences of the individual. Our study was not designed to focus on the effect of music preferences; however, further studies could investigate this effect. We did purposely select instrumental beats that were not common to eliminate any possible emotional bias. An additional implication for future testing could incorporate popular slow tempo and fast tempo songs to determine the emotional impact of songs in addition to tempo that music has on post-exercise recovery.

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